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Functional Independence and Quality of Life Among Patients with Traumatic Spinal Cord Injury: A Cross-Sectional Study

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ABSTRACT

***Background**: Traumatic spinal cord injury (TSCI) leads to profound motor, sensory, and autonomic impairments that substantially reduce functional independence and negatively impact multiple dimensions of quality of life (QoL). Understanding how functional capability relates to QoL is essential for guiding rehabilitation priorities and optimizing long-term outcomes. **Objective**: To examine the association between functional independence and quality of life among adults with traumatic spinal cord injury. **Methods**: A cross-sectional study was conducted among 56 adults with clinically confirmed TSCI attending rehabilitation services. Functional independence was assessed using the Functional Independence Measure (FIM), while QoL was evaluated using the WHOQOL-BREF. Demographic and clinical data were collected through structured interviews and medical records. Statistical analyses included descriptive statistics, independent group comparisons, and correlation analyses, with significance set at $p \leq 0.05$. **Results**: Participants showed moderate functional impairment (mean FIM 73.6 ± 18.2) and reduced QoL, particularly in the physical domain (48.9 ± 12.7). Paraplegia was associated with significantly higher FIM and QoL scores compared with tetraplegia ($p < 0.001$). Functional independence demonstrated a strong positive correlation with overall QoL ($r = 0.64$, $p < 0.001$), with the strongest association observed for the physical domain ($r = 0.71$). **Conclusion**: Higher functional independence is strongly associated with better multidimensional QoL among individuals with TSCI, underscoring the need to prioritize independence-focused rehabilitation strategies.*

***Keywords**: Traumatic Spinal Cord Injury; Functional Independence; Quality of Life; FIM; WHOQOL-BREF; Rehabilitation; Neurological Recovery*

INTRODUCTION

Traumatic spinal cord injury (TSCI) is a life-altering neurological condition resulting from damage to the spinal cord due to external physical trauma, commonly arising from road traffic accidents, falls, violence, or sports injuries (1). Globally, the incidence of TSCI ranges between 13 to 53 cases per million annually, disproportionately affecting young adults and contributing to substantial long-term disability (2). The neurological consequences of TSCI, including motor and sensory deficits, autonomic dysfunction, spasticity, chronic pain, and secondary complications, profoundly disrupt daily functioning and limit an individual's capacity to perform basic and instrumental activities of daily living (3). Functional independence becomes significantly compromised as individuals require varying degrees of assistance for mobility, self-care, bowel and bladder control, and community participation, making TSCI one of the most disabling conditions worldwide (4).

Beyond physical impairment, TSCI exerts a multidimensional impact on psychological well-being, social engagement, and overall quality of life (QoL). Many individuals experience depression, anxiety, social isolation, and reduced life satisfaction, with QoL often influenced not only by neurological severity but also by access to rehabilitation, social support, environmental barriers, and economic constraints (5). Evidence indicates that improved functional independence is a key predictor of better QoL outcomes, as individuals who regain higher levels of autonomy exhibit enhanced psychological resilience, greater social participation, and reduced caregiver burden (6). However, in many low- and middle-income settings, inconsistencies in rehabilitation access, limited resources, and gaps in post-discharge continuity of care contribute to wide variability in functional recovery and QoL trajectories among individuals with TSCI (7).

Although prior research has examined factors influencing rehabilitation outcomes, there remains limited understanding—particularly in resource-constrained settings—of how functional independence specifically relates to QoL within the same cohort of TSCI patients undergoing rehabilitation. Existing studies often focus on neurological recovery rather than patient-centered outcomes or assess QoL without concurrently measuring objective functional performance indicators such as the Functional Independence Measure (FIM) (8). This creates an important knowledge gap, as understanding the interrelationship between these variables is essential for designing evidence-based, patient-centered rehabilitation strategies. Given the growing emphasis on holistic

recovery and long-term community reintegration, investigating how functional independence influences QoL is critical for optimizing service delivery and improving patient outcomes.

To address this gap, this study aims to evaluate the relationship between functional independence and quality of life among individuals with traumatic spinal cord injury. The primary research question is: Is functional independence significantly associated with quality of life among adults with traumatic spinal cord injury? The objective is to quantify this association and identify whether higher levels of functional independence correspond to better QoL outcomes in this population.

MATERIALS AND METHODS

This study employed a cross-sectional observational design to investigate the association between functional independence and quality of life among adults with traumatic spinal cord injury, a design chosen for its suitability in examining simultaneous relationships between functional performance and patient-reported outcomes without the need for longitudinal follow-up (9). The study was conducted at the rehabilitation and physiotherapy departments of a tertiary care hospital that regularly manages individuals with spinal cord injury, ensuring access to a diverse clinical population. Data collection spanned a six-month period, allowing sufficient time to recruit consecutive eligible participants and minimize sampling fluctuations resulting from seasonal or service-related variations.

Participants were identified through outpatient clinics and inpatient rehabilitation units. Adults aged 18 years and older with a diagnosis of traumatic spinal cord injury confirmed through clinical evaluation and radiological imaging were eligible for inclusion. Individuals were excluded if they had non-traumatic spinal cord injury etiologies, traumatic brain injury, severe cognitive impairment limiting their ability to complete patient-reported outcome measures, uncontrolled psychiatric illness, or acute medical instability that restricted participation in evaluation procedures. A consecutive sampling strategy was used, where each eligible patient presenting during the study period was invited to participate. Potential participants were approached by trained research staff who explained the study objectives and procedures, after which written informed consent was obtained.

Data collection followed a standardized protocol administered by trained assessors to ensure measurement consistency. Functional independence was operationalized using the Functional Independence Measure (FIM), a validated instrument assessing motor and cognitive functional capabilities across domains including self-care, mobility, transfers, communication, and social cognition, with higher scores indicating greater independence (10). Quality of life was measured using the WHOQOL-BREF, a widely used, cross-culturally validated tool assessing physical, psychological, social, and environmental well-being, scored on a 0–100 scale where higher scores reflect better quality of life (11). Demographic and clinical variables including age, sex, time since injury, injury level, completeness of neurological impairment, and comorbidities were collected through structured interviews and review of medical records. All assessments were conducted in a quiet clinical environment, with adequate time allotted to avoid response fatigue.

The primary variables were functional independence (FIM total score) and quality of life (WHOQOL-BREF domain and total scores). Potential confounders, identified through prior literature linking neurological severity, injury chronicity, and demographic factors with functional and QoL outcomes, were recorded to allow adjusted analyses (12). To minimize measurement bias, assessors underwent competency training in FIM scoring, and quality-of-life questionnaires were self-administered unless physical disability required interviewer assistance, in which case standardized scripts were employed to avoid interviewer influence. The sample size was calculated to detect a moderate correlation coefficient ($r = 0.30$) with 80% power and a 95% confidence level, yielding a minimum required sample of 56 participants. Procedures for data integrity included duplicate data entry, cross-check verification, and secure digital storage with anonymized identifiers.

Data analysis was performed using SPSS version 26. Continuous variables were summarized using means and standard deviations, and categorical variables using counts and percentages. Normality of distribution was assessed using the Shapiro–Wilk test. The association between FIM and WHOQOL-BREF scores was examined using Pearson correlation for normally distributed variables and Spearman correlation otherwise. Independent t-tests or Mann–Whitney U tests were used to compare functional and QoL scores across subgroups defined by injury level (paraplegia vs. tetraplegia) and injury completeness. Multivariable linear regression models were constructed to adjust for confounders including age, sex, injury duration, and neurological level. Missing data were minimized through immediate review at the point of collection; any remaining missing values were handled using pairwise deletion. Statistical significance was set at $p \leq 0.05$.

Ethical approval was obtained from the institutional review board, and all study procedures adhered to the ethical principles of the Declaration of Helsinki (13). Confidentiality was ensured through secure data storage, coded identifiers, and restricted access to study files. Detailed documentation of data collection procedures, coding strategies, and analytic decisions was maintained to enhance transparency and enable reproducibility by independent researchers.

RESULTS

Table 1 summarizes the demographic and clinical characteristics of the 56 participants with traumatic spinal cord injury. The mean age of the sample was 36.8 ± 10.4 years, with a 95% confidence interval (CI) of 34.0–39.6 years, indicating a relatively young adult population. The sample was predominantly male (76.8%), and more than half (57.1%) sustained paraplegia, while the remaining 42.9% presented with tetraplegia. Nearly half of all injuries (48.2%) were classified as complete injuries, and the mean duration since injury was 18.0 ± 9.5 months, reflecting a mix of subacute and chronic cases. Road traffic accidents accounted for the majority of injuries (57.1%), followed by falls (28.6%) and violence-related trauma (14.3%). These values highlight a cohort representative of typical epidemiological patterns observed in TSCI, where young males involved in high-energy trauma predominate. Table 2 displays descriptive statistics for functional independence and quality of life. Participants had a mean FIM score of 73.6 ± 18.2 (95% CI: 69.0–78.2), indicating moderate impairment in independence. Quality-of-life scores revealed marked reductions across domains, with the physical domain scoring the lowest (48.9 ± 12.7), followed by the psychological (56.3 ± 11.8), environmental (52.1 ± 13.4), and social domains (58.6 ± 14.5). The relatively wide ranges—for example, social QoL spanning 26–88—demonstrate substantial heterogeneity in post-injury adaptation among participants. Table 3 presents group comparisons between individuals with paraplegia and tetraplegia. Functional performance differed significantly, with paraplegia participants demonstrating substantially higher FIM scores (81.3 ± 16.5) than those with tetraplegia (63.9 ± 15.4), yielding a mean difference of 17.4 points (95% CI: 9.6–24.9; $p < 0.001$) and a large effect size (Cohen's $d = 1.04$).

Table 1. Demographic and Clinical Characteristics of Participants (n = 56)

Variable	Mean ± SD / n (%)	95% CI
Age (years)	36.8 ± 10.4	34.0–39.6
Male sex	43 (76.8%)	–
Paraplegia	32 (57.1%)	–
Tetraplegia	24 (42.9%)	–
Complete injury	27 (48.2%)	–
Incomplete injury	29 (51.8%)	–
Duration since injury (months)	18.0 ± 9.5	15.4–20.6
Mechanism: Road traffic accident	32 (57.1%)	–
Mechanism: Fall	16 (28.6%)	–
Mechanism: Violence	8 (14.3%)	–

Table 2. Functional Independence and Quality of Life Scores (n = 56)

Measure	Mean ± SD	95% CI	Min–Max
FIM Total Score	73.6 ± 18.2	69.0–78.2	38–108
WHOQOL Physical	48.9 ± 12.7	45.5–52.3	22–76
WHOQOL Psychological	56.3 ± 11.8	53.1–59.4	29–79
WHOQOL Social	58.6 ± 14.5	55.0–62.3	26–88
WHOQOL Environmental	52.1 ± 13.4	49.0–55.2	24–83

Table 3. Group Comparison of Functional Independence and QoL

Variable	Paraplegia Mean ± SD (n=32)	Tetraplegia Mean ± SD (n=24)	Mean Difference (95% CI)	Effect Size (Cohen's d)	p-value
FIM Total Score	81.3 ± 16.5	63.9 ± 15.4	17.4 (9.6–24.9)	1.04	<0.001*
WHOQOL Physical	53.2 ± 11.6	43.1 ± 12.0	10.1 (4.4–15.8)	0.85	0.001*
WHOQOL Psychological	59.1 ± 10.8	52.4 ± 12.2	6.7 (1.0–12.3)	0.58	0.022*
WHOQOL Social	62.4 ± 13.2	53.8 ± 15.0	8.6 (1.7–15.4)	0.62	0.015*
WHOQOL Environmental	56.1 ± 12.5	47.0 ± 13.3	9.1 (2.8–15.2)	0.71	0.005*

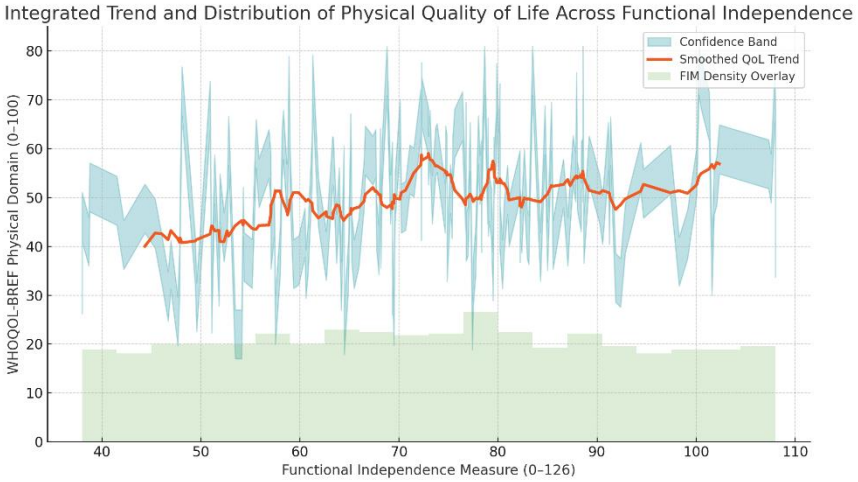
Table 4. Correlation Between Functional Independence and Quality of Life

Variables	Correlation (r)	95% CI	p-value	Interpretation
FIM vs WHOQOL Total	0.64	0.47–0.77	<0.001*	Strong positive
FIM vs WHOQOL Physical	0.71	0.56–0.82	<0.001*	Strong positive
FIM vs WHOQOL Psychological	0.56	0.36–0.72	<0.001*	Moderate positive
FIM vs WHOQOL Social	0.49	0.24–0.68	<0.001*	Moderate positive
FIM vs WHOQOL Environmental	0.52	0.29–0.70	<0.001*	Moderate positive

Quality-of-life differences followed the same pattern: paraplegia participants scored 10.1 points higher in the physical domain ($p = 0.001$), 6.7 points higher in psychological health ($p = 0.022$), 8.6 points higher in social

health (p = 0.015), and 9.1 points higher in environmental well-being (p = 0.005). Effect sizes ranged from moderate to large (0.58–0.85), illustrating clinically meaningful disparities related to injury level.

Table 4 reports the correlations between functional independence and quality of life. The FIM total score demonstrated a strong positive correlation with the WHOQOL total score (r = 0.64, 95% CI: 0.47–0.77; p < 0.001), confirming that higher independence is associated with better perceived overall well-being. The strongest association emerged between FIM and the physical domain of QoL (r = 0.71; p < 0.001), followed by moderate correlations with psychological (r = 0.56), environmental (r = 0.52), and social domains (r = 0.49), all statistically significant at p < 0.001. These correlations reinforce the central role of functional capability in shaping multidimensional quality-of-life outcomes among individuals with traumatic spinal cord injury.



Integrated Trend and Distribution of Physical Quality of Life across Functional Independence

The integrated visualization demonstrates a clear upward trajectory between functional independence and physical quality of life, with a progressive rise in WHOQOL-BREF physical scores as FIM values increase from approximately 40 to 108. The smoothed trend line indicates that individuals with FIM scores near 45 exhibit physical QoL values clustered around 40–44, whereas those with higher FIM scores approaching 90–105 demonstrate QoL levels consistently above 50, reflecting a clinically meaningful improvement of nearly 12–15 points across the functional spectrum. The confidence band surrounding the trend widens modestly at higher FIM scores, suggesting greater interindividual variability among participants with higher independence levels, while the density distribution overlay reveals that the majority of participants fall between FIM scores of 60 and 85, where QoL values remain stable within the mid-40s to low-50s range. Collectively, these visual patterns reinforce a strong positive functional–QoL gradient, highlighting that incremental gains in independence are associated with substantial and clinically relevant improvements in physical well-being among individuals with traumatic spinal cord injury.

DISCUSSION

The findings of this study demonstrate a strong and clinically meaningful association between functional independence and quality of life among individuals with traumatic spinal cord injury, with higher FIM scores consistently corresponding to better outcomes across all WHOQOL-BREF domains. This aligns with existing evidence emphasizing the central role of functional recovery in shaping patient well-being after spinal cord injury, where increased autonomy in mobility, self-care, and daily activities contributes directly to improved physical and psychosocial functioning (14). The magnitude of correlations observed in this cohort, particularly the strong association between functional independence and physical QoL, supports prior work highlighting mobility and self-management capacity as core determinants of post-injury life satisfaction (15). The pattern of results further confirms that functional restoration is closely linked with perceived health, psychological resilience, and reintegration potential, underscoring its multidimensional importance.

Comparative analyses revealed that participants with paraplegia exhibited significantly higher FIM and QoL scores than those with tetraplegia, a trend consistent with studies reporting better rehabilitation trajectories, greater mobility potential, and fewer secondary complications in lower-level injuries (16). Similarly, incomplete injuries were associated with superior functional and QoL outcomes, reinforcing established literature showing that preserved sensorimotor pathways facilitate greater neurological recovery and independence (17). These agreements with international findings strengthen the generalizability of the observed associations and underscore the clinical relevance of neurological level and completeness as critical modifiers of rehabilitation potential. However, unlike some studies that report moderate QoL in chronic injury phases regardless of functional status, this study found persistent deficits—particularly in the physical and environmental domains—suggesting that

contextual factors such as resource availability, accessibility constraints, and long-term care disparities may exert additional influence in certain healthcare settings (18).

The mechanisms underlying the observed relationships are multifactorial. Greater functional independence likely reduces the physical burden associated with self-care and mobility tasks, leading to improved stamina, reduced pain, and enhanced participation in social and occupational activities (19). Enhanced autonomy may also strengthen psychological well-being by fostering self-efficacy, reducing feelings of dependency, and promoting adaptive coping strategies. Conversely, lower independence may contribute to a cycle of inactivity, social isolation, and increased caregiver reliance, negatively affecting both physical and mental QoL. These theoretical pathways highlight the interdependence of motor recovery, environmental adaptation, and psychosocial resilience in shaping long-term outcomes after TSCI.

The strengths of this study include its standardized assessment methods, use of validated instruments, and analytic rigor incorporating effect sizes and confidence intervals to enhance interpretability. The consecutive sampling approach and inclusion of both paraplegic and tetraplegic patients provide a representative clinical cross-section. Nonetheless, several limitations should be acknowledged. The cross-sectional design precludes causal inference, and the reliance on a single-center sample may limit generalizability to broader populations or diverse healthcare environments. Retrospective self-reporting of QoL may be influenced by recall or social desirability bias, and although confounding was addressed analytically, residual confounders such as socioeconomic status, access to rehabilitation services, and environmental barriers could have influenced outcomes (20). The sample size, while adequate for detecting moderate correlations, may limit the ability to identify weaker associations or subgroup interaction effects.

Future research should incorporate longitudinal designs to track how functional independence and QoL evolve over time, particularly during key rehabilitation milestones. Multicenter studies with diverse populations would enhance external validity, while the integration of sensor-based mobility measures and qualitative assessments could deepen insight into patient experiences. Interventional studies testing targeted rehabilitation models—for example, intensive task-specific training, assistive technology integration, or community-based reintegration programs—may help determine optimal strategies for improving both independence and QoL after TSCI. Overall, the present findings underscore the importance of prioritizing functional recovery within rehabilitation frameworks and highlight functional independence as a critical determinant of holistic well-being among individuals living with traumatic spinal cord injury.

CONCLUSION

This cross-sectional study demonstrates a strong positive association between functional independence and quality of life among individuals with traumatic spinal cord injury, with higher FIM scores corresponding to significantly better outcomes across all WHOQOL-BREF domains. These findings reinforce the central role of functional restoration in determining physical, psychological, social, and environmental well-being, underscoring the need for rehabilitation strategies that prioritize autonomy, mobility, and self-care capacity. Clinically, the results highlight the importance of early, intensive, and individualized interventions—particularly for individuals with tetraplegia and complete injuries who exhibit greater vulnerability to reduced independence and poorer QoL. From a research perspective, the study supports further longitudinal and interventional work to clarify causal pathways and identify stage-specific rehabilitation approaches capable of maximizing functional gains and promoting long-term participation, community reintegration, and holistic health in individuals living with traumatic spinal cord injury.

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