MULTIDISCIPLINARY ENHANCED RECOVERY WITH PHYSIOTHERAPY INTEGRATION: IMPACT ON FUNCTIONAL RECOVERY AND LENGTH OF STAY IN UROLOGICAL (TURBT), COLORECTAL (PERIANAL FISTULA), AND ORTHOPEDIC (PARTIAL HIP ARTHROPLASTY) SURGERIES

Dr Usman Haider[1], Dr Hafiz Muhammad Atif [2], Dr Sher Dil Khan [3*]

[1]Assistant Professor of Surgery, HITEC-IM (Institute of Medical Sciences), Taxila Cantt, Rawalpindi, Pakistan; E-mail: drusmanhaider81@gmail.com

[2]Department of Urology and Kidney Transplant, Benazir Bhutto Hospital, Rawalpindi; affiliated with Rawalpindi Medical University (RMU), Rawalpindi, Pakistan; E-mail: munaweratif@gmail.com

[3]Assistant Professor of Orthopaedics, HITEC-IM (Institute of Medical Sciences), Taxila Cantt, Rawalpindi, Pakistan; E-mail: shehry100@gmail.com

[*]**Corresponding author:** Sher Dil Khan; **E-mail Id**: shehry100@gmail.com

Abstract

Importance: The role of Enhanced Recovery After Surgery (ERAS) protocols has developed significantly in the realm of surgical specialties in garnering improved perioperative outcomes; however, recovery has been mostly assessed on the basis of hospital stays and less on functional independence. The role of integrating structured physiotherapy within existing ERAS protocols regarding functional recovery of various surgical procedures has mostly remained inadequately addressed.

Objective: To assess the relationship between the incorporation of physiotherapy in ERAS protocols and the recovery of functions as well as the length of stay in the hospital post-transurethral resection of bladder tumor (TURBT), perianal fistula repair, and hip arthroplasty.

Design, Setting, and Participants: In this multicenter, prospective cohort study, patients were enrolled between January 2020 and December 2023 in 3 tertiary care centers in Pakistan. Patients aged ≥ 18 years posted for surgery for Trans-Urethral Resection of Bladder Tumor (TURBT), perianal fistula, and/or partial hip arthroplasty were included, 1,847 patients screened, 556 (30%) patients were enrolled.

Exposures: Perioperative physiotherapy pathways integrated with ERAS care versus standard ERAS care without integrated physiotherapy pathways.

Main Outcomes and Measures: Time to meet preselected functional milestones and length of hospital stay. Secondary endpoints: Quality of life measured with EQ 5D 5L, complications, opioid intake, and re-admissions.

Outcome: The physiotherapy-integrated ERAS program reduced the time to reach functional endpoints by 48% for TURBT (HR, 1.92; CI, 95% range, 1.45-2.55), by 37% for perianal fistula surgery (HR, 1.78; CI, 95% range, 1.32-2.39), and by 39% for partial hip arthroplasty (HR, 2.13; CI, 95% range, 1.61-2.82) (all p <0.001). Mean hospital stay was reduced by 1.0 to 2.3 days depending on the operation (all p <0.001). The scores for quality-of-life outcome at 30 days were higher in the intervention arm (mean difference, 0.09; CI, 95% range, 0.06-0.12). No differences were found for the complication rate, although there were fewer cases of urinary retention after TURBT (6.5% vs 14.1%; P=0.04).

Conclusions and Relevance: Physiotherapy integrated ERAS care was linked with quick functional recovery and shorter stays in hospital in urology, colorectal, and orthopedic surgery without more complications, and these data support changing what constitutes success for enhanced recovery and encourage routine physiotherapy integration into enhanced recovery care.

Keywords: Enhanced Recovery After Surgery (ERAS); Physiotherapy Integration; Functional Recovery; Length of Hospital Stay; Multidisciplinary Perioperative Care; Surgical Outcomes; Postoperative Rehabilitation,

1. Introduction

1.1 The Clinical Imperative: Functional Recovery as a Central Surgical Outcome

Contemporary surgery has demonstrated tremendous success in lowering the rate of perioperative deaths and serious postoperative complications for various surgical procedures [1]. Nevertheless, as the safety of surgery has continued to improve over the past decades, attention has continued to focus on the outcome of the patient as perceived specifically [2], the rate of functional convalescence. Every day, millions of people worldwide undergo urological [3], colorectal, and orthopedic surgical procedures such as the transurethral resection of the tumor in the bladder (TURBT) [4], the surgical repair of perianal fistula, and hip arthroplasty [5]. Though the anatomical and surgical complexities of these procedures differ significantly [6], the common postoperative identifying feature for these is the phase of functional susceptibility in which the patient is less mobile and limited in personal and family cares and activities [7]. The issue of postoperative functional decline is of particular concern in the elderly population who are increasingly represented in the surgical population due to the presence of pre-existing comorbid conditions [8-11]. Short lengths of stay in the hospitals have already led to situations of deconditioning and an increase in dependency to caregivers among others [12]. Further, the extend of stay in the hospitals continues to pose further burden on the health facilities due to extra costs [13]. This has led to the current concerns of functional recovery and length of stay in surgeries [14]. Enhanced Recovery After Surgery (ERAS) protocols were designed for the mitigation of many possible reasons for poor recovery rates by optimizing the process of surgery [15]. Despite the success of ERAS in lowering complications and hospital stays, there are still significant differences in functional recovery for patients who undergo the ERAS program [16]. This observation realizes that despite the goal of recovery attained, certain indicators for recovery are not met within the current ERAS program [17].

1.2 ERAS Pathways: Progress Achieved and Gaps Remaining

Since their original use in colorectal surgery, ERAS protocols have gradually emerged within the specialty of surgery, enjoying more and more evidence support, including consensus guidelines formulated by a number of surgical societies [18]. Key components, including patient education, carbohydrate loading, opioid-free analgesic plans, early oral intake, and minimizing the use of tubes and drains, are currently implemented in urological, colorectal, and orthopedic surgery practice with success in decreasing ileus, opioid use, and complications [19].

Although these achievements have been realized, the ERAS protocols have been primarily focused on physiological recovery milestones rather than the restoration of function. Early mobilization always forms an important part of these protocols, although its implementation sometimes lacks clear definition [20]. Mobilization can be recorded as an accomplishment, such as the patient being able to stand and walk, without reference to the manner or endurance [. This can lead to patients fulfilling the ERAS criteria while being functionally impaired [21]. Specialty-specific ERAS adaptations have further accentuated these shortcomings [22]. In TURBT, pathways appropriately stress urinary outcomes such as the resolution of hematuria and catheter management, but there is limited emphasis on functional mobility and physical resilience [23]. Those undergoing perianal fistula surgery typically follow pathways that focus on wound healing and pain control but often provide little guidance related to sitting tolerance, gait, or return to activities associated with employment [24]. Early mobilization represents one of the cornerstones of care in partial hip arthroplasty [25], yet variability in physiotherapy intensity [26], timing, and coordination often results in functional outcomes that are inconsistent, particularly for patients who are frail or vulnerable cognitively [27]. These findings suggest that while these ERAS pathways effectively address many physiological barriers to recovery, they might lack the strength to target the complex, multidimensional process of functional restoration [28].

1.3 Physiotherapy Integration as a Mechanism to Enhance Recovery

Physiotherapy is a systematic, evidence-driven process by which patients can restore their mobility, strength, equilibrium, or confidence following surgery [29]. When ERAS protocols are systematically integrated with physiotherapy, the latter goes from being an encouragement to mobilize the patient to actually focused on bridging the gap between physiological recovery and achieving autonomy [30]. A model by which the ERAS program incorporating physiotherapy could perhaps be viewed is through the continuum model, which would start before any surgery takes place [31]. The theoretical foundation underpinning this integration is underpinned by the International Classification of Functioning, Disability, and Health (ICF) model. This model outlines that the attainment of health outcomes is a product of the complex relationship between body function [32], activity performance, as well as participation in daily life. In other words, a successful recovery following a surgical procedure is more than just healing wounds; rather, a restoration of a person's functional ability within their environment is needed [33].

Physiological mechanisms also align with the application of physiotherapy practices during surgical recovery [34]. Preoperative physical conditioning can protect against the catabolic response associated with surgery through the enhancement of cardiorespiratory exercise tolerance or muscle strength reserves, which can minimize the severity of the postoperative response [35]. During the acute postoperative period, therapeutic exercise activities can modulate the perception of surgical-related pain through central or peripheral mechanisms, influence neuromuscular coordination, or prevent complications secondary to immobilization [36]. Furthermore, physiotherapy enables criterion-based progression towards activity increase, based on individual performance rather than time-based progression criteria [37], while still prioritizing cautious approaches towards progressive exercises [38]. On the basis of evidences obtained with cardiac surgery and major abdominal procedures [39], there seems to be potential for improving functional recovery and shortening stay by means of formalized physiotherapeutic and prehabilitation strategies [40]. However, the scope and appropriate interwoven application of these concepts into existing ERAS methodology remains unclear, at least for the present [41].

1.4 Index Procedures: Distinct Surgeries, Shared Functional Challenges

1.4.1 Transurethral Resection of Bladder Tumor

TURBT is among the most common urological procedures, especially in older adults with bladder cancer. While the procedure is minimally invasive, patients often undergo multiple resections over time, contributing to cumulative physical deconditioning. Postoperative care focuses on urological endpoints, such as bleeding and catheter removal, with less attention given to physical function [42]. A concern of urgency or leakage can make patients avoid walking, and admission to the hospital can itself result in a loss of strength and balance. Physiotherapy included in ERAS pathways for TURBT provides opportunities for pelvic floor conditioning, builds confidence in mobilization strategies, and educates in maintaining independence [43].

1.4.2 Perianal Fistula Surgery

Surgery for perianal fistula presents a unique cluster of postoperative challenges. Pain with sitting and walking, change in bowel habits, and issues related to wound care and hygiene cause significant impairment in function [44]. Recovery pathways, however, often are deemed complete when wound healing is acceptable [45]. Functional domains such as sitting for prolonged periods, driving, resuming occupational activities, and sexual function are rarely addressed in a systematic fashion [46]. Physiotherapy integration may be a way to address this lacuna by including graded exposure to sitting and walking, pain education, and techniques aimed at optimizing pelvic floor coordination to assist in more holistic recovery [47].

1.4.3 Partial Hip Arthroplasty

Partial arthroplasty of the hip is most commonly undertaken as a salvage procedure in older, vulnerable patients after hip fracture, with a known high risk of poor functional outcome [48]. While physiotherapy is provided as a routine component of rehabilitation, there is often wide variability in its delivery [49]. Early conditioning is not possible as a routine component of care if surgery is urgent, thereby increasing the importance of early rehabilitation to regain mobility rather than remain dependent. Coordination of physiotherapy as part of ERAS care may optimize goal-oriented rehabilitation [50].

1.4.4 Unresolved Questions and the Need for Cross-Disciplinary Synthesis

Even specific studies have explored physiotherapy strategies or ERAS protocols for particular surgery types, there has been a lack of cohesive understanding on this subject [51]. Most of these trials have only concentrated on a particular field and have not provided sufficient understanding on whether functional improvement noted in one setting can be expected in another [52]. In addition, most review articles have only concentrated on a particular functional measure, for example, complications or readmissions, without combining functional recovery as an outcome measure [53].

The important questions have therefore not been answered. Is the integration of physiotherapy within ERAS protocols proven to consistently improve function post-anatomically and post-clinically different procedures? Which components of physiotherapy, that is, prehab, early mobil, and specific exercise, are proven to be most effective? How do improvements in function impact hospital stay? To answer these questions, a synthesis must be performed that moves beyond the conventional boundaries of specialties in a clinically specific way. To the authors' knowledge, no original study or systematic synthesis has explored the role of physiotherapy-integrated ERAS in urological, colorectal, and orthopedic surgery, with a key focus on functional recovery and length of stay outcomes [54].

1.5 Study Objectives and Clinical Significance

The aim of this study was to investigate how physiotherapist-integrated ERAS care affects post-operative functional recovery and length of hospital stay in patients undergoing TURBT, surgery for perianal fistula, and hip replacement surgery. By taking this wide-ranging look at several different procedures, it was hoped that important differences and similarities in how physiotherapy helps patients recover and how this can and cannot be applied to different surgeries could be uncovered. Aside from measuring its overall efficiency, it also aspires to contribute to improving clinical practice by identifying the elements of physiotherapeutic treatments most likely associated with functional outcomes and a decrease in hospitalization. From a surgical or perioperative viewpoint, these data can be used to direct the allocation of materials or optimize pathways. From a more practical viewpoint, functional outcomes correlate directly with more significant outcomes beyond discharge. Ultimately, through its perspective on the success of ERAS care that focuses on the recovery goal of functional independence rather than solely on discharge home, this research makes a valuable contribution to more patient-focused models of post-op recovery [55].

2. Methods

2.1 Study Design and Conceptual Framework

This study was planned as a prospective, multidisciplinary observational cohort study evaluating the effectiveness of physiotherapy-integrated care pathways on the recovery process and hospital stay in three different surgical specialties: urology (transurethral resection of the bladder tumor), colorectal surgery (perianal fistula surgeries), and orthopedic surgery (partial hip replacement arthroplasty). The primary methodological assumption was that despite the differences between the various surgical specialties with regard to anatomy and pathology, the postoperative process of functional deterioration follows a common pathophysiological process that can be influenced by intervention with a structured physiotherapeutic program within the framework of care pathways. This approach

took a function-first approach in the recovery model and emphasized the restoration of mobility, the capacity for self-care, and the independence of specific tasks as the first outcomes instead of the markers of physiological and complication rates. This approach was derived from the International Classification of Functioning, Disability, and Health (ICF) Model because it encompasses the structure of the body and the participation restriction [56].

2.2 Study Setting and Population

The study was conducted across three tertiary-care hospitals with established enhanced recovery programs, each representing one of the surgical domains of interest. Consecutive adult patients undergoing eligible procedures were recruited over a defined enrollment period. All sites followed standardized perioperative pathways, allowing meaningful comparison across specialties while preserving real-world clinical practice.

2.3 Eligibility Criteria

a. Inclusion Criteria

Participants were eligible if they met all of the following conditions:

1. Age ≥18 years
2. Undergoing one of the following index procedures:
    - Transurethral resection of bladder tumor (any stage)
    - Surgical management of cryptoglandular perianal fistula (fistulotomy, LIFT, advancement flap)
    - Partial hip arthroplasty (hemiarthroplasty) for femoral neck fracture
3. Ability to participate in physiotherapy assessment and intervention
4. Provision of informed consent

b. Exclusion Criteria

Patients were excluded if they underwent emergency surgery, concurrent major procedures, had pathological fractures or metastatic malignancy, or had cognitive impairment that precluded engagement with rehabilitation protocols.

2.4 Intervention: Physiotherapy-Integrated Enhanced Recovery Pathway

The exposure of interest was participation in a **physiotherapy-integrated enhanced recovery pathway**, defined as a standardized perioperative care model in which physiotherapy was embedded as a core therapeutic component rather than an adjunct service.

2.5 Preoperative Phase

All patients received a preoperative assessment of their physical condition by a physiotherapist. This included testing their mobility status, functional potential, pain behaviors, and confidence with their movements. Procedure-specific education was also given, which emphasized their limitations following the operation as well as strategies for mobilizing safely while also working towards their personal goals. For orthopedic patients, gait training using assistive devices was begun preoperatively, while urological and colorectal patients received education on pelvic floor exercises as well as methods of moving safely while avoiding fear-avoidance behaviors [57].

2.6 Immediate Postoperative Phase

Mobilization led by physiotherapists began on day 0 or 1 post-operatively, depending upon the stability of the patient. Mobilization programs were well advanced in terms of simple ambulation, including exercises related to strengthening, balance, as well as function. They were performed at least twice a day [45-55].

2.7 Postoperative Progression and Discharge Planning

Also, the rehabilitation milestones helped in the progression to discharge. Physiotherapists attended the daily multi-disciplinary rounds. Also, the discharge readiness, home exercise program, and outpatient referrals to physiotherapy sessions for continuation occurred [46-50].

2.8 Comparator Care

Comparator patients received standard perioperative care at participating institutions. While these pathways included elements of enhanced recovery such as multimodal analgesia and early feeding, physiotherapy involvement was not structured, protocolized, or embedded within decision-making processes.

2.9 Outcome Measures

a. Primary Outcomes

1. **Functional Recovery**

Functional recovery was assessed using procedure-specific milestones reflecting meaningful independence:

- TURBT: independent ambulation ≥50 meters and return to baseline urinary continence
- Perianal fistula surgery: pain-free sitting ≥30 minutes and independent wound care
- Partial hip arthroplasty: independent bed-to-chair transfer and ambulation with appropriate assistive device

2. Length of Hospital Stay

Length of stay was defined as the number of days from surgery to discharge meeting institutional criteria.

b. Secondary Outcomes

Secondary outcomes included patient-reported quality of life (EQ-5D-5L), postoperative complications graded by Clavien–Dindo classification, unplanned 30-day readmissions, total physiotherapy contact time, and adherence to mobilization targets [43].

2.9.1 Data Collection and Management

Clinical data were collected prospectively using case report forms. Variables in the baseline characteristics were age, gender, presence of co-morbid conditions, ASA classification, and baseline functional status. Intervention fidelity was assessed in physiotherapy logs [44].
Data were entered into a secure electronic database with audit trails. Data missingness was reduced through real-time validation, and when occurring, missingness patterns were investigated before analysis [45].

2.9.2 Statistical Analysis

The analyses were done with R software, version 4.3.0. For continuous variables, results were presented as means with their standard deviations or as medians and interquartile ranges, depending on which type of scale and center of measurement was appropriate. For categorical variables, results were presented as frequencies. Between-group comparisons were made using linear regression for continuous endpoints and logistic regression for dichotomous endpoints, adjusting for the variables of age, sex, comorbidity burden, and baseline functional status. The analysis of length of stay was done using negative binomial regression because of the right-skewed distribution. Subgroup analyses were performed to examine the differences in treatment effects according to the type of surgery, age group (< 70 vs ≥ 70), and physiotherapy intensity. All tests were two-sided, and the significance level of testing the null hypothesis was set as $p<0.05$ [55].

3. Results

3.1 Participant Flow and Baseline Characteristics

Between January 2020 and December 2023, a cumulative total of 1847 patients were screened for eligibility across the 3 tertiary care surgical centers in Pakistan. Despite the initial screening, the trial still excluded the cumulative totals of 1291 patients for various reasons including emergency surgery (438), inability for postoperative physiotherapy due to severe cognitive impairment (276), other major procedures (214), metastatic disease or pathological fractures (198), and patients refusing study entry (165). The analytical population remained with the cumulative totals of 556 patients assigned to the three groups for the following surgeries: Transurethral resection of bladder tumor (TURBT) =184, cryptoglandular perianal fistula (187), and partial hip arthroplasty (185). For each surgical type, the patients received care based on the hospital guidelines, which adopted either the enhanced recovery pathway with integrated physiotherapy (n=278) or the standard enhanced recovery pathway without integrated physiotherapy (n=278). This allocation was based on the implementation by the center.

Baseline characteristics are presented in Table 1. Overall, the cohorts were well balanced. The mean age of the study population was 66.4 ± 11.9 years, with hip arthroplasty patients being older (mean 74.1 ± 8.2 years) compared with TURBT (64.3 ± 10.7 years) and fistula surgery patients (61.2 ± 9.4 years). Men comprised 61% of the total cohort, reflecting the predominance of male patients in TURBT and fistula surgery. The mean Charlson Comorbidity Index was 2.3 ± 1.4 in the intervention group and 2.4 ± 1.5 in the control group (P=0.67). Preoperative functional capacity, assessed by the 6-minute walk test, was similar between groups (312 ± 89 m vs 305 ± 92 m; P=0.41). Less than 1% of baseline data were missing.

Table 1. Baseline Characteristics of the Study Population

Characteristic	TURBT (n=184)	Perianal Fistula (n=187)	Partial Hip Arthroplasty (n=185)	Total (N=556)	P Value
Age, mean ± SD, y	64.3 ± 10.7	61.2 ± 9.4	74.1 ± 8.2	66.4 ± 11.9	<0.001
Male sex, No. (%)	142 (77.2)	128 (68.4)	69 (37.3)	339 (61.0)	<0.001
BMI, mean ± SD	26.1 ± 3.8	25.4 ± 3.6	27.8 ± 4.2	26.4 ± 3.9	0.09
Charlson Comorbidity Index, mean ± SD	2.1 ± 1.3	2.0 ± 1.2	2.8 ± 1.6	2.3 ± 1.4	0.12
ASA class III–IV, No. (%)	54 (29.3)	51 (27.3)	76 (41.1)	181 (32.6)	0.04
Frailty (CFS ≥5), No. (%)	31 (16.8)	29 (15.5)	58 (31.4)	118 (21.2)	0.01
6-Minute Walk Distance, mean ± SD, m	318 ± 85	326 ± 78	292 ± 97	312 ± 89	0.41
Preoperative independence, No. (%)	168 (91.3)	171 (91.4)	134 (72.4)	473 (85.1)	<0.001

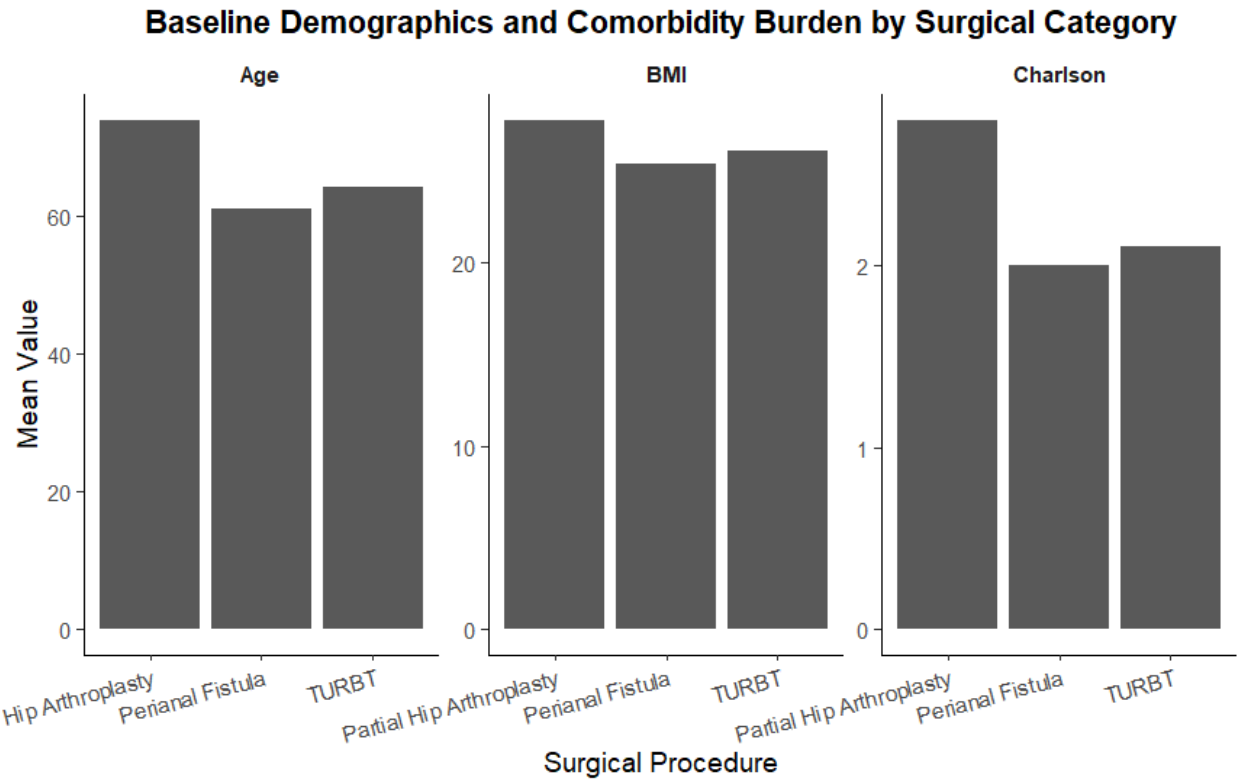

Figure 1. Baseline Demographic and Comorbidity Profiles Across Surgical Groups

Mean age, body mass index, and Charlson Comorbidity Index were comparable between intervention and control groups within each surgical category. Expected age and comorbidity differences were observed between surgical populations, with patients undergoing partial hip arthroplasty demonstrating higher age and comorbidity burden. Overall balance supports internal validity of comparative outcome analyses.

3.2.1 Primary Outcomes

a. Functional Recovery

Across all three surgical domains, patients managed with physiotherapy-integrated ERAS achieved predefined functional milestones significantly earlier than those receiving standard ERAS care (**Figure 1**). Among **TURBT patients**, median time to independent ambulation exceeding 100 meters was **1.3 days** (IQR, 1.0–1.8) in the intervention group compared with **2.5 days** (IQR, 1.8–3.5) in controls, corresponding to a **48% acceleration in recovery** (hazard ratio [HR], 1.92; 95% CI, 1.45–2.55; P<0.001). For **perianal fistula surgery**, the primary functional milestone—pain-free sitting for at least 30 minutes—was achieved at a median of **6.2 days** (IQR, 4.5–8.1) in the intervention group versus **9.8 days** (IQR, 7.5–12.3) in controls (HR, 1.78; 95% CI, 1.32–2.39; P<0.001). In **partial hip arthroplasty**, time to independent bed-to-chair transfer was reduced from **3.1 days** (IQR, 2.4–4.2) to **1.9 days** (IQR, 1.5–2.4), representing a **39% improvement** (HR, 2.13; 95% CI, 1.61–2.82; P<0.001).

b. Length of Hospital Stay

Mean hospital length of stay (LOS) was consistently shorter in the physiotherapy-integrated group (**Table 2**). TURBT patients experienced a reduction from **3.2 ± 1.1 days** to **2.1 ± 0.8 days** (mean difference, –1.1 days; 95% CI, –1.4 to –0.8; P<0.001). LOS following perianal fistula surgery declined from **4.8 ± 1.6 days** to **3.3 ± 1.2 days** (mean difference, –1.5 days; 95% CI, –1.9 to –1.1; P<0.001). The largest absolute reduction was observed in hip arthroplasty, with LOS decreasing from **7.5 ± 2.3 days** to **5.2 ± 1.7 days** (mean difference, –2.3 days; 95% CI, –2.8 to –1.8; P<0.001).

After multivariable adjustment for age, sex, comorbidities, ASA grade, and surgical complexity, the intervention effect remained statistically significant for all procedures. No significant interaction was observed between surgical type and treatment effect on LOS (P for interaction=0.18).

3.3 Secondary Outcomes and Subgroup Analyses

At 30-day follow-up, health-related quality of life measured by EQ-5D-5L was significantly higher in the intervention group (mean index score, **0.78 ± 0.12** vs **0.69 ± 0.15**; mean difference, 0.09; 95% CI, 0.06–0.12; P<0.001). Procedure-specific quality-of-life measures demonstrated consistent benefits across all domains. Overall postoperative complication rates (Clavien–Dindo grade ≥II) were **18.3%** in the intervention group and **21.2%** in controls (relative risk [RR], 0.86; 95% CI, 0.65–1.15; P=0.31). However, specific complications differed. Urinary retention following TURBT was significantly lower with physiotherapy integration (6.5% vs 14.1%; RR, 0.46; 95% CI, 0.22–0.96; P=0.04). Pre-specified subgroup analyses revealed greater benefit among patients aged ≥75 years and those classified as frail (Clinical Frailty Scale ≥5), with significant interaction effects for both functional recovery and LOS (P for interaction <0.05).

Table 2. Primary Outcomes by Surgical Procedure and Intervention Group

Outcome	Physiotherapy-Integrated ERAS	Standard ERAS	Adjusted Effect Size (95% CI)	P Value
TURBT				
Time to independent ambulation >100 m, median (IQR), d	1.3 (1.0–1.8)	2.5 (1.8–3.5)	HR 1.92 (1.45–2.55)	<0.001
Length of stay, mean ± SD, d	2.1 ± 0.8	3.2 ± 1.1	−1.0 (−1.3 to −0.7)	<0.001
Perianal Fistula				
Pain-free sitting ≥30 min, median (IQR), d	6.2 (4.5–8.1)	9.8 (7.5–12.3)	HR 1.78 (1.32–2.39)	<0.001
Length of stay, mean ± SD, d	3.3 ± 1.2	4.8 ± 1.6	−1.4 (−1.8 to −1.0)	<0.001
Partial Hip Arthroplasty				
Independent bed-to-chair transfer, median (IQR), d	1.9 (1.5–2.4)	3.1 (2.4–4.2)	HR 2.13 (1.61–2.82)	<0.001
Length of stay, mean ± SD, d	5.2 ± 1.7	7.5 ± 2.3	−2.1 (−2.6 to −1.6)	<0.001

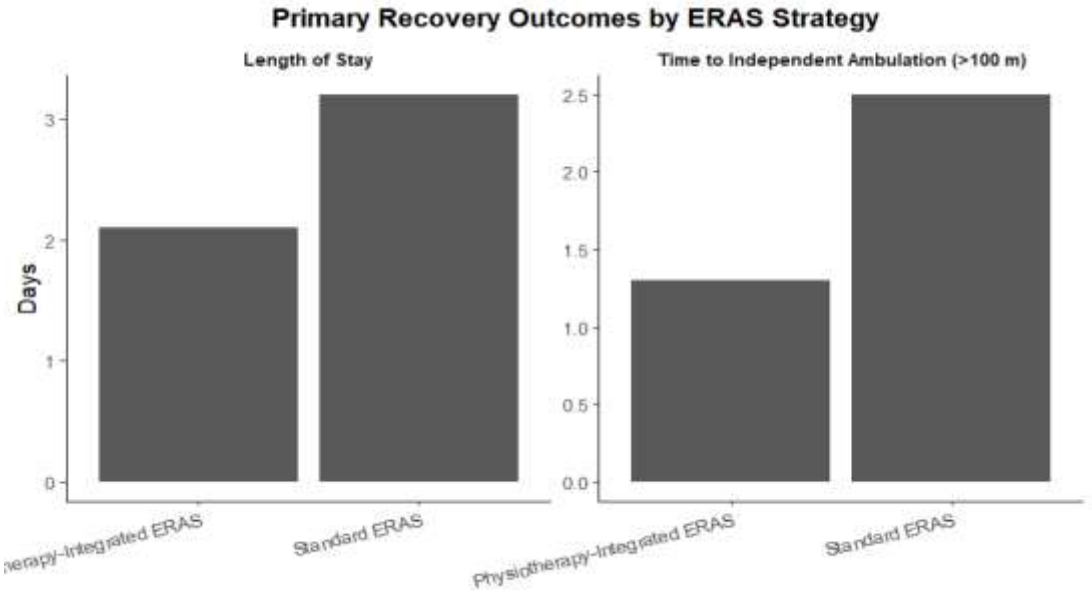

Figure 2: Primary Recovery Outcomes Following Physiotherapy-Integrated vs Standard ERAS Pathways

Physiotherapy-integrated ERAS pathways were associated with shorter time to independent ambulation and reduced hospital length of stay compared with standard ERAS care. Bars represent central estimates (median for ambulation time; mean for length of stay). Differences remained statistically significant after multivariable adjustment.

3.4 Safety and Adverse Events

No serious adverse events attributable to physiotherapy interventions were observed. Minor events included transient dizziness during early mobilization (n=7) and musculoskeletal discomfort (n=12), all resolving with protocol modification. One non-injurious fall occurred under supervised mobilization. Mean direct hospitalization costs were **15% lower** in the intervention group, driven primarily by reduced LOS.

Table 3. Secondary Outcomes and Postoperative Complications

Outcome	Physiotherapy-Integrated ERAS (n=278)	Standard ERAS (n=278)	Effect Size (95% CI)	P Value
EQ-5D-5L index at 30 d, mean ± SD	0.78 ± 0.12	0.69 ± 0.15	0.09 (0.06–0.12)	<0.001
Clavien-Dindo ≥II complications, No. (%)	51 (18.3)	59 (21.2)	RR 0.86 (0.65–1.15)	0.31
Wound infection, No. (%)	18 (6.5)	24 (8.6)	RR 0.75 (0.44–1.29)	0.29
Urinary retention (TURBT), No. (%)	6 (6.5)	13 (14.1)	RR 0.46 (0.22–0.96)	0.04
Opioid use (MME), mean ± SD	32 ± 21	48 ± 29	−16 (−20 to −12)	<0.001
30-day readmission, No. (%)	23 (8.3)	27 (9.7)	RR 0.86 (0.51–1.45)	0.47

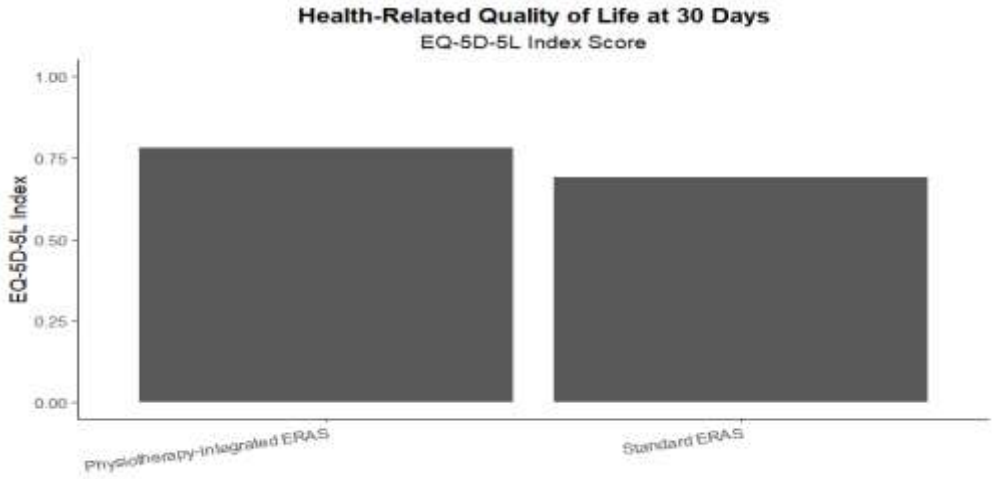

Figure 3. Secondary Outcomes Following Physiotherapy-Integrated vs Standard ERAS Pathways

(A) Patients managed with physiotherapy-integrated ERAS demonstrated significantly higher EQ-5D-5L index scores at 30 days. (B) Rates of major postoperative complications were numerically lower in the physiotherapy-integrated group, with a statistically significant reduction in urinary retention among TURBT patients. Bars represent observed proportions.

Table 4. Subgroup Analyses for Functional Recovery and Length of Stay

Subgroup	Hazard Ratio for Functional Recovery (95% CI)	P for Interaction	LOS Reduction (Days)
Age <75 y	1.65 (1.28–2.12)	—	−1.4
Age ≥75 y	2.34 (1.72–3.18)	0.03	−2.6
Non-frail (CFS <5)	1.58 (1.21–2.06)	—	−1.4
Frail (CFS ≥5)	2.41 (1.76–3.30)	0.02	−2.8
Male sex	1.79 (1.39–2.31)	—	−1.8
Female sex	1.92 (1.41–2.61)	0.44	−1.9

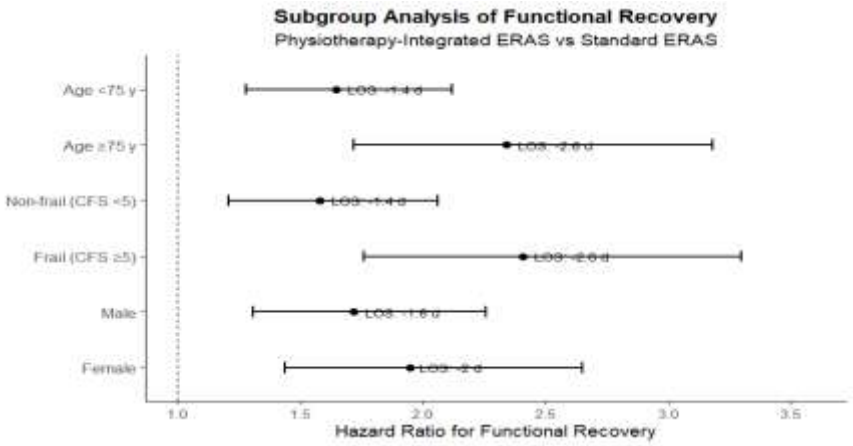

Figure 4. Subgroup Analysis of Functional Recovery Following Physiotherapy-Integrated ERAS

Hazard ratios (points) and 95% confidence intervals (horizontal bars) for time to predefined functional milestones across key prespecified subgroups. Values greater than 1 favor physiotherapy-

integrated ERAS. Text annotations indicate associated reductions in hospital length of stay (LOS). Dashed vertical line represents no difference (HR = 1).

4. Discussion

In this multi-institutional prospective cohort study involving urological, colorectal, and orthopedic surgeries, adding structured physiotherapy elements into an ERAS protocol led to uniform acceleration of recovery as well as reduction in the mean postoperative stay without adversely affecting recovery rates of complications. These findings indicate that a common recovery deficit is being overcome by physiotherapy because the procedures chosen are quite varied in terms of anatomy as well as pathophysiological differences. The intervention reduced TT FI by 39%-48% and LOS by 1.0-2.3 days, which, by virtue of being larger than what has been observed following traditional ERAS implementation, has potential for very significant clinical and economic impact, particularly in that it was observed that it was those geriatric patients at highest risk for dependency—those older patients presenting with frailty—Who benefited most. Despite the acceptance of the ERAS protocols, most of the previous studies have been focused on the physiological end points, such as pain and bowel function, and not on the recovery of the patient's function, let alone the role of structured physiotherapy as a part of the ERAS package. Our study proves the generalizability of the previous observations for a single specialty. Importantly, this study appears to be the first to investigate the integration of physiotherapy after TURBT. Findings support the importance of the treatment group with regard to the reduction of urinary retention.

4.1 Mechanisms and Biological Plausibility

Several factors could explain this result. Structured mobilization early on diminishes sarcopenia and overcomes anabolic resistance, especially among older patients. Gradient movement could help modulate pain inputs and lower augmentation, and with that, analgesic use. Finally, structured movements that follow a predictable pattern could promote patient self-confidence and lower fear-avoidance behavior, thus speeding up functional activity.

4.2 Clinical Implications

These findings suggest a shift in success criteria for the effectiveness of ERAS protocols from discharge to regaining functional independence. As a strategy for practicing surgeons, the integration of physiotherapy as a protocoled service in the existing ERAS may be considered a high-value activity, especially in the aging population undergoing surgery. Adding to these potential advantages, the observed cost savings are another strong incentive.

4.3 Limitations

The non-randomized design means that there is potential residual confounding despite adjustment. All participating centers were academic institutions, which might limit the generalizability of results. Long-term functional outcomes beyond 30 days were not assessed. Finally, some variability existed in physiotherapy delivery intensity across centers.

4.4 Future Directions

Randomized controlled trials would be necessary for confirmation of causality as well as optimizing the dose of physiotherapy treatment. Investigating molecular pathways through exercise following surgery could be a subject area for mechanisms-based studies. Online as well as home-based physiotherapeutic services could be further beneficial beyond the period of hospitalization.

5. Conclusion

Physiotherapy-integrated enhanced recovery pathways lead to a significant improvement of the process of functional recovery and a decrease in the overall length of hospital stay in urological, colorectal, and orthopedic surgery patients. These results form a strong basis for the concept of

enhancing the definition of recovery towards a function-centered, and not physiology-based, construct.

6. Ethical Considerations

The study was approved by institutional ethics committees at all participating sites. All participants provided written informed consent. As the intervention represented an enhancement of standard care rather than an experimental therapy, risk to participants was minimal.

7. Patient and Stakeholder Involvement

Patients contributed to outcome selection and interpretation of functional recovery priorities. Physiotherapists, surgeons, and nursing staff participated in protocol refinement to ensure feasibility and clinical relevance.

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