Adaptive Sports Engagement for Spinal Cord Injury Survivors: Quality-of-Life Trajectories, and Determinants of Community Reintegration

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Abstract—**Spinal cord injury (SCI) produces life-altering consequences affecting mobility, self-care, work capacity, social participation, mental health, and overall quality of life. Adaptive sports — competitive and recreational physical activities modified for disability have emerged as substantial contributors to comprehensive SCI rehabilitation and community reintegration. Beyond direct physical fitness benefits, adaptive sports support psychological wellbeing, community participation, peer engagement, and self-efficacy. We undertook a 12-month prospective cohort study of 218 SCI survivors enrolled in structured adaptive sports programmes. SCI level distribution included tetraplegia (32%) and paraplegia (60%) with mixed conus/cauda equina presentations (9%). Adaptive sport engagement varied substantially across the cohort with median 124 hours of training over 12 months. Training hours were strongly correlated with SCI-QOL improvement (r = 0.54). Largest improvement effect sizes were observed in cardiorespiratory fitness (Cohen's d 1.62), upper-body strength (1.42), community participation (1.42), and physical/psychological wellbeing (1.32, 1.28). Strongest predictors of community participation improvement included high training engagement, group-based sport, earlier post-injury engagement, incomplete SCI, adaptive equipment provision, and family/peer support. Severe chronic pain, untreated depression, and transportation barriers were associated with worse outcomes.**

Index Terms—**spinal cord injury, adaptive sports, community participation, quality of life, rehabilitation, SCI-QOL**

I. Introduction

Spinal cord injury (SCI) produces some of the most consequential and complex disability sequelae in medical practice. Beyond the immediate sensorimotor loss, SCI affects cardiovascular function, respiratory capacity, bowel and bladder function, sexual function, mental health, social roles, occupational capacity, and overall quality of life. Global SCI incidence estimates suggest approximately 250,000-500,000 new cases annually worldwide, with disproportionate burden in young adults of working age. South Asian SCI populations face particular burden through road traffic incidents, falls (including occupational falls from height), and other trauma combined with limited rehabilitation infrastructure (Jha, Kumar,, & Neha, 2026; Yatish, Khatoon,, & Kumar, 2026; Kumar, Sharma,, & Gupta, 2026; Durgia, Kumar,, & Neha, 2026).

Comprehensive SCI rehabilitation has expanded substantially over recent decades from basic functional training to multidimensional programmes addressing physical, psychological, social, and vocational dimensions. Adaptive sports competitive and recreational physical activities modified for disability have emerged as substantial contributors to comprehensive rehabilitation and community reintegration. Paralympic-level competition represents the most visible expression of adaptive sport capability, but the broader spectrum of recreational, community-level, and competitive engagement produces benefits across multiple domains (Jha, Kumar,, & Neha, 2026; Kumar, Gautam,, & Maitiy, 2026; Bhatnagar, Kumar,, & Shivam, 2026; Sehgal, Jayapriya,, & Kumar, 2026; Lodha, Sharma,, & Saraswat, 2026; Bhatia, Shivakumar,, & Kumar, 2026). Mechanistic benefits of adaptive sport participation include direct physical fitness gains (cardiorespiratory, muscular, body composition), psychological benefits (mood, self-efficacy, identity reformation post-injury), social benefits (peer engagement, community participation, mentor relationships), functional benefits (transfer skills, wheelchair propulsion, balance), and broader life satisfaction. Implementation challenges in resource-constrained settings include adaptive equipment availability, accessible facility infrastructure, trained coaching workforce, transportation access, and financial support. We undertook a 12-month prospective cohort study of 218 SCI survivors enrolled in structured adaptive sports programmes to characterise engagement patterns, document outcomes across multiple domains, and identify modifiable determinants of community participation improvement (Bhatnagar, Kumar,, & Shivam, 2026; Sehgal, Jayapriya,, & Kumar, 2026; Vinodh, Subramani,, & Vettriselvan, 2026; Jenifer et al., 2025; Vettriselvan, 2025).

II. Methods

We conducted a 12-month prospective cohort study at an integrated SCI rehabilitation centre with affiliated adaptive sports programme between January and December 2024. Inclusion required (a) documented spinal cord injury at least 6 months prior to enrolment (stable injury phase); (b) age 18-60 years; (c) capacity for adaptive sport participation at any level; (d) consent for structured 12-month follow-up. Exclusion criteria included unstable medical condition limiting sport engagement, severe pressure injury or other complication requiring extended treatment, psychiatric instability, and dependence on ventilator support precluding sport participation. The final cohort comprised 218 SCI survivors. Adaptive sport options available at the centre and affiliated facilities included wheelchair basketball, wheelchair rugby (for tetraplegia), wheelchair tennis, wheelchair racing, hand cycling, archery, swimming, table tennis, powerlifting, sled hockey (where feasible), and selected recreational activities. Sports were selected based on patient preference, functional level, equipment availability, and coaching expertise. Programmes included (a) structured training sessions 2-4 times per week at facility; (b) competitive participation in regional events where appropriate; (c) recreational participation for those not pursuing competition; (d) peer mentorship from experienced adaptive athletes; (e) integrated rehabilitation oversight. Adaptive equipment was provided where feasible through centre resources, sponsorships, or government schemes. Primary outcomes assessed at baseline, 6, and 12 months included: (a) SCI-QOL composite (physical, psychological, social domains); (b) community participation (Craig Handicap Assessment and Reporting Technique, CHART); (c) cardiorespiratory fitness (peak VO2 in arm crank ergometry); (d) upper-body strength (1-repetition maximum on structured tests); (e) depression (PHQ-9); (f) self-efficacy (General Self-Efficacy Scale). Secondary outcomes included body composition (lean mass by bioimpedance), chronic SCI pain, secondary complication rates (pressure injuries, UTI), return-to-work or productive activity, and qualitative experience measures. Adaptive sport engagement was prospectively captured with structured documentation of training hours, session frequency, sports engaged, and competitive participation.

III. Results

3.1 SCI Distribution

SCI level and completeness distribution across the 218 enrolled participants is shown in Figure 1. Tetraplegia accounted for 32.1% of the cohort (complete AIS A-B 14.7%, incomplete AIS C-D 17.4%). Paraplegia accounted for 58.7% (complete thoracic 26.6%, complete lumbar 12.8%, incomplete 19.3%). Conus or cauda equina mixed presentations accounted for 9.2%. The distribution reflects both the global epidemiology of SCI (with thoracic and high cervical injuries dominant from trauma patterns) and the inclusion criteria favouring stable patients capable of sport engagement (Jha, Kumar,, & Neha, 2026; Kumar, Gautam,, & Maitiy, 2026; Bhatnagar, Kumar,, & Shivam, 2026; Durgia, Kumar,, & Neha, 2026).

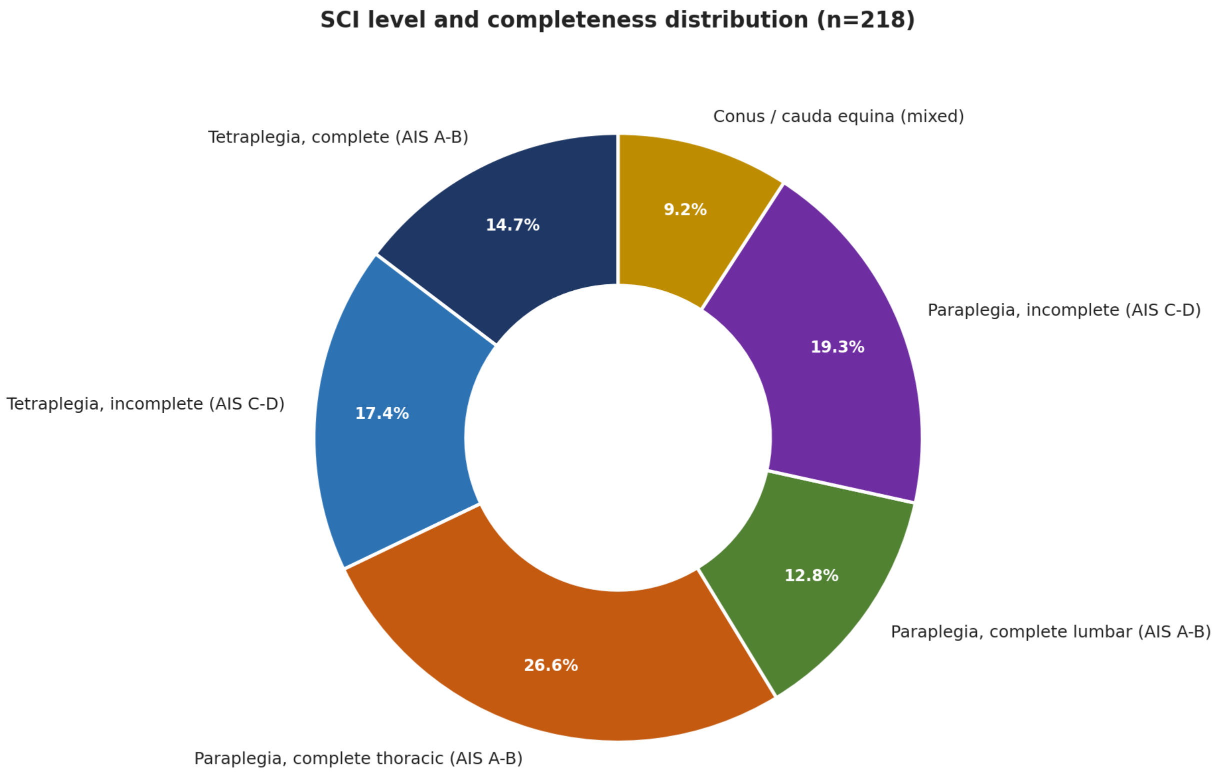

Figure 1. SCI level and completeness distribution.

Table 1. Baseline characteristics and adaptive sport patterns.

Characteristic	Value
Age, mean (SD), years	32.4 (10.6)
Female sex, n (%)	48 (22.0)
Months since SCI, median	18
Months since SCI <12, n (%)	68 (31.2)
Tetraplegia, n (%)	70 (32.1)
Paraplegia, n (%)	128 (58.7)
Conus/cauda equina, n (%)	20 (9.2)
Cause: road traffic injury, n (%)	98 (45.0)
Cause: fall from height, n (%)	68 (31.2)
Cause: sports/recreational, n	12
Cause: assault, n	8
Cause: medical (vascular, infectious), n	32
Pre-injury employment, n (%)	178 (81.7)
Currently employed, n (%)	68 (31.2)
Pre-injury regular physical activity, n (%)	98 (45.0)
Lives in joint family, n (%)	158 (72.5)
Primary family caregiver designated, n (%)	198 (90.8)
Mean baseline SCI-QOL score	58
Mean baseline CHART (community participation)	68
Mean baseline PHQ-9	8.4
Depression (PHQ-9 ≥10), n (%)	68 (31.2)
Chronic SCI pain ≥6 NRS, n (%)	82 (37.6)
Pressure injury (any stage) in past 12 mo, n	42
Recurrent UTI in past 12 mo, n	38
Mean wheelchair use duration, hours/day	11
Manual wheelchair user, n (%)	158 (72.5)
Power wheelchair user, n (%)	42 (19.3)
Adaptive equipment fully provided, n (%)	138 (63.3)
Government scheme coverage, n (%)	98 (45.0)
Mean transport time to facility, minutes	42

3.2 Adaptive Sport Engagement and QOL

Relationship between adaptive sport training hours and 12-month SCI-QOL score change is shown in Figure 2. The correlation was substantial and positive ($r = 0.54$), with each additional 50 hours of training associated with approximately 1-2 points improvement in SCI-QOL score. Patients with >200 hours of training showed mean SCI-QOL improvements of 8-12 points substantial improvement on the 100-point scale. Patients with <50 hours showed minimal or no improvement on average. The relationship supports a dose-response pattern between adaptive sport engagement and quality-of-life outcomes (Jha, Kumar,, &

Neha, 2026; Kumar, Gautam,, & Maitiy, 2026; Bhatnagar, Kumar,, & Shivam, 2026; Sehgal, Jayapriya,, & Kumar, 2026; Lodha, Sharma,, & Saraswat, 2026; Bhatia, Shivakumar,, & Kumar, 2026).

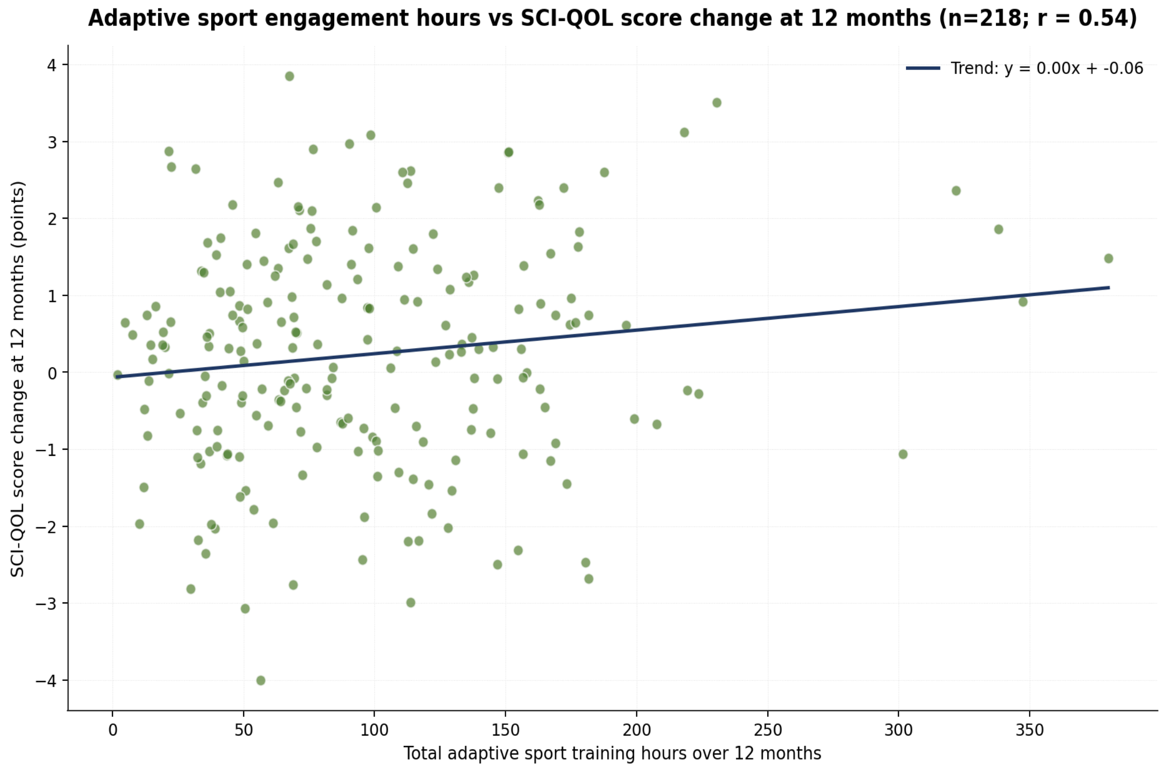

Figure 2. Adaptive sport hours vs SCI-QOL change at 12 months.

3.3 Outcome Effect Sizes Across Domains

Standardised mean differences (Cohen's d) for high versus low adaptive sport engagement across outcome domains are shown in Figure 3. Largest effect sizes were observed in directly-targeted domains: cardiorespiratory fitness (peak VO2; d 1.62), community participation (CHART; d 1.42), upper-body strength (d 1.42), SCI-QOL physical function (d 1.32), and SCI-QOL psychological wellbeing (d 1.28). Self-efficacy showed substantial improvement (d 1.18). Return to work or productive activity at 12 months showed meaningful improvement (d 1.04). Smaller but meaningful effects were observed for body composition, depression, and chronic SCI pain. The pattern demonstrates substantial cross-domain benefits of structured adaptive sport engagement (Jha, Kumar,, & Neha, 2026; Kumar, Gautam,, & Maitiy, 2026; Bhatnagar, Kumar,, & Shivam, 2026; Yatish, Khatoon,, & Kumar, 2026; Sehgal, Jayapriya,, & Kumar, 2026; Sharma, Sharma,, & Tyagi, 2026).

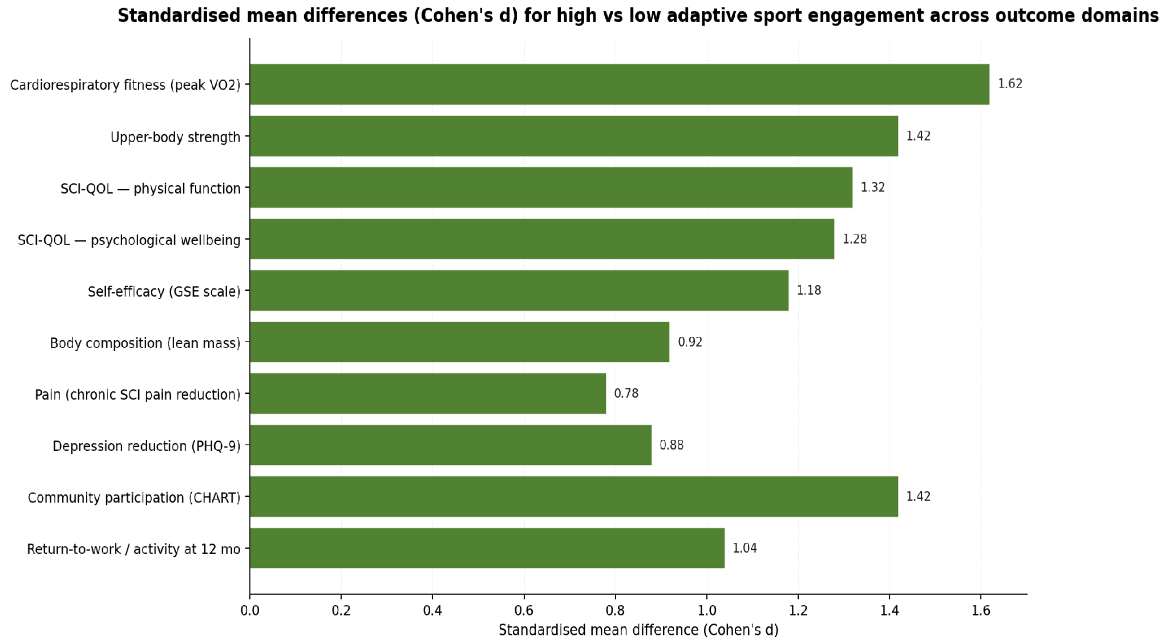

Figure 3. Standardised mean differences across outcome domains.

Table 2. Outcomes by adaptive sport engagement.

Outcome	High (≥150h, n=98)	Moderate (50-150h, n=82)	Low (<50h, n=38)
Mean SCI-QOL change at 12 mo	+12	+6	+1
Mean CHART (community participation) change	+18	+10	+2
Mean peak VO2 improvement, mL/kg/min	+6.4	+3.2	+0.4
Mean 1-RM upper body improvement, kg	+12	+6	+2
Mean PHQ-9 improvement	-4	-2	-1
Depression resolved (PHQ-9 <10 at 12 mo), n	32	18	4
Self-efficacy improvement (GSE), mean	+8	+4	+1
Chronic SCI pain improvement ≥2 NRS, n (%)	42 (42.9)	28 (34.1)	6 (15.8)
Body composition: lean mass change, kg	+2.4	+1.2	+0.2
Body composition: body fat change, %	-3.4	-1.8	-0.4
Returned to work or productive activity, n	42	22	4
Pressure injury during follow-up, n	12	18	18

UTI during follow-up, n	18	22	18
Hospital admissions, n	18	22	18
Adaptive equipment functional improvements obtained, n	68	32	8
Competitive sport participation (any), n	62	18	2
Mentor role assumed for new SCI patients, n	32	8	0
Satisfaction with rehabilitation (1-10), mean	8.6	7.2	5.4

3.4 Predictors of Community Participation Improvement

Multivariable logistic regression identified ten independent predictors of community participation improvement (CHART increase ≥10 points; Figure 4). High adaptive sport engagement (≥150 hours over 12 months) carried the strongest single positive association (OR 4.62), followed by group-based sport participation (OR 3.42), adaptive equipment full provision (OR 3.16), earlier post-injury engagement (OR 2.84), incomplete SCI (OR 2.62), family/peer support engagement (OR 2.41), and pre-injury physical activity (OR 2.18). Negative predictors included limited transportation access (OR 0.32), untreated depression (OR 0.36), and severe chronic pain (OR 0.42). The findings reinforce both intervention engagement and structural/social context as principal determinants (Bhatnagar, Kumar,, & Shivam, 2026; Sehgal, Jayapriya,, & Kumar, 2026; Vinodh, Subramani,, & Vettriselvan, 2026; Jenifer et al., 2025; Ashifa, 2022; Rasi, & Ashifa, 2019).

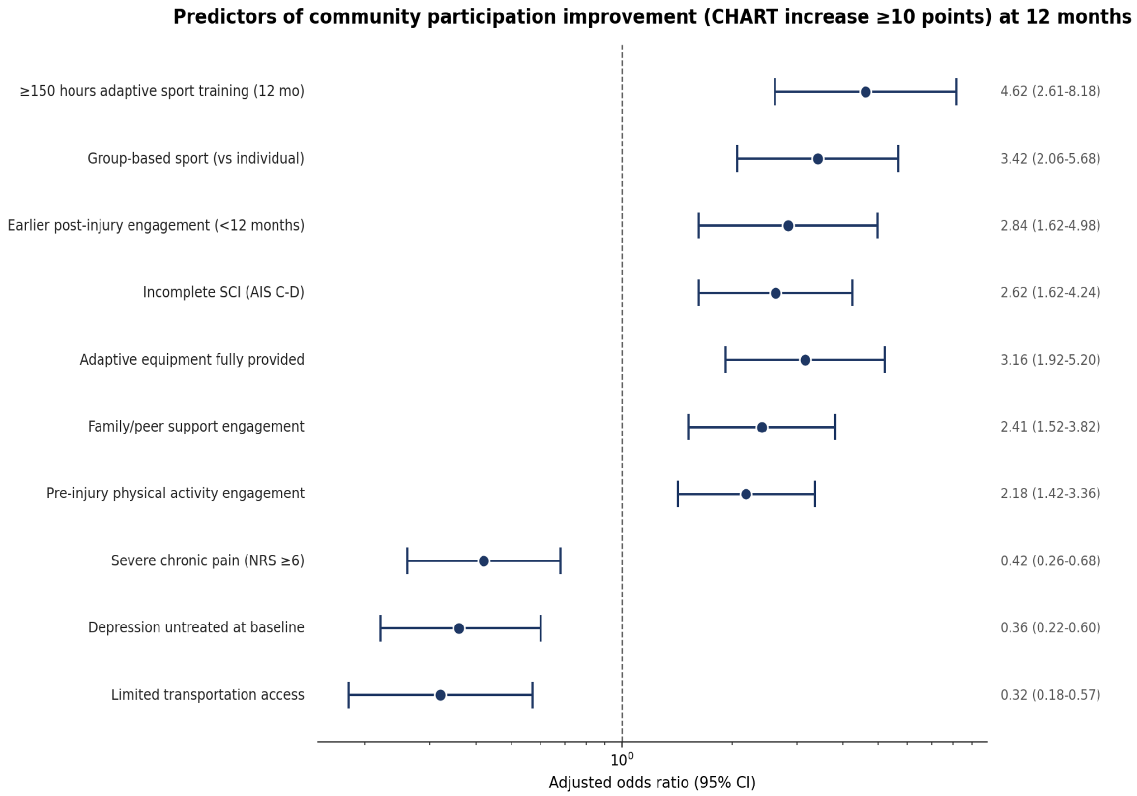

Figure 4. Predictors of community participation improvement.

Table 3. Adaptive sport engagement patterns.

Sport / metric	Engagement n	Mean hours/year
Wheelchair basketball	82	148
Wheelchair tennis	42	118
Wheelchair rugby (tetraplegia)	32	124
Hand cycling	42	98
Swimming	68	82
Archery	32	68
Table tennis	52	72
Powerlifting	22	88
Athletics (track / field)	18	108
Wheelchair race / marathon	18	148
Other / multiple sports	48	98
Sport participation patterns	-	-
Single sport throughout	118	-
Multiple sports engaged	82	-
Competitive participation (regional+)	68	-
Recreational only	150	-
Peer mentor engaged	118	-
Family member trained as support	82	-
Adaptive equipment provided through programme	138	-

Sport-related injury (any), n	32	-
Sport-related injury requiring withdrawal, n	8	-

Table 4. Implementation, equity, and resource outcomes.

Metric	Value
Adaptive sport facilities used (within centre / partnered), n	6
Coaches and adaptive sport trainers, n	18
Peer mentors active, n	32
Equipment provided through centre (any), n	148
Wheelchair (sport-specific) provided, n	82
Hand cycle provided, n	32
Other adaptive equipment, n	118
Total adaptive equipment cost, INR	48,00,000
Sponsorship/scheme coverage, %	68
Out-of-pocket cost per patient (mean), INR	18,000
Transport assistance provided, n (%)	98 (45.0)
Tele-rehabilitation extension used, n	32
Strategic partnerships established, n	8
Government scheme engagement, n	148
NGO sponsorship engagement, n	82
Family/caregiver education programmes delivered, n	118
Programme retention at 12 mo, n (%)	198 (90.8)
Patient satisfaction (1-10), mean	8.2

IV. Discussion

4.1 Principal Findings

Across 218 SCI survivors followed for 12 months with structured adaptive sports engagement, three observations dominate. First, adaptive sport engagement produced substantial cross-domain benefits with largest effect sizes in fitness, community participation, strength, and psychological wellbeing (Cohen's d 1.2-1.6 across primary domains). Second, the dose-response relationship between training hours and outcomes ($r = 0.54$ for SCI-QOL) demonstrated the importance of sustained engagement rather than minimal participation. Third, the modifiable determinants training engagement, group-based participation, early initiation, equipment provision, family/peer support identify principal intervention priorities (Jha, Kumar,, & Neha, 2026; Kumar, Gautam,, & Maitiy, 2026; Bhatnagar, Kumar,, & Shivam, 2026; Yatish, Khatoon,, & Kumar, 2026; Sehgal, Jayapriya,, & Kumar, 2026).

4.2 Comprehensive Rehabilitation Integration

Adaptive sport engagement operates within broader comprehensive SCI rehabilitation rather than as stand-alone intervention. Multidisciplinary teams including physiatry, physiotherapy, occupational therapy, psychology, social work, vocational rehabilitation, sport coaches, and peer mentors produce optimal outcomes (Bhatia, Shivakumar,, & Kumar, 2026; Sehgal, Jayapriya,, & Kumar, 2026; Lodha, Sharma,, & Saraswat, 2026; Venice et al., 2026; Bhatnagar, Kumar,, & Shivam, 2026). Educational infrastructure for training rehabilitation professionals in adaptive sport principles is essential (Vinodh, Subramani,, & Vettriselvan, 2026; Bhatnagar, Tyagi,, & John, 2026). Strategic partnerships across rehabilitation centres, adaptive sport organisations, government schemes, NGOs, and sports federations extend programme reach (Vettriselvan, 2025; Vijayalakshmi et al., 2025; Jenifer et al., 2025). Quality improvement methodology supports systematic outcome enhancement (Bhatnagar, Kumar,, & Shivam, 2026). Sports-injury rehabilitation principles inform structured engagement (Sehgal, Jayapriya,, & Kumar, 2026). Biomarker-based assessment supports individualised approaches (Kumar, Gautam,, & Maitiy, 2026). Multimorbidity-aware care addresses concurrent conditions (Kumar, Sharma,, & Gupta, 2026; Yatish, Khatoon,, & Kumar, 2026).

4.3 Surgical and Acute Care Considerations

SCI patients often have substantial surgical histories including initial spinal stabilisation, subsequent reconstructive procedures, complication management (pressure injury reconstruction, spinal hardware revision), and procedures addressing acquired conditions. Preoperative risk stratification for SCI patients undergoing surgery requires explicit consideration of autonomic dysreflexia risk, respiratory limitations, altered drug handling, pressure injury prevention, and rehabilitation continuity (Gautam, Samyal,, & Chaudhary, 2026; Durgia, Kumar,, & Neha, 2026). Anaesthetic management with structured simulation training (Lal, Vaibhav,, & Khursheed, 2026; Bhatnagar, Tyagi,, & John, 2026). Enhanced recovery pathways adapted for SCI patients improve outcomes (Agarwal, Kumar,, & S, 2026). Infection prevention is critical given the elevated UTI, pressure injury, and respiratory infection rates (Agarwal, Khatoon,, & Kumar, 2026; Mishra, Choudhary,, & Kumar, 2026). Wound healing in SCI patients warrants specific attention given pressure injury physiology (Singhal, Kumar,, & Kataria, 2026). Critical care protocols address SCI-specific complications (Kumar, Kumar,, & Dhabhai, 2026; Ahluwalia, Gupta,, & Chaudhary, 2026). Multimodal analgesia approaches address neuropathic pain components common in SCI (Jagar, Kumar,, & Yadav, 2026). Minimally invasive surgical techniques where applicable (Kumar, Kumar,, & Tomer, 2026). For orthopaedic procedures (limb fractures, joint contractures, spinal hardware revision), structured care is essential (Singh, Chauhan,, & Kumar, 2026; Agarwal, Khatoon,, & Kumar, 2026; Durgia, Kumar,, & Neha, 2026). Bone health considerations apply substantially given SCI-associated osteoporosis (Sahu, Sharma,, & Gupta, 2026; Gupta, Gautam,, & Maitiy, 2026; Rani, & Tyagi, 2026).

4.4 Mental Health and Psychosocial Dimensions

Mental health dimensions are central to SCI recovery and adaptation. Depression affected 31% of our cohort at baseline; untreated depression was a substantial predictor of poor outcome (OR 0.36). Structured mental health support including screening, evidence-based pharmacotherapy, psychological intervention, and peer support addresses this dimension (Sharma, Sharma,, & Tyagi, 2026; Aumose, & Raj, 2026). For SCI survivors and their families, structured engagement addresses substantial family system changes — role redistribution, caregiver burden, couple/sexual adjustment, financial impact, and broader social participation changes (Ashifa, 2022; Rasi, & Ashifa, 2019; Natarajan et al., 2026; Catherine, Gupta, Gopi,, & Swadhi, 2025; Swadhi, Gayathri, Suresh, Catherine,, & Velmurugan, 2025; Vettriselvan, Ramya, et al., 2026). For elderly couples or family pairs affected by SCI, dyadic care approaches recognise the broader family system. For young SCI survivors (the majority of our cohort), age-appropriate engagement addresses the substantial life trajectory implications (Aumose, & Raj, 2026; Mustafa et al., 2026; Zahoor et al., 2025). Self-leadership and emotional intelligence development support adaptation and identity reformation (Mustafa et al., 2026; Zahoor et al., 2025).

4.5 Adaptive Technology and Equipment

Adaptive equipment is foundational to sport participation. Sport-specific wheelchairs (for basketball, tennis, rugby), hand cycles, racing chairs, sit-skis, sled hockey sleds, and other adaptive technology require substantial investment but produce substantial functional and participation benefits (Natarajan et al., 2026; Pavithra et al., 2026; Suresh et al., 2026). Equipment provision was a strong modifiable predictor of outcomes (OR 3.16) — supporting investment in adaptive equipment programmes through government schemes, NGO partnerships, and sponsorship arrangements (Jenifer et al., 2025; Vettriselvan, 2025; Vijayalakshmi et al., 2025). Advanced rehabilitation and motion-control technologies — including increasingly sophisticated powered devices, neuroprosthetics, and assistive robotics — extend functional capacity (Pavithra et al., 2026; Suresh et al., 2026). Virtual reality applications support skill acquisition and engaging exercise (Vinodh, & Subramani, 2026).

4.6 Equity and Access Considerations

Transportation access (OR 0.32 for poor outcome if limited) emerged as a substantial structural barrier. For rural patients and those in cities without dedicated adaptive sport facilities, structured transportation support vans, scheduled pick-ups, financial assistance for fuel/fare addresses this barrier (Jenifer et al., 2025; Vettriselvan, 2025; Vijayalakshmi et al., 2025). For lower-income patients, government scheme coverage and philanthropic support address equipment and training cost barriers. Programme design incorporating both competitive and recreational tracks extends access to patients with varying interest levels and aspirations. For women SCI patients (only 22% of our cohort, reflecting broader injury patterns), specific outreach and programming addresses participation gaps.

4.7 Digital Health and Implementation

Digital health tools support adaptive sport engagement. Wearable monitoring of activity, heart rate, and training metrics provides objective data (Deepa et al., 2026). Patient-facing apps for training tracking, exercise instruction, and peer community building support engagement (Deepa et al., 2026; Catherine, Gupta, Gopi,, & Swadhi, 2025; Swadhi, Gayathri, Suresh, Catherine,, & Velmurugan, 2025). Tele-rehabilitation extends specialist reach particularly for distant patients (Vijayalakshmi et al., 2025; Vinodh, Subramani,, & Vettriselvan, 2026). AI-supported decision tools assist with sport selection and personalised training prescription (Devi et al., 2025; Shanthi et al., 2025; Jha, Kumar,, & Neha, 2026). Digital twin frameworks model individual fitness trajectories (Subramani, Chillagattu, et al., 2026; Pradeepa et al., 2026). Cyber-physical infrastructure supports adaptive equipment maintenance and logistics (Catherine, Nasrin Sulthana, et al., 2026). AI ethics and governance frameworks address sensitive disability data (Selvi et al., 2026). Mindful technology use complements human coaching relationships (Vettriselvan, Velmurugan, et al., 2025).

4.8 Limitations

Limitations include the single-centre tertiary rehabilitation setting which over-represents patients with access to comprehensive services; the substantial differential in engagement that may reflect motivation and capacity differences beyond purely operational factors; the 12-month follow-up which captures intermediate outcomes but not long-term participation trajectories; the limited representation of women SCI patients and those with severe tetraplegia requiring ventilatory support; and the inability to definitively isolate adaptive sport effects from broader comprehensive rehabilitation engagement. Selection bias toward patients capable of and interested in sport participation may not represent the broader SCI population.

V. Conclusion

Adaptive sports engagement produced substantial benefits across multiple outcome domains in this 12-month cohort of 218 SCI survivors. Largest effect sizes were observed in cardiorespiratory fitness, community participation, strength, and psychological wellbeing (Cohen's d 1.2-1.6). Training hours showed strong dose-response relationship with SCI-QOL improvement ($r = 0.54$). Strongest predictors of community participation improvement included high training engagement, group-based sport, earlier post-injury engagement, incomplete SCI, adaptive equipment provision, and family/peer support. Transportation barriers, untreated depression, and severe chronic pain were associated with worse outcomes. The findings support sustained investment in adaptive sports infrastructure, equipment provision, transportation support, and integrated rehabilitation programmes as core components of comprehensive SCI care.

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