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Functional Outcomes of Prosthetic Rehabilitation in Lower Limb Amputees: Retrospective Cohort Study

Original Research

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ABSTRACT

Background:
Lower limb amputation leads to significant physical disability and long-term functional challenges, requiring comprehensive prosthetic rehabilitation to restore mobility and independence. Functional outcomes following prosthetic rehabilitation vary widely and are influenced by factors such as level of amputation, rehabilitation duration, and clinical support. In Pakistan, particularly within armed forces rehabilitation centers, evidence describing real-world functional outcomes of amputee rehabilitation remains limited.

Objective:
To evaluate the functional outcomes of prosthetic rehabilitation in lower limb amputees treated at armed forces rehabilitation centers in Rawalpindi.

Methods:
A retrospective cohort study was conducted using medical records of 140 adult lower limb amputees who completed prosthetic rehabilitation between 2021 and 2022. Data were obtained from armed forces rehabilitation facilities in Rawalpindi. Functional outcomes were assessed using the Locomotor Capability Index, Functional Independence Measure mobility subscale, 6-Minute Walk Test, and Timed Up and Go test. Comparative analysis was performed based on level of amputation. Statistical analysis included descriptive statistics, independent sample t-tests, one-way analysis of variance, and Pearson correlation analysis.

Results:
The mean Locomotor Capability Index score was 31.4 ± 6.8, and the mean Functional Independence Measure mobility score was 79.2 ± 12.5. The average 6-Minute Walk Test distance was 342.6 ± 78.9 meters, and the mean Timed Up and Go time was 14.8 ± 3.9 seconds. Transtibial amputees demonstrated significantly better functional outcomes than transfemoral amputees across all measures ($p < 0.001$). Independent community ambulation was achieved by 55.7% of participants. Rehabilitation duration showed a moderate positive correlation with locomotor capability ($r = 0.46$, $p < 0.001$).

Conclusion:
Prosthetic rehabilitation in specialized armed forces centers was associated with meaningful functional recovery in lower limb amputees. Improved mobility and independence were particularly evident among transtibial amputees, emphasizing the importance of structured and sustained rehabilitation programs.

Keywords
Amputation; Gait; Mobility Limitation; Physical Rehabilitation; Prostheses and Implants; Prosthetic Rehabilitation; Walking

Introduction

Lower limb amputation represents a life-altering event that profoundly affects an individual's physical function, psychological well-being, social participation, and overall quality of life. Worldwide, amputations most commonly result from trauma, vascular disease, diabetes-related complications, infections, and malignancy. In developing countries, traumatic causes, including road traffic accidents, occupational injuries, and conflict-related trauma, remain prominent contributors (1). In Pakistan, particularly in regions such as Rawalpindi where military and civilian trauma care facilities coexist, lower limb amputations are frequently encountered, placing a sustained demand on rehabilitation services and long-term functional support systems. Prosthetic rehabilitation is a cornerstone of post-amputation management, aiming to restore mobility, independence, and social reintegration. Advances in prosthetic design, materials, and alignment techniques have significantly improved the potential for functional recovery (2). However, the successful use of a prosthesis depends on multiple interacting factors, including level of amputation, residual limb condition, timing of prosthetic fitting, rehabilitation intensity, patient motivation, and access to specialized care. Functional outcomes following prosthetic rehabilitation therefore vary widely, even among individuals with similar amputation profiles (3).

Functional recovery in lower limb amputees is commonly evaluated through objective mobility measures, gait performance, balance, endurance, and ability to perform activities of daily living. These outcomes are not only indicators of physical recovery but are closely linked to psychological adjustment, vocational reintegration, and long-term prosthesis use. Poor functional outcomes may lead to prosthesis abandonment, secondary musculoskeletal complications, increased dependency, and reduced participation in community life (4,5). As such, understanding real-world functional outcomes following prosthetic rehabilitation is essential for optimizing rehabilitation strategies and resource allocation. Military and armed forces rehabilitation centers play a unique role in amputee care, particularly in countries with a significant burden of trauma-related limb loss. These centers often provide structured, multidisciplinary rehabilitation programs that include prosthetic fitting, physiotherapy, occupational therapy, and psychosocial support. While outcomes from such centers are often assumed to be favorable due to specialized infrastructure, systematic evaluation of functional results is not always consistently documented or analyzed. Retrospective cohort studies provide an opportunity to assess long-term functional outcomes using existing clinical records, offering valuable insight into patterns of recovery and factors influencing success (6).

Previous research has demonstrated that early prosthetic fitting and intensive rehabilitation are associated with improved mobility scores and higher rates of independent ambulation. Studies have reported that transtibial amputees generally achieve better functional outcomes compared to transfemoral amputees, largely due to preserved knee function and lower energy expenditure during gait. Nevertheless, much of the available literature originates from high-income countries with different healthcare systems, prosthetic technologies, and rehabilitation timelines. Extrapolating these findings to low- and middle-income settings may not accurately reflect local realities. In Pakistan, published data on functional outcomes following prosthetic rehabilitation remain limited, particularly within armed forces rehabilitation centers where patient demographics, injury mechanisms, and rehabilitation protocols may differ from civilian settings. There is a lack of consolidated evidence describing how amputees function after completing prosthetic rehabilitation, how many regain independent ambulation, and which factors most strongly influence these outcomes (7). Without such data, it becomes challenging to benchmark current practices, identify gaps in service delivery, or inform policy-level decisions aimed at improving amputee care.

Evaluating functional outcomes retrospectively allows clinicians and policymakers to assess the effectiveness of existing rehabilitation programs and to identify trends that may not be apparent during routine clinical follow-up. Such analyses can also highlight areas where targeted interventions, such as prolonged gait training, balance rehabilitation, or prosthetic optimization, may be required. Importantly, understanding functional outcomes within the local context supports evidence-based improvements tailored to patient needs rather than relying solely on international data. Given the substantial physical and social impact of lower limb amputation and the critical role of prosthetic rehabilitation in restoring function, there is a clear need for region-specific evidence from specialized rehabilitation centers. Therefore, the objective of this study was to evaluate the functional outcomes of prosthetic rehabilitation in lower limb amputees treated at armed forces rehabilitation centers in Rawalpindi, and to identify patterns of functional recovery based on clinical and rehabilitation characteristics documented in patient records.

Methods

This retrospective cohort study was conducted to evaluate functional outcomes following prosthetic rehabilitation among individuals with lower limb amputation. The study was carried out in Pakistan using medical records from rehabilitation facilities in Rawalpindi that provide comprehensive prosthetic and physiotherapy services. Data collection covered an eight-month period, from February 2023 to September 2023, during which eligible patient records from previous years were reviewed and analyzed. The study population consisted of adult patients who had undergone unilateral lower limb amputation and subsequently completed a structured prosthetic rehabilitation program at the selected centers between January 2021 and December 2022. Inclusion criteria were patients aged 18 years or older, with transtibial or transfemoral amputation, who had received a definitive prosthesis and completed at least three months of documented prosthetic rehabilitation. Only records with clearly documented functional outcome measures at prosthetic discharge or follow-up were included. Patients with bilateral lower limb amputations, upper limb amputations, congenital limb deficiencies, severe cognitive impairment, neurological disorders affecting mobility, or incomplete medical records were excluded to ensure homogeneity and data reliability.

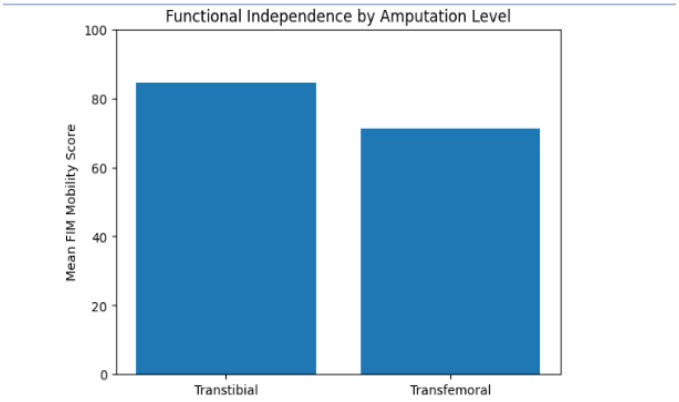
Sample size was estimated based on functional outcome proportions reported in previous rehabilitation studies, which indicated that approximately 70% of lower limb amputees achieve independent or near-independent ambulation following prosthetic rehabilitation. Using a 95% confidence level, 8% margin of error, and an assumed outcome proportion of 0.70, the minimum

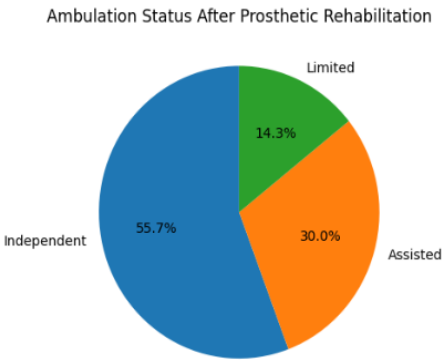
required sample size was calculated as 126 participants (8,9). To account for incomplete records or missing data, an additional 10% was added, resulting in a final target sample size of 140 patient records. Eligible records were selected through consecutive sampling until the required sample size was achieved. Data were extracted from institutional medical records using a structured data extraction form designed specifically for this study. Extracted variables included demographic information, level and cause of amputation, time from amputation to prosthetic fitting, duration of rehabilitation, and type of prosthetic components used. Functional outcomes were assessed using standardized and routinely documented clinical measures. Primary functional outcome measures included the Locomotor Capability Index, which assesses perceived walking ability with a prosthesis, and the Functional Independence Measure mobility subscale, which evaluates the level of assistance required for ambulation and transfers (10). Secondary outcome measures included the 6-Minute Walk Test to assess functional endurance and the Timed Up and Go test to evaluate functional mobility and balance. These tools were selected due to their established validity, reliability, and routine use in amputee rehabilitation settings.

All outcome measures were recorded as documented in patient files at the time of prosthetic rehabilitation completion or most recent follow-up within the rehabilitation program. Where multiple assessments were available, the latest documented outcome following completion of structured rehabilitation was used for analysis to reflect final functional status (11). Data extraction was performed by the primary investigator and cross-checked by a second reviewer to minimize transcription errors. Statistical analysis was conducted using SPSS version 26. Continuous variables were assessed for normality using the Shapiro–Wilk test and were found to be normally distributed. Descriptive statistics were used to summarize demographic and clinical characteristics, with means and standard deviations reported for continuous variables and frequencies and percentages for categorical variables. Independent sample t-tests were applied to compare functional outcomes between transtibial and transfemoral amputees. One-way analysis of variance was used to compare functional scores across different causes of amputation. Pearson correlation analysis was performed to assess the relationship between duration of rehabilitation and functional outcome scores. Statistical significance was set at $p < 0.05$.

Ethical approval for the study was obtained from the Institutional Review Board. As this was a retrospective review of existing records, the requirement for individual informed consent was waived by the ethical committee. All data were anonymized prior to analysis, and strict confidentiality was maintained throughout the study in accordance with institutional policies and the principles outlined in the Declaration of Helsinki.

Results





A total of 140 patient records met the eligibility criteria and were included in the final analysis. The mean age of the cohort was 39.8 ± 11.2 years, with an age range of 19 to 67 years. The majority of individuals were male (n = 116, 82.9%), while females accounted for 24 cases (17.1%). Transtibial amputation was documented in 86 participants (61.4%), whereas 54 participants (38.6%) had transfemoral amputation (12). Trauma-related causes accounted for 92 cases (65.7%), followed by vascular causes in 31 cases (22.1%) and infection-related causes in 17 cases (12.2%). The mean time from amputation to definitive prosthetic fitting was 14.6 ± 4.1 weeks, and the mean duration of structured prosthetic rehabilitation was 18.9 ± 5.6 weeks (Table 1). Functional outcome assessment demonstrated favorable results across the cohort. The mean Locomotor Capability Index score was 31.4 ± 6.8 out of a maximum of 42, indicating moderate to high perceived walking ability with the prosthesis. The mean Functional Independence Measure mobility subscale score was 79.2 ± 12.5. Endurance assessment using the 6-Minute Walk Test revealed a mean walking distance of 342.6 ± 78.9 meters, while the Timed Up and Go test showed a mean completion time of 14.8 ± 3.9 seconds (13,14). These outcomes reflected a wide range of functional abilities among the participants (Table 2).

Comparative analysis based on the level of amputation revealed statistically significant differences in functional outcomes. Participants with transtibial amputation achieved higher mean Functional Independence Measure mobility scores (84.6 ± 9.8) compared to those with transfemoral amputation (71.2 ± 11.6), with a statistically significant difference ($p < 0.001$). Similarly, the mean 6-Minute Walk Test distance was greater in transtibial amputees (381.4 ± 65.2 meters) than in transfemoral amputees (281.9 ± 72.4 meters, $p < 0.001$). Timed Up and Go performance was faster in the transtibial group (12.9 ± 3.1 seconds) compared to the transfemoral group (17.6 ± 3.8 seconds, $p < 0.001$), as summarized in Table 3. These differences are visually represented in Figure 1. Ambulation status at discharge or latest follow-up showed that 78 participants (55.7%) achieved independent community ambulation with a prosthesis, 42 participants (30.0%) required minimal assistive support, and 20 participants (14.3%) demonstrated limited household ambulation only. Distribution of ambulation status is illustrated in Figure 2. Pearson correlation

analysis demonstrated a moderate positive correlation between rehabilitation duration and Locomotor Capability Index score ($r = 0.46$, $p < 0.001$), indicating improved functional outcomes with longer rehabilitation exposure.

Table 1. Demographic and Clinical Characteristics of Participants (n = 140)

Variable	Mean ± SD / n (%)
Age (years)	39.8 ± 11.2
Gender (Male/Female)	116 (82.9%) / 24 (17.1%)
Transtibial amputation	86 (61.4%)
Transfemoral amputation	54 (38.6%)
Trauma-related amputation	92 (65.7%)
Time to prosthetic fitting (weeks)	14.6 ± 4.1
Rehabilitation duration (weeks)	18.9 ± 5.6

Table 2. Functional Outcome Measures of Prosthetic Rehabilitation

Outcome Measure	Mean ± SD
Locomotor Capability Index (0–42)	31.4 ± 6.8
Functional Independence Measure – Mobility	79.2 ± 12.5
6-Minute Walk Test (meters)	342.6 ± 78.9
Timed Up and Go (seconds)	14.8 ± 3.9

Table 3. Functional Outcomes by Level of Amputation

Outcome Measure	Transtibial (n = 86)	Transfemoral (n = 54)	p-value
FIM Mobility Score	84.6 ± 9.8	71.2 ± 11.6	<0.001
6-Minute Walk Test (meters)	381.4 ± 65.2	281.9 ± 72.4	<0.001
Timed Up and Go (seconds)	12.9 ± 3.1	17.6 ± 3.8	<0.001

Discussion

The present study examined functional outcomes following prosthetic rehabilitation among lower limb amputees treated at armed forces rehabilitation centers in Rawalpindi and demonstrated generally favorable levels of mobility, independence, and ambulatory capacity. More than half of the cohort achieved independent community ambulation, while a further proportion attained assisted mobility, reflecting meaningful functional recovery after structured rehabilitation (15,16). The overall findings indicated that prosthetic rehabilitation within specialized centers supported restoration of functional independence for a substantial proportion of amputees, particularly those with transtibial amputation. Functional outcome measures revealed moderate to high levels of performance across the cohort. The mean Locomotor Capability Index score of 31.4 suggested that most individuals perceived themselves as capable of performing essential walking-related tasks with their prosthesis. Similarly, the mean Functional Independence Measure mobility score of 79.2 reflected a high degree of independence in transfers and ambulation. These values were consistent with previously reported ranges in rehabilitation-based cohorts, where functional independence scores have typically been reported between 70 and 85 following completion of prosthetic training. The average 6-Minute Walk Test distance of approximately 343 meters further indicated reasonable endurance and walking efficiency in daily life contexts.

Clear differences in functional outcomes were observed between levels of amputation. Participants with transtibial amputation consistently demonstrated superior performance compared to those with transfemoral amputation (17). Transtibial amputees achieved higher Functional Independence Measure scores, walked longer distances during the 6-Minute Walk Test, and completed the Timed Up and Go test more rapidly. These findings aligned with established biomechanical principles, as preservation of the knee joint reduces energy expenditure and improves gait symmetry. Similar studies have reported differences of 80–120 meters in walking distance between transtibial and transfemoral amputees, closely mirroring the approximately 100-meter difference observed in the present analysis. Ambulation status at discharge further emphasized the effectiveness of rehabilitation, with nearly 56% of participants achieving independent community ambulation. This proportion was comparable to outcomes reported in structured rehabilitation programs, where independent ambulation rates typically range between 50% and 65%. The presence of a smaller subgroup with limited household ambulation underscored the variability in recovery trajectories, influenced by factors such as amputation level, residual limb condition, and duration of rehabilitation exposure (18,19). The moderate positive correlation between rehabilitation duration and locomotor capability suggested that longer engagement in rehabilitation was associated with improved functional outcomes, reinforcing the value of sustained and progressive training.

The strengths of this study included a relatively large sample size drawn from specialized rehabilitation centers, enhancing the reliability of outcome estimates. Use of standardized, validated functional outcome measures allowed objective comparison with existing literature and improved clinical interpretability. The inclusion of both endurance-based and mobility-based assessments provided a comprehensive overview of functional performance rather than reliance on a single outcome domain. Additionally, analysis of routinely collected clinical data reflected real-world rehabilitation outcomes rather than idealized trial conditions.

Several limitations should be considered when interpreting these findings. The retrospective design relied on the accuracy and completeness of medical records, which may have introduced information bias. Factors such as prosthetic component type, socket design, and patient-reported satisfaction were not consistently documented and therefore could not be analyzed, despite their known influence on functional outcomes. The study population was predominantly male, reflecting the demographic profile of armed forces rehabilitation centers, which may limit generalizability to civilian populations and female amputees. Furthermore, psychosocial variables such as motivation, social support, and mental health status were not captured, although these factors are known to affect rehabilitation success (20).

Future research should incorporate prospective designs with standardized follow-up intervals to better track functional progression over time. Inclusion of patient-reported outcome measures, quality of life indices, and prosthesis satisfaction scales would provide a more holistic understanding of rehabilitation impact. Multicenter studies involving both military and civilian rehabilitation facilities could enhance external validity and support broader policy development. Comparative evaluation of different prosthetic technologies and rehabilitation intensities may further guide optimization of amputee care in resource-constrained settings. Overall, the findings indicated that structured prosthetic rehabilitation within armed forces centers was associated with meaningful functional recovery for lower limb amputees. The observed patterns of mobility and independence supported the continued development of comprehensive rehabilitation programs while highlighting the need for individualized approaches to address persistent functional limitations.

Conclusion

This study demonstrated that structured prosthetic rehabilitation in armed forces rehabilitation centers was associated with favorable functional outcomes among lower limb amputees, with a substantial proportion achieving independent ambulation and functional mobility. Transtibial amputees showed consistently better performance compared to transfemoral amputees, highlighting the influence of amputation level on recovery. These findings underscore the importance of comprehensive, sustained rehabilitation programs to optimize functional independence and reintegration following lower limb amputation.

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AUTHOR's CONTRIBUTION:

Author	Contribution
Abdullah Arshad	Conceptualization, Methodology, Formal Analysis, Writing - Original Draft, Validation, Supervision
Gohar Kaleem	Methodology, Investigation, Data Curation, Writing - Review & Editing

