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ORIGINAL RESEARCH ARTICLE

Early ambulation during hospitalization after lower limb salvage surgery for bone and soft-tissue sarcomas: An observational retrospective study

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Abstract

Introduction: Evidence on early functional recovery and inpatient physiotherapy after lower limb salvage surgery for bone sarcomas is limited.
Objective: This study aims to describe early ambulation and explore potential prognostic factors.
Methods: A retrospective cohort study was conducted, including patients aged 12–70 years with bone and soft-tissue sarcoma who underwent lower limb resection and reconstruction between 2019 and 2023. The primary outcome was time to ambulation, and the secondary outcome was length of hospital stay.
Results: A total of 84 patients were included in this study. The median time to ambulation was 4 post-operative days (interquartile range [IQR], 4), and the median length of stay was 8 (IQR, 4). In multivariable Cox regression, earlier ambulation was associated with tumor location in the diaphysis/other sites (hazard ratio [HR] = 4.39, p=0.002), older age (HR = 1.02 per year, p=0.006), and higher physiotherapy intensity when initiated on post-operative day 1 (HR = 1.74, p=0.001). Bone graft/other procedures were associated with a lower hazard of ambulation compared with prosthetic reconstruction (HR 0.46, p=0.037). Each additional day of ambulation was associated with a 12% lower hazard of discharge (HR = 0.88, p=0.009).
Conclusion: Early mobilization and intensive physiotherapy appear to facilitate functional recovery following lower limb salvage surgery for bone and soft-tissue sarcomas. These findings emphasize the value of structured, staff-led rehabilitation programs that actively encourage and guide recovery, highlighting the role of clinical staff in optimizing post-operative outcomes and may improve patients' independence.

Keywords: Bone sarcoma; Physiotherapy; Early ambulation; Lower limb salvage surgery; Risk factors; Length of stay

1. Introduction

Bone cancer is a rare disease, with approximately 660 new cases per year in Italy among individuals up to 19 years of age.[1] Osteosarcoma and Ewing's sarcoma are the most common types, with an incidence in the United Kingdom (UK) of 0.25 per 100,000 and 0.15/100,000, respectively.[2] Soft-tissue tumors are more common and affect a wider age range; in Italy, there are approximately 2,300 new cases per year.[3] Advances in surgical techniques, chemotherapy, and other treatments such as radiotherapy have, over time, improved the 5-year survival rates, while highlighting the ongoing challenge of improving patients' quality of life.[4] Surgical treatment is complex and diverse, ranging from amputation to reconstruction with megaprostheses or massive bone grafts, and may cause significant functional limitations. Limb salvage surgery is considered the treatment of choice for musculoskeletal system tumors, offering the potential for long-term functional preservation.[5-7] While favorable functional outcomes have been reported,[8,9] restoration of full participation in work and sports activities remains challenging.[10-12]

Rehabilitation plays a key role after surgery, aiming to reduce disability and help patients recover as much function as possible.[13] As highlighted by McCarthy *et al.*,[14] there are no specific guidelines for rehabilitative treatment, and in the UK, 41% of patients were not referred to a rehabilitation center[14,15] Given the high surgical complexity, the patients must begin rehabilitation in the earliest post-operative stages to regain basic autonomy, such as walking, as quickly as possible.[16] In the initial post-operative phase, rehabilitation has been described mainly in case reports and series, emphasizing the importance of joint mobilization exercises, muscle strengthening, proprioceptive training, and balance exercises.[16-19] However, data describing early recovery after surgery for bone and soft-tissue tumors remain limited. An enhanced recovery after surgery (ERAS) program has been proposed for soft-tissue sarcomas, with reduced hospital length of stay and without compromising surgical and oncological outcomes.[20-22] The applicability of ERAS-type care pathways to patients undergoing resection and reconstruction for bone tumors is less clear, and there is no definitive guidance on optimal care from the immediate post-operative phase.

Andreani *et al.*[23,24] and Andreani *et al.*[23,24] highlighted the importance of joint recovery and early ambulation as central elements of rehabilitation to ensure surgical success in patients undergoing megaprosthesis of the proximal and distal femur. Similarly, Grushina and Teplyakov[25] observed improved functional recovery without increased complications when early post-operative rehabilitation was implemented in patients undergoing prosthetic replacement for bone tumors. However, these studies did not investigate clinically relevant aspects of care, such as the timing of physiotherapy initiation and therapy intensity. Furthermore, potential prognostic factors related to functional outcomes, such as age, gender, or tumor type, were not defined.

From a clinical and assistive practice perspective, in a complex context such as oncological orthopedics, advanced practice nurses may play an important role in coordinating care, facilitating early mobilization from the patient's bed, and educating patients.[26,27]

Therefore, the present study aims to describe ambulation recovery in patients who underwent lower limb salvage surgery for bone and soft-tissue sarcomas, explore potential prognostic factors associated with earlier ambulation, and investigate the association between ambulation recovery and post-operative hospital length of stay. Understanding how quickly patients regain walking ability and which factors influence recovery may help clinicians and nursing staff tailor physiotherapy programs, plan hospital resources, and improve clinical and assistive practice.

2. Data and methods

2.1. Data

A retrospective cohort study was conducted as part of a larger study protocol aimed at defining the recovery path of patients who underwent resection and reconstruction surgery, from the time of surgery to 6 months postoperatively. The study was approved by the Ethics Committee of the Area Vasta Emilia Centro (protocol no. 111/2024/Oss/IOR_EM1) and was registered at ClinicalTrial.gov (NCT06376539). The study was conducted at the Oncological Orthopaedics Department of a single-specialty orthopedic hospital in Northern Italy. Digitized medical records of patients admitted from 2019 to 2023 were reviewed.

2.2. Method

2.2.1. Participants

All patients aged 12–70 years with a diagnosis of bone sarcoma who were consecutively admitted for lower limb resection and reconstruction surgery for a tumor in the pelvis, femur, tibia, or bones of the foot were considered eligible for the study. Patients were excluded if the surgery had been performed at another hospital or center, or if no physiotherapy pathway had been initiated during the initial hospital stay.

2.2.2. Physiotherapy treatment pathway and outcome measures

Physiotherapy treatment was requested by the orthopedist on the first post-operative day; however, the request could be postponed according to the patient's clinical condition. The rehabilitation pathway comprised two physiotherapy sessions per day from Monday to Friday and one session on Saturday. Each session lasted approximately 30 min and involved two main phases.

The first phase consisted of active-assisted mobilization exercises, progressing to active mobilization of the joints involved in the surgery, as well as adjacent areas, as soon as possible. Isometric exercises were initially required, followed by muscle reactivation exercises compatible with the type of reconstruction performed.

The second phase aimed to restore basic motor autonomy, such as postural changes in bed, transfers to and from bed, and use of the bathroom. Patients were taught to reach the sitting position, maintain static sitting, and walk using strategies aimed at progressively increasing autonomy. When required by the procedure, an orthosis was used (e.g., a hip–thigh brace or knee extension brace), and patients were trained to manage it independently. During gait training, patients were instructed in the correct use of mobility aids (e.g., a walker or forearm crutches) and adherence to weight-bearing restrictions prescribed by the orthopedist (toe-touch weight-bearing, partial weight-bearing, or weight-bearing as tolerated). When possible, patients were encouraged to practice ascending and descending steps using a handrail and/or forearm crutches.

2.2.3. Outcome measures

The primary outcome was the number of days required for the patient to resume ambulation after surgery. Ambulation was considered achieved when the patient was able to walk at least 10 m, regardless of the assistive device used (forearm crutches or walker), independently or with supervision only by the physiotherapist. The physiotherapist assessed achievement of the goal and recorded the activity in the patient's daily treatment diary.

The secondary outcomes were as follows:

(i) Achievement of ascending and descending three steps with the help of handrails or forearm crutches. This activity was one of the objectives of physiotherapy, and achievement was regularly recorded in the daily treatment diary.

(ii) Length of hospital stay, expressed in days from the day of surgery.

2.2.4. Variables

Potential risk and confounding factors were identified through multidisciplinary discussion among professionals experienced in orthopedic oncology, including orthopedists, nurses, and physiotherapists. The variables collected were age, gender, oncological diagnosis (osteosarcoma/Ewing's sarcoma vs. soft-tissue/other musculoskeletal tumors), anatomical site of the tumor lesion (pelvis, proximal femur, distal femur, proximal tibia, diaphysis/other), type of surgery (modular prosthesis, bone graft, or other), duration of surgery (hours), and length of bone resection (cm). Surgical complications were recorded, including surgical wound infection, neurological lesions, and circulatory complications (ischemia, hematoma). Peak pain levels during each of the first 3 post-operative days were assessed using the Numerical Rating Scale pain scale (0–10). Laboratory variables included pre-operative hemoglobin (g/dL), the minimum hemoglobin value during the hospital stay and the post-operative day on which it was recorded, and hemoglobin drop, defined as the difference between the pre-operative value and the minimum post-operative value. Two variables were collected to describe physiotherapy treatment: the post-operative day on which physiotherapy was initiated and treatment intensity, defined as the ratio between the number of physiotherapy sessions performed and the period between treatment initiation and discharge.

2.2.5. Data sources

Outcome measures and descriptive variables were collected by reviewing patients' electronic clinical documentation, including medical history, surgical logbook, laboratory tests, and clinical diary. Rehabilitation-related outcomes and variables were extracted from physiotherapy documentation, in which activities performed and outcomes achieved were recorded daily (e.g., attainment of sitting position, standing balance, ambulation, and ascending/descending steps). Adverse events that limited recovery were also recorded in the clinical diary notes. Data collection and database construction were performed by two physiotherapists in the research. An initial training session was held to standardize procedures and identify the sections of the medical records, followed by a follow-up meeting after approximately half of the records had been reviewed. These steps ensured consistency in data collection and minimized errors in document review and data transcription.

2.3. Statistical analysis

Baseline characteristics were described for the entire cohort and stratified by diagnosis type (osteosarcoma/

Ewing's sarcoma vs. soft-tissue sarcoma/other sarcomas). Continuous variables were summarized as mean and standard deviation (SD) or as median and interquartile range (IQR), depending on their distribution. Dichotomous variables were summarized as absolute frequencies and percentages. Differences between the two groups were analyzed using Student's *t*-test or the Mann–Whitney *U* test for continuous variables, and the Chi-square test for categorical variables.

Time to ambulation recovery was analyzed using survival methods. Patients who did not regain ambulation during the hospital stay were right-censored at discharge. The cumulative probability of recovery was estimated using the 1– Kaplan–Meier curve and represented graphically. Hazard ratios (HRs) were calculated to assess associations between the primary outcome and individual explanatory variables. To identify independent factors associated with time to ambulation recovery, a multivariable Cox proportional hazards model was fitted and adjusted for confounders. Covariates were selected based on clinical experience and backward selection with a *p*-value threshold of 0.05. All available variables were considered, except the length of resection, which was excluded because it was not available for all patients, particularly those with pelvic tumors.

To evaluate the association between time to ambulation recovery and post-operative length of hospital stay, univariable and multivariable Cox regression models were fitted, with the multiple model adjusted for age, gender, anatomical location of the lesion, and minimum post-operative hemoglobin value.

Given the rarity of musculoskeletal oncological pathology, the eligible population included all patients consecutively admitted to the hospital according to the inclusion/exclusion criteria, with a planned convenience sample of 100 patients. Previous studies focusing on the early post-operative phase included smaller sample sizes of 16, 22, and 36 patients.[23-25] A power analysis was conducted based on the number of patients enrolled. Assuming 80% power, the minimum detectable HR was calculated for dichotomous variables assuming a frequency of 50% and for continuous variables assuming a mean of 0 and a variance of 1.

3. Results

3.1. Demographics and study population

A total of 96 patients were assessed for eligibility. Of these, six were excluded based on the inclusion/exclusion criteria. In an additional five cases, a hip spica cast was applied to prevent verticalization, and in one case, physiotherapy was not requested. The final study sample included 84 patients (Figure 1).

Baseline characteristics of the samples are presented in Table 1. The median age was 24.5 years (IQR 27), and 28.6% were female. Osteosarcoma was the most frequent diagnosis (67.9%), and the distal femur was the most common tumor site (51.2%). Prosthetic reconstruction was performed in 80.9% of the cases. Physiotherapy began on the first post-operative day in 58.3% of the patients, with a median intensity of 1.5 sessions/day (IQR 0.3) (Table 1). Missing data were present for the length of resection in nine patients (10.7%), including all patients operated on for pelvic tumors; for peak pain on the first post-operative day in six patients (7.1%), and for the duration of surgery in four patients (4.8%).

Patients diagnosed with osteosarcoma/Ewing's sarcoma were younger and underwent longer surgery, and these differences were statistically significant. Tumor site also differed by diagnosis: bone tumors were more frequently located around the knee (distal femur and proximal tibia), whereas soft-tissue sarcomas/other sarcomas were more often located in the proximal femur; however, this difference did not reach statistical significance (*p*=0.08).

3.2. Recovery of ambulation

The median time to ambulation recovery was 4 days (IQR 4), and the 1 – Kaplan–Meier curve describing the cumulative probability of ambulation recovery is shown in Figure 2 and indicates a more pronounced increase in recovery during the first 4 post-operative days.

Time to ambulation recovery varied by surgical site. Patients who underwent pelvic surgery had the longest recovery time, with a mean of 12.6 days (SD 19.3). One patient had a markedly prolonged recovery time (47 days), whereas in the other cases, ambulation was regained

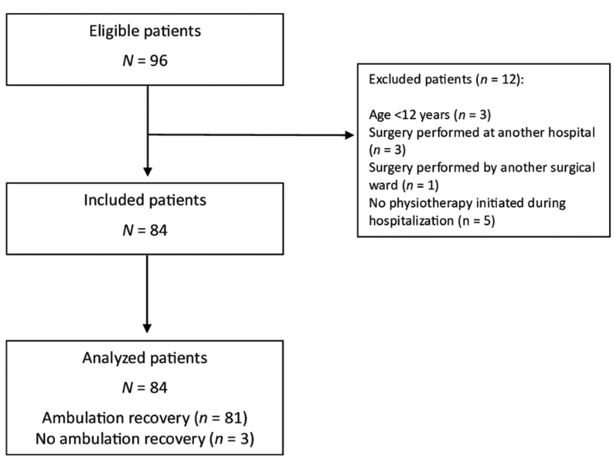

Figure 1. Study flow diagram

Table 1. Baseline characteristics of the patient sample

Variables	*n*=84	Osteosarcoma/Ewing's sarcoma (*n*=67)	Soft tissue/other tumor (*n*=17)	*p*-value
Age, median (IQR), year	24.5 (27)	22 (22)	41 (19)	<0.001
Gender, *n* (%)				0.059
Male	60 (71.4)	51 (76.1)	9 (52.9)	
Female	24 (28.6)	16 (23.9)	8 (47.1)	
Reconstruction by, *n* (%)				0.598
Prosthesis	68 (80.9)	55 (82.1)	13 (76.5)	
Bone graft/other surgery	16 (19.1)	12 (17.9)	4 (23.5)	
Tumor site, *n* (%)				0.080
Pelvis	5 (5.9)	4 (6.0)	1 (5.9)	
Proximal femur	12 (14.3)	6 (9.0)	6 (35.3)	
Distal femur	43 (51.2)	37 (55.2)	6 (35.3)	
Proximal tibia	16 (19.1)	14 (20.9)	2 (11.8)	
Other site (diafisis/other)	8 (9.5)	6 (9.0)	2 (11.8)	
Length of bone resection[a], median (IQR), cm	15 (8)	15 (8)	15 (7.5)	0.688
Length of surgery[b], median (IQR), h	3.0 (0.9)	3 (1)	2.5 (1)	0.007
Post-operative complications[#], *n* (%)	18 (21.4)	14 (20.9)	4 (23.5)	0.813
Peak pain on the first day after surgery[c]	3 (2)	3 (2)	3 (1.5)	0.826
Pre-operative hemoglobin[b], mean (SD), g/dL	11.4 (1.8)	11.3 (1.8)	11.4 (1.9)	0.836
Pre- to post-operative hemoglobin difference[b], median (IQR), g/dL	3 (3.3)	3.3 (3)	1.8 (3)	0.174
Physiotherapy program				
Physiotherapy started on post-operative day 1, *n* (%)				0.251
No	35 (41.7)	30 (44.8)	5 (29.4)	
Yes	49 (58.3)	37 (55.2)	12 (70.6)	
Physiotherapy intensity (sessions/day)[##], median (IQR)	1.5 (0.3)	1.5 (0.3)	1.3 (0.3)	0.230

Notes: [a]9 missing; [b]4 missing; [c]6missing. [#]Neurological complications (n=15). Circulatory (n=3). [##]Calculated as number of physiotherapy sessions divided by days from initiation to discharge.
Abbreviations: h: Hour; IQR: Interquartile range; SD: Standard deviation.

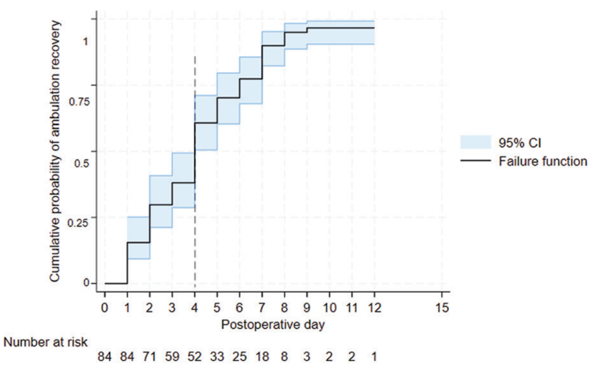

Figure 2. Cumulative probability of ambulation recovery after surgery (1 – Kaplan–Meier estimate) with 95% confidence interval. The dashed line indicates the median time to ambulation (4 post-operative days).

between 2 and 7 days after surgery, similar to patients with tumors in other anatomical areas. For proximal femur procedures, ambulation was typically regained after 4.7 days (SD 3.0), whereas patients who underwent distal femur surgery ambulated after 3.9 days (SD 1.9). Proximal tibia procedures were associated with a mean recovery time of 5.3 days (SD 2.7), and surgeries at other sites showed the shortest recovery time (mean 2.6 days, SD 2.2).

In the multivariable Cox regression (Table 2), earlier ambulation was associated with tumor location in the diaphysis/other sites (HR 4.39, p = 0.002), older age (HR 1.02 per year, p = 0.006), and higher physiotherapy intensity when initiated on post-operative day 1 (HR 1.74, p=0.001). Bone graft/other procedures were associated with a lower hazard of ambulation compared with prosthetic reconstruction (HR 0.46, p=0.037). The multivariable analysis was performed on 77 patients following exclusion of individuals with missing data. Despite differences in baseline characteristics between patients with osteosarcoma/Ewing's sarcoma and those with soft-tissue tumors (e.g., age), the multivariable Cox regression did not identify diagnosis as a factor significantly associated with outcome.

The proportional hazards assumption was assessed using Schoenfeld residuals, with no violations detected (global $\chi^2 = 1.49$, df = 4, p=0.8281). The final Cox regression model showed a significant global likelihood-ratio test (LR χ^2 (4) = 24.31, p<0.001) and a log-likelihood of −255.932, indicating a good fit to the data.

A *post hoc* descriptive analysis was conducted to examine the interaction between the physiotherapy start day and treatment intensity. A cutoff of 1.5 sessions/day was chosen based on clinical expertise to distinguish low- from high-intensity rehabilitation. Table 3 shows that

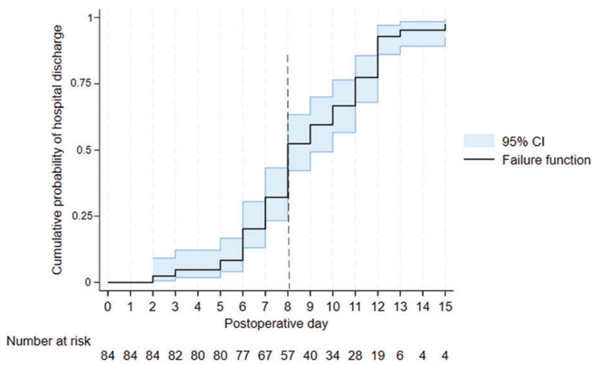

Figure 3. Cumulative probability of hospital discharge after surgery (1 – Kaplan–Meier estimate) with 95% confidence interval. The dashed line indicates the median length of stay (8 post-operative days).

patients starting physiotherapy on day 1 with high intensity recovered fastest (median 2 days, IQR 3), whereas those starting on day ≥2 with low intensity recovered slowest (median 6 days, IQR 4).

The power analysis was performed on a cohort of 84 patients, of whom 81 experienced the event (recovery of walking ability), and 3 were censored. The minimum detectable HR with α = 0.05 and 80% power was 1.87 for dichotomous variables and 1.36 for continuous variables (per unit increase).

3.3. Length of stay

The median hospital stay was 8 days (IQR 4), and Figure 3 shows the 1 – Kaplan–Meier curve for discharge. In the Cox regression assessing the association between time to ambulation recovery and length of hospital stay, each additional day required to recover ambulation was associated with a 12% reduction in the hazard of discharge (HR 0.88, 95% confidence interval 0.80–0.97, p=0.009).

These results suggest that individual outcomes can differ substantially, likely due to differences in surgical complexity, patient condition, and rehabilitation progress.

4. Discussion

In patients undergoing lower limb salvage surgery for bone sarcoma, ambulation recovery may begin during the post-operative hospital stay, even in the presence of peak pain, hemoglobin drops, or post-operative complications. Early initiation of physiotherapy and the provision of intensive rehabilitation during hospitalization were associated

Table 2. Multivariable Cox regression (backward selection; p<0.05) for time to ambulation recovery

Variables	HR	95% CI		p-value
		Upper limit	Lower limit	
Age	1.02	1.01	1.03	0.006
Diaphysis/other site	4.39	1.72	11.18	0.002
Bone graft/other surgery	0.46	0.22	0.95	0.037
Physiotherapy on post-operative day 1×physiotherapy intensity	1.74	1.25	2.43	0.001

Abbreviations: CI: Confidence interval; HR: Hazard ratio.

Table 3. *Post hoc* description: interaction between the physiotherapy start day and intensity

Start of physiotherapy	Intensity category	n	Median days to ambulation (IQR)
Day 1	Low intensity	34	3 (2)
Day 1	High intensity	15	2 (3)
Day ≥2	Low intensity	15	6 (4)
Day ≥2	High intensity	20	5 (2.5)

Notes: Intensity calculated as total number of sessions divided by number of days from initiation to discharge; cutoff=1.5 sessions/day.

with earlier ambulation, suggesting that organized post-operative care can support functional recovery and may reduce length of hospital stay. Previous studies have encouraged early rehabilitation for patients undergoing surgery for soft-tissue sarcomas,[20,21] but limited evidence exists for those treated with lower limb salvage surgery for bone sarcomas, who frequently require complex reconstruction of bone segments and joint structures. These results add to the literature by showing that, despite differences between patients with osteosarcoma or Ewing's sarcoma and those with other sarcomas, diagnosis did not significantly influence early ambulation recovery. In this cohort, the median time to ambulation recovery was 4 days, consistent with the findings reported by Andreani *et al*.[23,24] (mean 6.4 days for proximal femur and 4.5 days for distal femur). However, comparisons are limited by differences in patient characteristics, as the populations reported in the studies had mean ages of 58.9 and 44.1 years, which were substantially higher than the median age of 24.5 years of the present cohort. Moreover, the present analysis considered a more heterogeneous population.

Patients with pelvic tumor localization showed greater variability in ambulation recovery (SD = 19.3), likely reflecting the complexity of pelvic reconstruction techniques. Farfalli *et al*.[28] and Wilson *et al*.[29] pointed out that patients have a higher risk of non-oncological complications and reoperations. Furthermore, in small subgroups, individual outliers can disproportionately influence mean recovery times and SDs. The variability of the court represents a limitation to the generalizability of the study. In patients who have undergone pelvic surgery, recovery times may be longer and more variable. In contrast, for other tumor locations, recovery patterns were more homogeneous, suggesting greater generalizability in these subgroups. From a clinical point of view, the complexity of these procedures supports the need for a multi-professional approach. Advanced practice nurses in orthopedic oncology surgery could play a key role in coordination and decision-making, facilitating integration across professional roles and identification of patients who require non-standard rehabilitation pathways.

Both patient- and treatment-related factors influenced the pace of ambulation recovery. While non-modifiable factors such as age, anatomical site of surgery, and type of surgery were associated with differences in recovery, the Cox regression model highlighted the important role of the physiotherapy approach. Patients undergoing bone grafting or other non-prosthetic reconstructions often receive stricter weight-bearing restrictions on the operated limb, which may explain their slower recovery of ambulation. Conversely, patients undergoing procedures not involving the pelvis or the hip and knee joints – mainly affecting the diaphysis or soft-tissue structures – can often regain joint mobility and lower limb movement earlier, facilitating earlier ambulation. Interestingly, younger patients in our study had more difficulty regaining ambulation than older patients. Although this trend may appear counterintuitive, post-operative factors such as load management, pain, and psychological adaptation may have a greater impact on younger patients, potentially delaying early recovery. Studies in non-oncologic settings have similarly highlighted that adolescents and young adults may face post-surgical recovery challenges related to psychological and pain-management factors[30-32] Lee and Park[33] emphasized that emotional factors in young adults are closely associated with functional outcomes.

From a clinical and care standpoint, this study offers significant insights for healthcare professionals engaged in patient management. A key contribution is the detailed description of the post-operative rehabilitation program. The approach, inspired by accelerated physiotherapy protocols used after hip and knee arthroplasty, prioritized early initiation and multiple daily sessions during the hospital stay, with the potential to enhance functional recovery and optimize hospital resource utilization. These aspects must be considered by the multidisciplinary rehabilitation team, including physiotherapists, orthopedic surgeons, and nurses, when designing a post-operative care pathway that integrates proactive strategies and a patient-centered, tailored approach. Grushina and Teplyakov[25] reported that multimodal rehabilitation starting the day after surgery enabled recovery of normal function, as measured using the Musculoskeletal Tumor Society score, in 80%, 72 %, and 59% of patients with distal femur, proximal tibia, and proximal femur resection, respectively, after 10 days of treatment.

Finally, earlier ambulation may contribute to shorter hospital stays, with potential economic and functional benefits. Similarly, in soft-tissue sarcoma, early post-operative rehabilitation was associated with reduced length of hospital stay, as shown by Michot *et al*.[21] in 257 patients who underwent limb or trunk surgery. However, further prospective, multicenter studies are needed to confirm this association and to account for confounding factors that may influence hospital stay.

5. Limitations

The results must be interpreted in light of the study limitations. First, the limited sample size, due to the rarity of bone sarcomas, resulted in small numbers in some anatomic subgroups. Compared to previous studies, such as those by Andreani *et al*.[23,24] and Andreani *et al*.,[23,24] which reported sample sizes of 16 and 22 patients for distal and proximal femur megaprosthesis procedures, respectively, the present data still provide a reasonably representative description of the early post-operative physiotherapy pathway. Nevertheless, the regression analyses should be interpreted with caution. The HRs from the multivariable Cox regression were consistent with the estimates derived from the power analysis. In addition, the inclusion of multiple tumor sites introduced variability, which requires careful interpretation of the results, particularly regarding implications for clinical care. Second, the retrospective design resulted in some missing data, and potential biases related to clinical decision-making and patient comorbidities may have influenced outcomes. These factors partly explain the observed variability in recovery times and should be acknowledged when interpreting the results. Given the retrospective nature of the data, possible confounding effects must be taken into account. Despite these limitations, this study offers a foundation for planning prospective multicenter studies with larger samples and more robust data collection.

6. Conclusion

In patients undergoing lower limb salvage surgery for bone and soft-tissue sarcomas, early and structured rehabilitation appears to support functional recovery, underscoring the importance of integrating physiotherapy programs within clinical care pathways. These findings emphasize the role of multidisciplinary teams, including surgeons, physiotherapists, and advanced practice nurses, in ensuring continuity of care, optimizing post-operative outcomes, and guiding individualized rehabilitation strategies.

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Conflict of interest

The authors declare they have no competing interests.

Author contributions

Conceptualization: Mattia Morri, Marco Cotti
Formal analysis: Mattia Morri, Riccardo Ruisi
Investigation: Marco Cotti, Riccardo Ruisi
Methodology: Mattia Morri, Pietro Cimatti, Davide Maria Donati
Writing – original draft: Mattia Morri
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Ethics approval and consent to participate

The study was approved by the Ethics Committee of the Vast Area of Central Emilia with protocol no. 111/2024/Oss/IOR_EM1. Informed consent was waived by the Ethics Committee.

Consent for publication

Consent for publication was not obtained, and no identifiable information was collected or reported.

Availability of data

The data are available from the corresponding author on reasonable request.

Further disclosure

Part or all of the findings were presented at the "25th European Musculoskeletal Oncology Society Nurse and Allied Professions Group Meeting" on [28–30 April], in [Padova, Italy], with the title: Early recovery of ambulation after lower limb resection and reconstruction surgery for musculoskeletal cancer.

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