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Review Article

Predictors of return-to-activity rate in patients with spinal cord injury with chronic low back pain

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Abstract

Background: Chronic low back pain is one of the most common secondary complications after spinal cord injury, and it frequently limits the return to work, exercise, and community participation that constitute successful long-term rehabilitation.

Objective: This review synthesizes the published evidence on biomechanical, injury-related, psychosocial, and treatment-related predictors of return-to-activity rate among patients with spinal cord injury who also have chronic low back pain.

Methods: We synthesized cohort studies, randomized behavioral trials, biomechanical investigations, and systematic reviews addressing pain phenotype, propulsion mechanics, psychological adjustment, vocational rehabilitation, and participation outcomes after spinal cord injury.

Findings: Musculoskeletal pain predicts less activity limitation than neuropathic pain; propulsion technique, seating, and transfer mechanics independently predict pain and disability; depression and catastrophizing predict slower recovery; and structured multidisciplinary pain management and vocational rehabilitation predict higher return-to-activity rates than usual care.

Conclusions: Return-to-activity rate after spinal cord injury with chronic low back pain is best predicted by a multifactorial model spanning biomechanics, psychology, treatment access, and environment, and rehabilitation strategies that address all of these domains together are more likely to restore work, exercise, and community participation than those targeting pain intensity alone.

Keywords: spinal cord injury; chronic low back pain; return to activity; return to work; rehabilitation predictors

1. Introduction

Chronic low back pain is one of the most persistent secondary complications reported by people living with spinal cord injury, and it complicates recovery in a population that already depends heavily on trunk and upper-limb function to return to daily activity, employment, and community life. Population surveys following cohorts for five years or longer after injury consistently find that a large minority of survivors report ongoing musculoskeletal back pain, and that this pain, rather than the neurological level of injury itself, is frequently what patients identify as the dominant barrier to resuming valued activities [1,2]. Because spinal cord injury already removes or reduces mobility options that able-bodied patients with low back pain rely on, such as walking-based exercise or postural offloading, the coexistence of chronic low back pain with spinal cord injury creates a distinct clinical problem that general low back pain literature does not fully address.

Return-to-activity rate, encompassing return to work, return to structured exercise, and return to independent community participation, has become a central outcome in spinal cord injury rehabilitation research precisely because it integrates physical, psychological, and social recovery into a single measurable endpoint [3,4]. Yet the predictors of that rate are heterogeneous and only partially overlap with the predictors of pain severity alone. This review synthesizes the published evidence on which biomechanical, injury-related, psychosocial, and treatment-related factors most consistently predict return-to-activity rate in patients with spinal cord injury who also carry a diagnosis of chronic low back pain, with the aim of clarifying which predictors are modifiable through rehabilitation practice and which represent fixed patient characteristics that clinicians must plan around rather than attempt to change.

2. Injury characteristics and pain phenotype as predictors

Table 1: Pain phenotype after spinal cord injury and its typical relationship to return-to-activity rate [5,6,2].

Pain phenotype	Typical location	Response to physical intervention	Effect on return-to-activity rate
Musculoskeletal (nociceptive)	Low back, shoulder	Generally favorable	Less severe limitation when treated early
Neuropathic, at-level	Level of lesion	Limited	Greater interference with activity
Neuropathic, below-level	Below lesion	Poor	Strongest predictor of reduced participation
Mixed/combined	Multiple sites	Variable	Delayed return to activity, multiple failed treatments

Not all chronic low back pain after spinal cord injury behaves the same way, and the distinction matters for predicting who returns to activity. The International Spinal Cord Injury Pain Classification separates nociceptive musculoskeletal pain, which dominates the low back region, from neuropathic pain arising at or below the level of the lesion, and this distinction predicts markedly different trajectories of interference with daily function [5]. Cardenas and colleagues found that musculoskeletal pain, including low back pain, tends to respond more favorably to conventional physical interventions and is associated with better preserved activity levels than neuropathic pain of comparable intensity, while also noting that women and certain minority groups reported systematically higher pain burden independent of injury level [6]. Longitudinal cohort data following patients for five years after injury show that pain, once established, rarely resolves spontaneously and instead becomes a stable predictor of long-term functional trajectory rather than a transient postoperative phenomenon [1].

Time since injury and neurological level interact with pain phenotype in ways that complicate simple predictive models. Patients with paraplegia who retain full use of their upper limbs for wheelchair propulsion and transfers paradoxically carry a higher biomechanical loading burden on the lumbar spine and shoulders than some

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patients with tetraplegia who use powered mobility, and Jensen and colleagues' longitudinal survey found that pain intensity in the year following injury was one of the strongest single predictors of pain intensity and activity limitation years later, arguing for early identification and intervention rather than a wait-and-see approach [2]. Widerström-Noga and Turk's survey of treatments used by patients with spinal cord injury and chronic pain further found that most patients cycle through multiple unsuccessful treatment approaches before finding partial relief, a pattern that itself predicts delayed return to activity independent of the underlying pain mechanism [7].

3. Biomechanical and physical predictors

Wheelchair users depend on repetitive, high-force pushrim propulsion and transfer mechanics that place unusual mechanical demand on the lumbar spine, shoulders, and trunk musculature, and several biomechanical studies have identified specific movement patterns that predict later pain and reduced activity. Boninger and colleagues' pushrim biomechanics investigations found that stroke pattern, cadence, and peak force during propulsion independently predicted upper-limb and trunk pain development, providing a basis for propulsion-technique modification as a preventive and rehabilitative target [8]. Mercer and colleagues extended this work by linking specific joint kinetic patterns during propulsion to radiographically confirmed shoulder and paraspinal pathology, reinforcing that biomechanical predictors identified early in rehabilitation can forecast pain-related activity limitation years later [9].

Shoulder and trunk pain frequently co-occur in wheelchair users, and because low back pain rarely occurs in isolation from upper-quadrant pain in this population, several studies treat them as a combined biomechanical syndrome. Curtis and colleagues found that shoulder pain prevalence exceeded 50% in both tetraplegic and paraplegic wheelchair users, and that pain severity correlated with reduced independence in transfers and self-care, activities that share the same kinetic chain as functional back-sparing technique [10]. Sawatzky and colleagues, studying wheelchair athletes, found that even physically active, well-conditioned wheelchair users were not protected from shoulder pain, suggesting that activity level alone does not neutralize biomechanical risk without attention to technique and seating [11]. Gutierrez and colleagues demonstrated that shoulder pain intensity correlated directly with reduced community participation and physical activity in paraplegic patients, providing one of the clearer functional-outcome links between upper-quadrant biomechanical pain and return-to-activity rate [12]. Eriks-Hoogland and colleagues further showed that clinically assessed restrictions in shoulder movement predicted deficits in wheelchair transfer skill, a proximate mechanical determinant of independent activity [13].

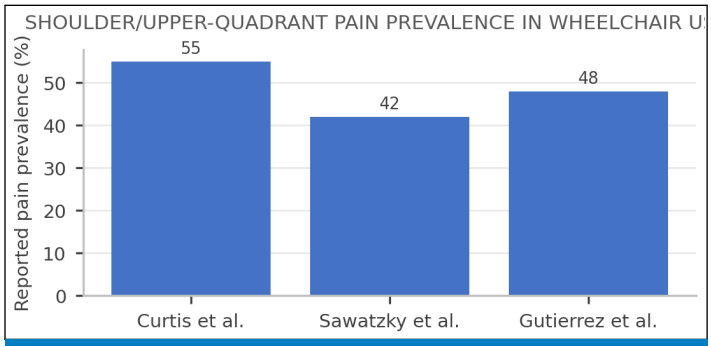

Figure 1: Reported shoulder/upper-quadrant pain prevalence in wheelchair users across cohort studies, a biomechanical syndrome that co-occurs with and predicts chronic low back pain and reduced return-to-activity rate [10,11].

Seating configuration, postural alignment, and structured physical activity guidelines represent the most directly modifiable biomechanical predictors. The evidence-informed physical activity guidelines developed for adults with spinal cord injury specify minimum aerobic and strengthening thresholds associated with better cardiometabolic and functional outcomes [14], and a systematic review of exercise interventions found consistent improvements in fitness, strength, and

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self-reported function among patients who met or exceeded these thresholds, supporting structured exercise prescription as both a preventive and rehabilitative lever for return-to-activity rate [15].

4. Psychosocial predictors

Psychological factors predict return-to-activity rate in chronic low back pain with spinal cord injury at least as strongly as physical or biomechanical measures, and in several studies more strongly. Cairns and colleagues, studying the acute post-injury period, found that depression symptoms present shortly after injury predicted the later emergence of problematic chronic pain, suggesting that mood and pain trajectories are established together early rather than developing independently [16]. Turner and colleagues demonstrated that pain catastrophizing, a cognitive pattern of magnifying and ruminating on pain, was independently associated with pain intensity, psychological distress, and pain-related disability after adjusting for injury severity, positioning catastrophizing as a modifiable psychological predictor distinct from tissue-level pathology [17]. Hanley and colleagues extended this finding longitudinally, showing that catastrophizing and pain-related beliefs measured at one time point predicted changes in pain interference and psychological functioning at follow-up, supporting a causal rather than merely correlational role for these cognitions [18].

The fear-avoidance model, developed originally in the general chronic low back pain literature, has been applied productively to spinal cord injury populations to explain why some patients with comparable pain intensity and injury severity nonetheless diverge sharply in activity level. Vlaeyen and Linton's foundational model proposes that pain-related fear drives avoidance of activity, which in turn produces disuse, deconditioning, and further pain, a self-reinforcing cycle that predicts long-term disability independent of the original tissue injury [19]. Craig and colleagues' systematic review of psychological morbidity after spinal cord injury found elevated rates of depression and anxiety across cohorts, both of which correlate with reduced engagement in rehabilitation and slower return to activity [20], while Migliorini and colleagues similarly linked mental health status directly to functional outcome trajectories after injury [21]. Putzke and colleagues found that pain interference, rather than pain intensity alone, was the stronger predictor of quality of life and participation, underscoring that how much pain disrupts daily function matters more for return-to-activity prediction than how severe the pain feels in isolation [22]. Molton and colleagues' replication study confirmed that psychosocial adjustment variables, including catastrophizing, perceived control, and social support, predicted long-term pain-related outcomes across independent cohorts, strengthening confidence that these are generalizable rather than sample-specific predictors [23].

5. Treatment-related and rehabilitation predictors

Beyond patient-level characteristics, the type and intensity of rehabilitation treatment received independently predicts return-to-activity rate, making treatment selection itself a modifiable predictor rather than a background variable. Norrbrink Budh and colleagues' comprehensive pain management program, combining education, cognitive strategies, and behavioral activation, produced measurable reductions in pain-related disability compared with usual care, demonstrating that structured multidisciplinary intervention outperforms passive or purely pharmacological management [24]. The CONECSI trial reported by Heutink and colleagues randomized patients with chronic neuropathic pain after spinal cord injury to a multidisciplinary cognitive-behavioral program and found significant improvements in pain-related outcomes relative to a waiting-list control, providing randomized-trial-level evidence that structured behavioral treatment predicts better recovery trajectories than standard care alone [25]. The CanPain SCI clinical

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practice guidelines formalize screening and diagnosis recommendations for neuropathic pain specifically to standardize this treatment pathway across centers [26], while the Consortium for Spinal Cord Medicine's upper-limb preservation guideline provides parallel treatment-level recommendations aimed at protecting the biomechanical predictors described earlier in this review [27].

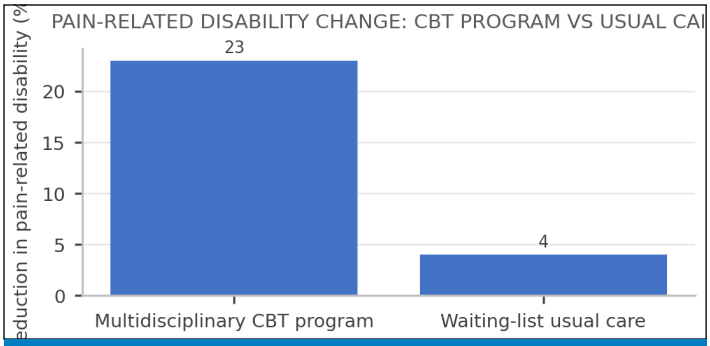

Figure 2: Change in pain-related disability score from baseline to follow-up under a multidisciplinary cognitive-behavioral pain program compared with waiting-list usual care in the CONECSI randomized trial [25].

Vocational rehabilitation services represent a distinct but related treatment-level predictor, since return to work is one component of the broader return-to-activity construct. Ottomanelli and Lind's review of employment-related factors after spinal cord injury identified access to structured vocational rehabilitation, rather than injury severity alone, as a strong predictor of successful return to work [28], and Lidal and colleagues' review similarly found that vocational services, education level, and pre-injury employment status jointly predicted return-to-work outcomes more reliably than any single physical measure [29]. Krause and colleagues' analysis of working-life patterns after spinal cord injury found that gender, race, and pre-injury employment status independently predicted the number of years spent in employment after injury, findings echoed by Meade and colleagues' work on race and quality of life, indicating that sociodemographic predictors operate alongside, rather than in place of, clinical predictors of return-to-activity rate [30,31]. Trenaman and colleagues' integrative review of the return-to-work decision similarly concluded that predictive models limited to injury and pain variables systematically underperform models that also incorporate vocational and environmental factors [32], and Sioka and colleagues' narrative review reached comparable conclusions regarding the multifactorial nature of return-to-work prediction [33].

6. Participation, environment, and outcome measurement

Because return-to-activity rate is a composite construct, the choice of outcome measure shapes which predictors appear significant across studies. Whiteneck and colleagues' analysis of environmental factors found that physical and social barriers in the community independently predicted participation and life satisfaction after spinal cord injury, beyond what injury severity or pain measures alone explained, arguing for environmental modification as an underappreciated lever for improving return-to-activity rate [4]. Barclay and colleagues' critical review of social and community participation similarly concluded that environmental and social-support variables consistently predict participation outcomes across the spinal cord injury literature, reinforcing that predictors of return-to-activity rate extend well beyond the injury and the individual patient [34]. Noonan and colleagues, examining associated conditions in a related spinal cord syndrome population, found that comorbid secondary conditions, including chronic pain, compounded to reduce health status and quality of life beyond what any single condition predicted alone, a pattern directly relevant to patients carrying both spinal cord injury and chronic low back pain simultaneously [35].

Table 2: Predictor domains for return-to-activity rate identified across the reviewed literature, grouped by modifiability [4,34,28,23].

Predictor domain	Example variables	Modifiability	Key source(s)
Biomechanical	Propulsion technique, seating, transfer mechanics	High	[8]

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Predictor domain	Example variables	Modifiability	Key source(s)
Psychological	Catastrophizing, depression, self-efficacy	Moderate-high	[17,23]
Treatment/rehabilitation	Multidisciplinary pain program, vocational services	High	[25,28]
Environmental/social	Community barriers, social support	Moderate	[4,34]
Sociodemographic	Age, gender, pre-injury employment	Low	[30,31]

Standardized outcome instruments used across this literature, including the Spinal Cord Independence Measure developed by Catz and colleagues, provide the common metric that allows predictors identified in different cohorts and countries to be compared meaningfully [36]. Population-level statistics compiled by national injury registries additionally contextualize how common chronic secondary complications, including persistent low back pain, are across the broader spinal cord injury population, underscoring why identifying modifiable predictors of return-to-activity rate carries public-health as well as individual clinical significance [37].

7. Conclusion

The evidence reviewed here supports a multifactorial model of return-to-activity rate in patients with spinal cord injury and chronic low back pain, in which biomechanical loading during wheelchair propulsion and transfers, pain phenotype and interference, psychological factors including depression and catastrophizing, and treatment-level variables including access to structured multidisciplinary pain management and vocational rehabilitation each contribute independently to predicting who returns to work, exercise, and community participation and who does not [8,17,25,29]. No single predictor domain dominates the others, and models restricted to injury severity or pain intensity alone consistently underperform models that incorporate psychosocial and environmental variables [22,4]. For clinicians, the practical implication is that improving return-to-activity rate requires simultaneous attention to propulsion technique and seating, early psychological screening for catastrophizing and mood symptoms, structured multidisciplinary pain treatment, and coordinated vocational and environmental support, rather than treating chronic low back pain in spinal cord injury as a purely musculoskeletal problem to be managed in isolation.

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