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Original article

Quality of life after total knee arthroplasty: effects of a 21-day inpatient rehabilitation program on pain and functional recovery

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Summary

Introduction. Effective rehabilitation is essential for recovery after total knee arthroplasty (TKA), yet the magnitude of benefit from intensive inpatient programs remains incompletely defined. This work aimed to evaluate the effects of a standardized 21-day inpatient rehabilitation program on pain, functional status, and health-related quality of life after TKA, and to assess differences according to sex, age, and timing of rehabilitation.

Methods. In this prospective observational study, 100 consecutive patients (67% women; mean age 68.9±5.4 years) undergoing primary TKA for end-stage osteoarthritis participated in a standardized 21-day inpatient rehabilitation program. Outcomes were assessed at admission and discharge using the Numeric Rating Scale (NRS), WOMAC index, and SF-36 questionnaire. Changes were analyzed using paired statistical tests with effect size estimation.

Results. All outcomes improved significantly with large effect sizes: NRS decreased from 3.7±2.1 to 1.5±1.4 (d=1.26), WOMAC from 26.9±6.5 to 17.7±6.0 (d=1.47), and SF-36 increased from 75.6±7.9 to 82.9±6.2 (d=1.03) (all $p<0.001$), indicating substantial magnitude of change. Women and patients ≥70 years had worse baseline functional status ($p<0.05$). Time to rehabilitation (1–6 months) was not associated with outcomes.

Conclusions. A structured 21-day inpatient rehabilitation program was associated with substantial improvements with large effect sizes in pain, function, and quality of life after TKA. Baseline disparities supported the need for tailored rehabilitation strategies, while findings suggested that program intensity might be more relevant than timing within the early postoperative period. Causal inference was limited by the observational design.

Key words: total knee arthroplasty, rehabilitation, physical therapy modalities, recovery of function, pain measurement, quality of life

Introduction

Osteoarthritis is one of the leading causes of disability worldwide, particularly among older adults [1, 2]. Total knee arthroplasty (TKA) is an effective surgical procedure for end-stage knee osteoarthritis, restoring pain-free mobility and improving joint function [3, 4]. Although most

patients achieve satisfactory outcomes, 20–30% express dissatisfaction postoperatively, often related to persistent pain, limited function, or unrealistic expectations [5, 6].

Postoperative rehabilitation plays a crucial role in recovery, aiming to optimize muscle strength, range of motion, functional independence, and pain control [7, 8]. Quality of life after TKA reflects not only pain reduction but also functional independence and participation in daily activities [9, 10]. Recovery after TKA is influenced by a combination of physical, psychological, and social factors, and rehabilitation increasingly follows a biopsychosocial model integrating these components [11]. Despite numerous studies, optimal timing, intensity, and duration of rehabilitation after TKA remain debated [12].

This study aimed to evaluate the effectiveness of a 21-day inpatient rehabilitation program after TKA and to explore whether baseline clinical status differed according to sex, age group, and time from surgery to rehabilitation.

Methods

Study design and participants

This prospective observational study was conducted at the Institute for Physical Medicine, Rehabilitation and Orthopaedic Surgery "Dr Miroslav Zotović" in Banja Luka, Bosnia and Herzegovina, between January 2022 and December 2023. A total of 100 consecutive patients aged 55–75 years who underwent primary TKA for end-stage knee osteoarthritis were enrolled.

Inclusion criteria were: patients undergoing primary TKA due to end-stage osteoarthritis, ability to participate in rehabilitation, and completion of baseline and follow-up assessments. Exclusion criteria included: revision TKA; surgery due to inflammatory rheumatism or trauma; neurological diseases (polyneuropathies, central or peripheral motor neuron lesions, prior stroke); muscle diseases (polymyositis, dermatomyositis, myopathies); BMI >40 kg/m²; opioid or co-analgesic therapy in the previous two months; severe comorbid conditions limiting participation; contraindications to physical therapy modalities; and incomplete data.

The study was conducted in accordance with the Declaration of Helsinki. All participants provided written informed consent. The study was approved by the Ethics Committee of the Institute (decision No. 116-01-11471-1/21 dated 09 September 2021). No formal a priori sample size calculation was performed; all consecutive eligible patients were included.

Rehabilitation protocol

All patients underwent a standardized 21-day inpatient rehabilitation program. The program included supervised kinesiotherapy, continuous passive motion (CPM), electrotherapy, magnetotherapy, hydrokinesiotherapy, and occupational therapy, delivered in daily sessions over 21 days.

Specific components were:

- Kinesiotherapy: breathing exercises; strengthening of pelvifemoral, thigh, trunk and upper extremity muscles; active and passive exercises to increase knee range of motion; coordination and balance exercises; gait training with crutches.
- Functional occupational therapy: training in self-care and daily activities; exercises to maintain range of motion and strengthen muscles.
- Cryotherapy: ice application before kinesiotherapy.
- Interferential currents: 0–100 Hz, 15 minutes daily for 15 days.
- Magnetotherapy: 50–70 Hz, 55% intensity, 20 minutes daily.
- Hydrokinesiotherapy: muscle strengthening and gait exercises in water.
- Rescue analgesia consisted of paracetamol up to 3 g/day as required.

Outcome measures

Outcomes were assessed on admission (day 1) and at discharge (day 21):

- Numeric Rating Scale (NRS): average pain over 24 hours (0 = no pain, 10 = worst possible pain) [13].
- Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC): assesses pain, stiffness, and physical function; higher scores indicate worse status [14]. The Likert version (score 0–4 per item) was used, with total score ranging 0–96. Functional status was categorized as: score <20 = good function, 20–40 = satisfactory function.
- Short Form 36 Health Survey (SF-36): multidimensional measure of health-related quality of life covering eight domains; higher scores indicated better quality of life [15]. For analysis, an overall SF-36 summary score was calculated as the mean of the eight domain scores, transformed to a 0–100 scale, where higher scores indicated better quality of life.

Statistical analysis

Data were analyzed using SPSS version 29.0 and R version 4.2.1. Data distribution was assessed using both the Shapiro–Wilk and Kolmogorov–Smirnov tests, supported by graphical inspection (histograms and Q-Q plots). Variables approximating normal distribution were analyzed using parametric tests, while non-normally distributed variables were analyzed using non-parametric methods. For within-group comparisons (admission vs. discharge), paired t-test was used for normally distributed data and Wilcoxon signed-rank test for non-normal data. Between-group comparisons (sex, age <70 vs. ≥70 years) used independent t-test or Mann-Whitney U test as appropriate. Associations were examined with Spearman's correlation. Mean differences, 95% confidence intervals (CI), and Cohen's d effect sizes for within-group change were calculated using standardized mean differences for paired observations. Statistical significance was set at $p<0.05$. All tests were two-tailed. Given multiple comparisons, results should be interpreted with caution due to the potential risk of type I error.

Results

Participant characteristics

The study included 100 patients, 67% women. Mean age was 68.9±5.4 years and mean BMI was 31.7±4.7 kg/m². The majority were workers (46%) or homemakers (31%), while 23% were retired. Thirty-five patients (35%) had received some form of prior therapy (e.g., physical therapy, injections). Before rehabilitation, only 25% of patients were able to walk without assistive devices (Table 1).

Table 1. Baseline sociodemographic and clinical characteristics (N=100)

Characteristic	Value
Sex (female), n (%)	67 (67.0)
Age (years), mean ± SD	68.9 ± 5.4
BMI (kg/m²), mean ± SD	31.7 ± 4.7
Occupation, n (%)	
Worker	46 (46.0)
Homemaker	31 (31.0)
Retired	23 (23.0)
Prior therapy (any), n (%)	35 (35.0)
Walking without assistive devices, n (%)	25 (25.0)

Changes after rehabilitation

All primary outcomes improved significantly, with large standardized effect sizes (all Cohen's d >1.0) (Table 2).

Table 2. Comparison of outcomes before and after rehabilitation

Outcome	Before (mean±SD)	After (mean±SD)	Mean difference (95% CI)	Cohen's d	p
NRS	3.7 ± 2.1	1.5 ± 1.4	–2.2 (–2.5 to –1.9)	1.26	<0.001
WOMAC	26.9 ± 6.5	17.7 ± 6.0	–9.2 (–9.8 to –8.6)	1.47	<0.001
SF-36	75.6 ± 7.9	82.9 ± 6.2	7.4 (6.4 to 8.4)	1.03	<0.001

NRS - Numeric Rating Scale; WOMAC - Western Ontario and McMaster Universities Osteoarthritis Index; SF-36 - Short Form-36 Health Survey.

Within-group comparisons: paired t-test for NRS and SF-36; Wilcoxon signed-rank test for WOMAC.

Median (interquartile range) values showed consistent improvement across all outcomes: NRS from 4.0 (2.0–5.0) to 1.0 (0.0–2.0); WOMAC from 26.0 (21.9–33.3) to 17.7 (13.5–21.9); SF-36 from 76.7 (70.8–81.0) to 83.0 (80.2–86.9). Before rehabilitation, the mean WOMAC score of 26.9 corresponded to satisfactory function based on the predefined categories. After rehabilitation, WOMAC scores shifted toward lower values, with the mean post-rehabilitation score falling within the good function range.

Influence of sex and age on baseline values

Women had significantly worse baseline WOMAC scores compared to men (27.9±6.1 vs. 24.9±7.0, p=0.034). NRS and SF-36 did not differ significantly by sex (Table 3).

Table 3. Baseline outcomes by sex

Outcome	Male (n=33)	Female (n=67)	p
NRS	3.48 ± 2.05	3.82 ± 2.09	0.298
WOMAC	24.95 ± 7.01	27.89 ± 6.11	0.034
SF-36	77.15 ± 8.04	74.80 ± 7.76	0.163

Patients aged ≥70 years had significantly worse baseline WOMAC scores than those <70 (28.2±6.5 vs. 25.7±6.4, p=0.049). NRS and SF-36 did not differ between age groups (Table 4).

Table 4. Baseline outcomes by age group

Outcome	<70 years (n=52)	≥70 years (n=48)	p
NRS	3.61 ± 1.94	3.82 ± 2.21	0.617
WOMAC	25.66 ± 6.36	28.23 ± 6.52	0.049
SF-36	76.72 ± 7.01	74.38 ± 8.63	0.139

Correlations with time to rehabilitation

Mean time from surgery to rehabilitation was 2.5±0.9 months (range 1–6 months). No significant correlation was found between time to rehabilitation and any post-rehabilitation outcome or change score (all p>0.05, Table 5). Preoperative pain duration (mean 5.1±3.5 years) also did not correlate with outcomes.

Table 5. Spearman's correlation between time from surgery to rehabilitation and outcomes (at discharge) and change scores (Δ)

Outcome after rehab	Rho	p
NRS (after)	0.125	0.215
WOMAC (after)	–0.059	0.559
SF-36 (after)	–0.049	0.629
Δ NRS	–0.022	0.829
Δ WOMAC	0.066	0.511
Δ SF-36	0.010	0.921

Discussion

In our cohort, patients improved substantially in pain, functional status, and quality of life over the 21-day inpatient rehabilitation period. Effect sizes were large (Cohen's d 1.03–1.47) — considerably larger than those typically reported for outpatient or home-based programs. While these effect sizes are substantial, they likely represent a combination of therapeutic benefit and the natural postoperative recovery trajectory. This suggests that intensive, supervised rehabilitation may offer substantial benefits. The mean WOMAC reduction of 9.2 points and the NRS reduction of 2.2 points approached or exceeded commonly cited minimal clinically important difference (MCID) thresholds reported for patients after total knee arthroplasty (approximately 10 points for the total WOMAC score and 2 points for NRS pain), indicating that the observed improvements were not merely statistically significant but also clinically relevant for patients' daily lives.

Comparison with previous studies

Our results align with systematic reviews demonstrating that structured rehabilitation after TKA improves outcomes compared to minimal or no intervention [7, 8]. However, the magnitude of improvement in our study (particularly for WOMAC) appears larger than that reported in some outpatient-based programs [18], although direct comparisons are limited by differences in study design, patient populations, and outcome assessment. A meta-analysis by Artz et al. [8] found pooled effect sizes of approximately 0.6–0.8 for functional outcomes, whereas our effect sizes ranged from 1.03 to 1.47. This difference may be related to the daily, supervised nature of our program, which included multiple therapeutic modalities (kinesiotherapy, hydrotherapy, electrotherapy) reinforcing each other.

Sex and age differences

Consistent with previous research [19, 20], women and older patients in our study had poorer baseline functional status. Women scored approximately 3 points higher (worse) on WOMAC compared to men, while patients ≥70 years scored approximately 2.5 points higher than younger patients. These differences, although modest, are clinically meaningful — they indicate that women and older patients entered rehabilitation with a functional disadvantage. At discharge, women and older patients continued to show lower absolute functional levels, suggesting that their baseline disadvantage was not fully overcome during the 21-day program. Several factors may contribute to this, including differences in symptom burden, comorbidity profiles, muscle reserve, and vulnerability to postoperative deconditioning [19–22]. These findings suggest that these subgroups may benefit from more individualized rehabilitation strategies, potentially including longer programs, additional strength training, or nutritional support.

Timing of rehabilitation

The absence of correlation between time from surgery to rehabilitation (1–6 months) and outcomes is an important finding. While some authors advocate for very early rehabilitation [12], our findings suggest that, within the first six postoperative months, the quality and intensity of the program may be more important than the exact timing of initiation. From a practical standpoint, this may allow somewhat greater flexibility in rehabilitation scheduling. However, we cannot exclude the possibility that rehabilitation initiated within the first few weeks might yield different results, and this merits further investigation.

Mechanisms of improvement

The multimodal nature of our program likely contributed to the large effect sizes. Kinesiotherapy targets muscle strengthening and range of motion, addressing the primary physical impairments after TKA. Hydrokinesiotherapy allows earlier weight-bearing and exercise with reduced joint loading, facilitating pain-free movement. Electrotherapy modalities may contribute to symptom relief, although the evidence for individual modalities remains heterogeneous. The combination of these interventions within the structured 21-day program, with daily supervision and progression, offers a level of support that is difficult to achieve in outpatient settings. Because the rehabilitation program was multimodal, the relative contribution of individual components to the overall outcome could not be determined.

Clinical implications

Our findings support the use of intensive inpatient rehabilitation for patients after TKA — particularly for those who start with poorer function. Given that only 25% of our patients could walk without assistive devices pre-rehabilitation, this population clearly benefited from structured intervention. Intensive inpatient rehabilitation may reduce long-term healthcare burden by accelerating functional recovery. For healthcare systems, the cost-effectiveness of such programs should be evaluated against the potential for reduced long-term disability and improved quality of life. The lack of correlation with timing suggests that patients who cannot access immediate rehabilitation may still achieve excellent outcomes if they receive a high-quality program later in the postoperative period. These findings are consistent with previous reports on acceptable functional outcomes following TKA in diverse patient populations [23].

Limitations

The main limitation is the absence of a control group. This limits causal interpretation — we cannot attribute the observed improvements solely to the rehabilitation program. Additional limitations include the lack of a priori sample size calculation, short follow-up (21 days only), reliance on patient-reported outcomes without objective physical performance measures, and single-center design. In addition, the use of an overall SF-36 summary score, rather than separate physical and mental component summaries, may have masked domain-specific changes. Future studies should analyze these components separately. The lack of multivariable analysis limits adjustment for potential confounders such as prior therapy or comorbidity burden. Furthermore, the absence of correction for multiple comparisons may increase the risk of type I error. Rehabilitation was initiated at varying intervals post-surgery (1–6 months), although correlation analyses did not show a significant impact. Psychological and social factors (anxiety, depression, expectations) were not assessed, despite their known influence on recovery [11]. Finally, the single-center design and specific inclusion criteria (e.g., age 55-75, BMI ≤40) limit the generalizability of our findings to all TKA patients.

Strengths and future directions

Despite these limitations, the study has strengths: a well-defined, reproducible rehabilitation protocol; use of validated outcome measures; consecutive patient enrollment reflecting real-world practice; transparent reporting of inclusion/exclusion criteria; calculation of effect sizes and clinically meaningful differences; and transparent reporting of negative findings. Future research should prioritize randomized controlled trials comparing inpatient versus outpatient rehabilitation,

with longer follow-up (6, 12, and 24 months), inclusion of objective physical measures, and comprehensive psychological assessments. Cost-effectiveness analyses would also be valuable for healthcare decision-makers.

Conclusions

In this study, participation in the intensive 21-day inpatient rehabilitation program after TKA was associated with large and clinically meaningful improvements in pain, functional status, and quality of life. Women and older patients had poorer baseline function, highlighting the need for tailored interventions. Time from surgery to rehabilitation (within six months) did not influence outcomes, suggesting that program quality may be more relevant than exact timing within the observed interval. Recovery after TKA is likely shaped by several interacting clinical and patient-related factors. However, due to the absence of a control group, causal inferences cannot be made. Controlled trials with longer follow-up periods are needed to confirm these findings and establish optimal rehabilitation strategies.

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Conflicts of interest. The authors declare no conflict of interest.

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Kvalitet života nakon totalne artroplastike koljena: efekti 21-dnevnog programa stacionarne rehabilitacije na bol i funkcionalni oporavak

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Uvod. Efikasna rehabilitacija predstavlja ključni faktor oporavka nakon totalne artroplastike koljena (TKA), dok obim efekta intenzivnih bolničkih programa još uvijek nije u potpunosti razjašnjen. Cilj je bio da se procijeni efekat standardizovanog 21-dnevnog bolničkog rehabilitacionog programa na bol, funkcionalni status i kvalitet života nakon TKA, te ispitati razlike prema polu, starosti i vremenu početka rehabilitacije.

Metode. Prospektivna opservaciona studija obuhvatila je 100 uzastopnih pacijenata (67% žena; prosječna starost 68,9±5,4 godina) nakon primarne TKA zbog terminalne osteoartroze. Ishodi su procijenjeni pri prijemu i otpustu pomoću NRS, WOMAC i SF-36 upitnika. Promjene su analizirane odgovarajućim testovima uz procjenu veličine efekta.

Rezultati. Zabilježena su značajna poboljšanja sa velikim efektima: NRS 3,7±2,1 na 1,5±1,4 (d=1,26), WOMAC 26,9±6,5 na 17,7±6,0 (d=1,47), SF-36 75,6±7,9 na 82,9±6,2 (d=1,03) (svi p<0,001). Žene i pacijenti ≥70 godina imali su lošiji početni funkcionalni status (p<0,05). Vrijeme do rehabilitacije (1–6 mjeseci) nije bilo povezano sa ishodima.

Zaključci. Standardizovani 21-dnevni bolnički rehabilitacioni program povezan je sa značajnim poboljšanjem bola, funkcionalnog statusa i kvaliteta života nakon TKA. Uočene razlike ukazuju na potrebu za individualizovanim pristupom, dok intenzitet programa može biti važniji od vremena početka. Zbog opservacionog dizajna, uzročni zaključci su ograničeni.

Ključne riječi: totalna artroplastika koljena, rehabilitacija, fizikalna terapija, funkcionalni oporavak, mjerenje bola, kvalitet života