

ORIGINAL ARTICLES

REHABILITATION AFTER KNEE ARTHROPLASTY: A RETROSPECTIVE ANALYSIS OF FUNCTIONAL OUTCOMES

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ABSTRACT

INTRODUCTION: Knee arthroplasty is an efficacious approach for managing advanced degenerative joint disorders, with the restoration of functional capacity largely dependent upon the rehabilitation phase. Modern rehabilitation methods encompass both terrestrial physiotherapy and hydrokinetic therapy; yet, there is inadequate information concerning their relative efficacy and the influence of the date of rehabilitation commencement.

AIM: The aim of this article is to assess the influence of rehabilitation on functional status, pain, and oedema in patients after knee arthroplasty, along with the effects of the date of rehabilitation commencement and the rehabilitation methodology on therapeutic results.

MATERIALS AND METHODS: A retrospective observational research was performed with 41 patients who completed a 7-day rehabilitation programme after knee arthroplasty. Medical records from May to November 2024 were analysed. The evaluation included both subjective and objective criteria: pain, joint and peripheral oedema (quantified using circumferential measurements), contracture, and range of motion (assessed via goniometry). Patients were categorised based on the timing of rehabilitation commencement and the type of therapy administered (land-based exclusively or in conjunction with aquatic exercises).

RESULTS: A statistically significant enhancement was noted in all evaluated measures post-rehabilitation ($p < 0.001$). Knee joint swelling diminished from 4.07 ± 1.84 cm to 2.66 ± 1.67 cm, and lower leg swelling reduced from 1.13 ± 1.40 cm to 0.54 ± 0.75 cm. Contracture decreased from $6.10 \pm 4.81^\circ$ to $2.32 \pm 3.18^\circ$, whereas knee flexion increased from $68.66 \pm 20.92^\circ$ to $84.63 \pm 16.41^\circ$. The percentage of patients without of discomfort significantly increased in both the medial and lateral joint compartments ($p < 0.001$). Prompt commencement of rehabilitation correlated with markedly improved management of lower leg oedema ($p = 0.013$). No substantial differences were identified among the various rehabilitation methods; however, a tendency for improved outcomes was noted with the simultaneous application of land-based and hydrokinetic therapy.

CONCLUSION: Rehabilitation following knee arthroplasty results in substantial enhancement of pain, oedema, and functional ability. The prompt commencement of therapy is essential for reducing postoperative oedema.

No statistically significant superiority was observed among various rehabilitation methods; yet, integrated programmes shown a tendency for improved functional outcomes. Additional research is required to validate these findings.

Keywords: knee arthroplasty, rehabilitation, physiotherapy, hydrokinetic therapy, functional recovery, range of motion, joint swelling, pain

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INTRODUCTION

Total knee arthroplasty is a commonly utilised procedure for addressing severe degenerative joint conditions, and the recovery of functional capacity post-surgery largely hinges on the rehabilitation programme executed. The primary objectives of postoperative physiotherapy encompass alleviation of pain and oedema, restoration of range of motion, and enhancement of muscular strength and functional autonomy in patients [1–3].

Hydrotherapy and aquatic exercises have been recognised as essential elements of holistic rehabilitation. Data from the literature suggest that exercises conducted in an aquatic setting, such as mineral pools, enhance cardiovascular endurance, muscle strength, and joint mobility, while concurrently alleviating pain and oedema in patients post-orthopaedic procedures, including hip and knee arthroplasty [4–6].

The therapeutic benefits of the aquatic environment arise from the synergistic influence of mechanical, thermal, and chemical elements. Buoyancy diminishes effective body weight and alleviates joint tension; when submerged to chest level, body weight may be decreased to roughly 25% of real weight. Hydrostatic pressure exerts peripheral compression that enhances venous and lymphatic drainage, therefore aiding in oedema reduction and enhancing joint mobility [7]. The activation of cutaneous receptors and joint mechanoreceptors enhances neuromuscular control and joint stability [8].

The viscosity of water, markedly higher than that of air, generates increased resistance during movement, necessitating enhanced muscular activation and fostering improvements in muscle strength and coordination. Water temperature significantly impacts outcomes, as lower temperatures (28–30°C) yield analgesic effects and diminish inflammation, whilst higher temperatures (37°C) enhance tissue perfusion and facilitate healing processes [5,9]. Furthermore, the mineral makeup of the water may have anti-inflammatory and analgesic benefits, aiding in oedema reduction and enhancing range of motion.

Aquatic exercise is infrequently employed as an independent therapeutic modality in clinical practice and is predominantly integrated with land-based physiotherapy to enhance functional recovery. Exist-

ing research indicates that both aquatic and terrestrial therapies enhance pain relief and joint mobility post-arthroplasty; however, there is inadequate data to support the superiority of a combined treatment. [1].

Individual clinical investigations indicate that hydrotherapy can be safely utilised in the early postoperative phase, resulting in enhancements in range of motion and functional status. However short-term therapies do not consistently provide significant improvements in muscle strength [2]. Systematic reviews suggest improved outcomes in range of motion and oedema reduction when aquatic and land-based therapies are integrated, while also highlighting limitations due to the limited number of studies and the variability of the data. [3].

Despite the increasing interest in water exercise, its implementation during the early postoperative phase is constrained in clinical practice due to safety concerns and the specific conditions of patients.

AIM

This retrospective observational study aims to assess the impact of rehabilitation on functional status, pain, and oedema in patients after total knee arthroplasty, while also examining the effects of the timing of rehabilitation initiation and the types of rehabilitation methods employed on therapeutic outcomes.

MATERIALS AND METHODS

A retrospective observational study was performed with 41 patients who participated in a 7-day rehabilitation programme after knee arthroplasty at the Department of Rehabilitation of St. Marina University Hospital from May 10, 2024, to November 28, 2024, utilising an analysis of medical records.

The kinesitherapy regimen for the gym-based cohort encompassed active exercises targeting the distal joints of the lower extremity, isometric contractions of the quadriceps and gluteal muscles, active movements in the knee and hip joints, alongside exercises for pelvic stabilisation and the restoration of knee extension. Each therapy session lasted 20 minutes.

Aquatic exercise therapy was performed in a pool with an average water temperature of 30°C. Prior to immersion, a waterproof dressing was affixed

to the surgical site of the knee in each patient. The therapeutic session lasted 20 minutes and encompassed forward and backward walking, lateral movements, leaping exercises, lower leg swings, knee flexion exercises, lunges, combination squats, and upper limb activities.

The evaluation of patients' functional status was conducted utilising a blend of subjective and objective clinical markers to monitor pain syndrome, periarticular alterations, and knee joint range of motion.

The subjective assessment involved palpation to evaluate pain sensitivity in the medial and lateral joint spaces of the knee. Pain intensity served as an indirect measure of localised inflammatory processes and tissue sensitivity.

The objective assessment included the following parameters:

- ◆ periarticular knee joint circumference, quantified using tape measuring, to evaluate the existence and advancement of joint oedema;
- ◆ lower leg circumference, ascertained via standardised tape measurements at certain anatomical sites, serves as an indirect predictor of peripheral oedema and trophic alterations in the musculature of the lower limb;
- ◆ the existence and degree of joint contracture, evaluated clinically by assessing the deficiency in knee extension range;
- ◆ knee flexion range of motion, assessed with goniometry in a standardised patient position, to objectively evaluate the functional recovery of joint mobility.

STATISTICAL METHODS

Quantitative data are expressed as mean $\pm$ standard deviation (Mean $\pm$ SD), whilst categorical variables are represented as frequencies and percentages (n, %). Given the absence of normal data distribution, the nonparametric Wilcoxon signed-rank test for paired samples was employed to evaluate differences between pre- and post-rehabilitation values. Comparisons across multiple independent groups (based on the postoperative time) were conducted using the Kruskal-Wallis test, whilst relationships between categorical variables were examined using the χ^2 test. The effect size for the Wilcoxon test was assessed using the rank-biserial correlation coefficient (r). Statis-

tical significance was established at $p < 0.05$ employing a two-tailed criteria. Statistical data analysis was conducted with Jamovi (version 2.6).

Ethics Approval

This study was approved by the Research Ethics Committee of the Medical University of Varna (Ref. No. 33 from 25 June 2026). The study was conducted in accordance with the Declaration of Helsinki and General Data Protection Regulation (GDPR) requirements.

RESULTS

Table 1 presents the demographic and clinical characteristics of the patients.

Table 1. Demographic and clinical characteristics of the patients.

Indicator	Category	N (%)
Sex	Female	34 (82.9)
Sex	Male	7 (17.1)
Affected knee joint	Left	14 (34.1)
Affected knee joint	Right	27 (65.9)
Postoperative period	Up to 2 weeks	15 (37.5)
Postoperative period	Up to 1 month	16 (40.0)
Postoperative period	Over 1 month	9 (22.5)
Oedema (subjective)	None	30 (73.2)
Oedema (subjective)	Present	11 (26.8)
Stiffness (subjective)	None	33 (80.5)
Stiffness (subjective)	Present	8 (19.5)
Movement limitations (subjective)	None	8 (19.5)
Movement limitations (subjective)	Present	33 (80.5)

The study sample was primarily composed of women (82.9%), with the right knee joint being more commonly affected (65.9%). Most patients commenced rehabilitation within the initial month post-surgery (77.5%). At baseline, 80.5% of patients reported movement limitations, 26.8% experienced oedema, and 19.5% exhibited stiffness.

Kinesitherapy was primarily administered in a gym environment (82.9%), although mixed therapy (aquatic and gym-based exercises) was utilised

in 14.6% of the patients. Only one patient engaged in aquatic exercise alone (Table 2).

Table 2. Distribution of patients according to the type of kinesitherapy performed.

Indicator	Yes	No
Gym-based exercises	34 (82.9%)	7 (17.1%)
Mixed therapy	6 (14.6%)	35 (85.4%)
Aquatic exercises	1 (2.4%)	40 (97.6%)

Effect of the Rehabilitation Programme

Statistically substantial enhancements were identified in all examined parameters subsequent to rehabilitation. Clinical signs and palpatory pain data are displayed in Table 3 and Table 4, respectively.

Table 3. Clinical indicators before and after rehabilitation.

Indicator	Before Rehabilitation (Mean $\pm$ SD)	After Rehabilitation (Mean $\pm$ SD)	p-value	Effect (r)
Knee circumference (cm)	4.07 $\pm$ 1.84	2.66 $\pm$ 1.67	<0.001	1.00
Lower leg circumference (cm)	1.13 $\pm$ 1.40	0.54 $\pm$ 0.75	<0.001	1.00
Contracture (range)	6.10 $\pm$ 4.81	2.32 $\pm$ 3.18	<0.001	1.00
Flexion (range)	68.66 $\pm$ 20.92	84.63 $\pm$ 16.41	<0.001	1.00

Table 4. Palpatory pain before and after rehabilitation.

Medial Joint Spaces $\chi^2 = 33.3$, $p < 0.001$		
Degree of Pain	Before Rehabilitation (%)	After Rehabilitation (%)
None	31.7	85.4
Mild	53.7	14.6
Moderate	9.8	0.0
Severe	2.4	0.0
Lateral Joint Spaces $\chi^2 = 41.0$, $p < 0.001$		
Degree of Pain	Before Rehabilitation (%)	After Rehabilitation (%)
None	39.0	90.2
Mild	51.2	0.0
Moderate	7.3	7.3
Severe	2.4	2.4

Knee joint oedema decreased significantly, with circumference measurements decreasing from 4.07 ± 1.84 cm to 2.66 ± 1.67 cm ($p < 0.001$). Likewise, lower leg oedema decreased from 1.13 ± 1.40 cm to 0.54 ± 0.75 cm ($p < 0.001$).

A notable reduction in contracture was observed (from $6.10 \pm 4.81^\circ$ to $2.32 \pm 3.18^\circ$, $p < 0.001$), along with a significant enhancement in knee flexion range (from $68.66 \pm 20.92^\circ$ to $84.63 \pm 16.41^\circ$, $p < 0.001$).

A statistically significant reduction in pain was noted in both the medial and lateral joint spaces. The percentage of patients devoid of pain in the medial joint space rose from 31.7% at baseline to 85.4% post-rehabilitation ($\chi^2 = 33.3$, $p < 0.001$). In the lateral joint space, this proportion increased from 39.0% to 90.2% ($\chi^2 = 41.0$, $p < 0.001$).

Impact of Rehabilitation Initiation Timing

At baseline, a statistically significant difference was noted only in lower leg circumference measurements ($p = 0.041$), with patients initiating rehabilitation within two weeks post-surgery exhibiting larger values than the other groups.

No statistically significant changes were observed between the groups concerning the other baseline variables, including knee joint circumference ($p = 0.187$), contracture ($p = 0.977$), and flexion range ($p = 0.067$).

A statistically significant difference in lower leg circumference measurements was seen at the end of the rehabilitation programme ($p = 0.013$). The lowest measurements were observed in patients who started rehabilitation within one month post-surgery (0.22 ± 0.32 cm), in contrast to those who began with-

in two weeks (1.03 ± 0.99 cm) and those who initiated after more than one month (0.33 ± 0.43 cm).

No statistically significant changes were seen between the groups for contracture ($p=0.501$) and flexion range ($p=0.109$).

Comparison According to the Type of Kinesiotherapy Performed

Table 5 presents the summarised final functional outcomes according to the type of rehabilitation performed.

Table 5. Comparison of final outcomes according to the type of rehabilitation performed.

Indicator	Gym-based Kinesiotherapy (n=34) Mean $\pm$ SD	Mixed therapy / Aquatic exercise therapy (n=7) Mean $\pm$ SD	p-value
Knee Circumference (final)	2.75 ± 1.64	2.21 ± 1.87	0.461
Lower leg Circumference (final)	0.60 ± 0.80	0.21 ± 0.39	0.186
Contracture (final)	2.21 ± 3.06	2.86 ± 3.93	0.732
Flexion (final)	83.82 ± 16.43	88.57 ± 17.01	0.516

The mean values of knee joint circumference at the end of rehabilitation were 2.75 ± 1.64 cm in patients who underwent gym-based kinesiotherapy and 2.21 ± 1.87 cm in those who participated in combined or aquatic exercise therapy, with the difference not reaching statistical significance ($p=0.461$).

Lower leg circumference measurements were 0.60 ± 0.80 cm in the first group and 0.21 ± 0.39 cm in the second group ($p=0.186$).

Concerning the functional indicators, the average contracture value was $2.21 \pm 3.06^\circ$ for patients who participated in gym-based kinesiotherapy and $2.86 \pm 3.93^\circ$ for those who underwent combination or aquatic exercise therapy ($p=0.732$). Knee flexion attained $83.82 \pm 16.43^\circ$ and $88.57 \pm 17.01^\circ$, respectively ($p=0.516$).

DISCUSSION

This retrospective observational study assessed the impact of rehabilitation on patients after total knee arthroplasty, along with the effects of rehabilitation scheduling and various kinesiotherapeutic methods on functional recovery. The results obtained indicated a statistically significant enhancement in all examined parameters, including pain and oedema

reduction, contracture decrease, and range of motion increase.

These findings correspond with existing studies indicating that structured rehabilitation programmes after total knee arthroplasty result in substantial functional improvement and symptom alleviation [10]. Recent systematic reviews and meta-analyses indicate that hydro-kinesiotherapy alleviates pain and enhances functional status, albeit without unequivocal evidence of superiority over land-based

therapy [11,12].

The current investigation demonstrated that the timing of rehabilitation initiation significantly impacted the reduction of postoperative oedema, with earlier mobilisation correlating with lower values at the conclusion of follow-up. This outcome may be attributed to enhanced venous and lymphatic drainage facilitated by early functional loading, aligning with the physiological impacts of hydrostatic pressure and positional compression [7]. Comparable mechanisms have been documented in the literature, underscoring the significance of early mobilisation in managing oedema and the inflammatory response post-orthopaedic surgery [13].

No statistically significant changes in range of motion and contracture were seen across the groups based on the timing of rehabilitation initiation. The restoration of joint mobility is influenced not just by early mobilisation but also by tissue healing, individual biomechanical traits, and the length of the rehabilitation procedure.

No statistically significant differences were seen between gym-based kinesiotherapy and combination or aquatic rehabilitation programmes regarding the type of rehabilitation techniques. Still, a preference for improved oedema and flexion results was not-

ed in patients participating in combination rehabilitation programmes. These findings align with current studies suggesting that aquatic therapy may offer supplementary advantages due to diminished gravity loading, hydrostatic pressure, and enhanced resistance in the aquatic environment, which facilitate muscle activation and movement control [14]. The clinical effects of hydrotherapy are important yet vary, depending upon the protocol, intensity, and phase of rehabilitation [11].

A major limitation of the current study is the pronounced imbalance between the groups, especially the exceedingly tiny cohort of patients receiving aquatic exercise therapy. This significantly restricts the capacity to identify statistically significant differences and to draw dependable comparative conclusions. A further disadvantage is the retrospective design and the comparatively little follow-up duration, which limits the evaluation of long-term functional results.

Notwithstanding these constraints, the findings affirm that rehabilitation after total knee arthroplasty yields substantial clinical enhancement, with the prompt commencement of therapy being especially crucial for oedema management. The identified trends supporting integrated rehabilitation methods align with existing literature; nonetheless, future prospective studies with larger sample sizes and more balanced groups are necessary to reach conclusive determinations about the efficacy of aquatic exercise therapy.

CONCLUSION

Rehabilitation after total knee arthroplasty results in substantial functional enhancement, evidenced by less pain and swelling, reduced contracture, and a bigger range of motion. Timely commencement of therapy correlates with improved management of postoperative oedema. No statistically significant differences were seen among the investigated rehabilitation approaches.

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