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Cluster Analysis and Chronic Pain: An Empirical Classification of Pain Subgroups in a Spinal Cord Injury Sample

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Abstract

Objective—To demonstrate the presence of homogeneous spinal cord injury (SCI) pain subgroups.

Design—Prospective longitudinal design.

Participants—Persons with traumatic onset SCI (n = 1,334) with self-reported pain, pain interference, and depression.

Outcome Measures—Pain (Verbal Analogue Scale); Pain Interference (item from Short Form 12); Depression (Brief Patient Health Questionnaire).

Results—Multivariate clustering indicated four SCI pain subgroups: (1) Low Pain (low pain intensity, pain interference, and depression); (2) Positive Adaptation to Pain (high pain intensity, low pain interference and depression); (3) Minimal Distress (high pain intensity, high pain interference, and low depression); and (4) Chronic Pain Syndrome (high pain intensity, pain interference, and depression).

Conclusions—Homogeneous SCI pain subgroups may be important for clinicians to consider in treatment planning and research.

Keywords

Spinal cord injury; Pain; Rehabilitation; Treatment outcome

Spinal cord injury (SCI) frequently results in the permanent loss of sensory functioning, motor functioning, or both. Estimates indicate that there are about 250,000 persons with SCI in the United States, with at least 11,000 new cases of SCI occurring per year (Lasfargues et al, 1995; DeVivo, 2002). Current prevalence estimates indicate 11% to as high as 94% of individuals with SCI develop chronic pain (Davidoff, Roth, Guarracini, Sliwa, & Yarkony, 1987; Rintala, Loubser, Castro, Hart, & Fuhrer, 1998; Turner, Cardenas, Warm, & McClellan, 2001). Pain onset is frequently reported within 6 months following SCI (Burke,

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1973; Nepomuceno et al., 1979; Mariano, 1992; Siddall, Taylor, McClelland, Rutkowski, & Cousins, 1999), but it has also been documented hours, months, and even years after injury (Turner et al., 2001). Furthermore, reports of pain indicate that SCI-related pain persists throughout life (Britell & Mariano, 1991; Rose, Robinson, Ells, & Cole, 1988).

Unfortunately, SCI-related pain has been associated with greater disability (Richards et al., 1980), depression (Elliott & Frank, 1996; Cairns, Adkins, & Scott, 1996), interference with activities (Nepomuceno et al., 1979; Putzke, Richards, & DeVivo, 2001), and familial and social difficulties (Richards et al., 1980; Summers et al., 1991), as well as decreased quality of life (Anke, 1995; Putzke, Richards, & DeVivo, 2001; Putzke, Richards, Hicken, & DeVivo, 2002).

Effective treatments for chronic pain for persons with SCI are lacking. Recent reports on the efficacy and satisfaction with current treatments suggest that many persons do not perceive current treatments as particularly effective or satisfactory (Ravenscroft, Ahmed, & Burnside, 2000; Murphy & Reid, 2001; Warm, Turner, Marshall, & Cardenas, 2002). However, a primary reason for poor treatment outcomes may be that pain is a multidimensional problem interfering with a host of domains, including physical, psychological, social, and environmental domains. Therefore, a unidimensional approach to pain management may be inadequate for such a broad range of heterogeneous complaints.

Several chronic pain researchers have recognized the problem of heterogeneity among chronic pain populations regardless of etiology. Based on characteristics associated with pain, some researchers have utilized clustering methodology to better understand the multidimensional nature of pain. For example, studies have been performed for classification of chronic pain subgroups in non-SCI samples on the basis of pain behaviors (Keefe et al., 1990), personality dimensions (Bradley et al., 1978; Bradley & Van der Heide, 1984; Rappaport, McNulty, Waggoner, & Brantley, 1987), and stages of change in pain management (Keefe et al., 2000). Other studies have established a diagnostic taxonomy of persons with chronic pain (Turk & Rudy, 1987, 1988) and evaluated pain treatment outcomes through clustering methods (Swimmer et al., 1992; Sanders et al., 1993; Talo et al., 2001). Multivariate clustering methods provide empirical support for the existence of homogeneous groups within the same population by aggregating or 'clustering' individuals according to their 'nearness' to each other on multiple dimensions. However, multivariate clustering techniques have never been utilized for the empirical classification of persons with chronic pain into subgroups in a population already suffering from a severe disability (for example, SCI) who require the implementation of effective interventions.

Cross-sectional and longitudinal research provides evidence for health-related stressors, such as pain, increasing the likelihood of activity interference, which in turn, predicts subsequent elevations in depressive symptoms (Williamson & Schultz, 1995; Williamson, 2000). This has been observed among persons with chronic pain associated with arthritis (Katz & Yelin, 1994; Hays et al., 1995), diabetes (Hays et al., 1995), cancer (Williamson, 2000), and low back conditions (Rudy, Turk, & Kerns, 1988). Moreover, pain has been consistently associated with activity interference and depression in comparisons between individuals with SCI with and without pain (Nepomuceno et al., 1979; Richards et al., 1982; Elliott & Harkins, 1991; Cairns et al., 1996). These three domains represent a cluster

of factors well-suited for the development of pain subgroups. For example, Klapow et al. (1993) presented evidence supporting an empirical classification of persons with chronic low back pain (CLBP) using scores from the McGill Pain Questionnaire (MPQ; Melzack, 1975), Sickness Impact Profile (SIP; Gilson et al., 1975), and Beck Depression Inventory (BDI; Beck et al., 1961). Using hierarchical cluster analysis, they reliably identified three distinct profiles of persons with CLBP who were classified as having a 'Chronic Pain Syndrome,' 'Good Pain Control,' or 'Positive Adaptation to Pain.' The largest subgroup, good pain control, represented persons with CLBP (N = 47) reporting low levels of pain, impairment, and depression. About the same number of persons with CLBP (N = 25) reporting high levels of pain, impairment, and depression were classified as having a chronic pain syndrome, while persons with CLBP (N = 24) reporting high levels of pain and low levels of impairment and depression were classified as having positive adaptation to pain. Klapow and colleagues' classification of pain subgroups appear applicable to the SCI pain population. For this study, however, the subgroup classified as 'Good Pain Control' was changed to 'Low Pain' to better describe persons with low levels of pain and not to infer that their pain is any less problematic.

Previous studies have never investigated an empirical classification of SCI pain subgroups based upon cluster analytic methodology. However, it seems clinically useful for the development of focused interventions to examine the relationship between pain intensity, pain interference, and depression in the context of cluster analytic methodology in this population. As indicated by Elliott and Frank (1996), the term "depression" is often interchangeably used to refer to a formal diagnosis of Major Depressive Disorder (MDD) and symptoms of depressive symptoms. The present study uses the term "depression" to refer to the severity of depressive symptoms rather than MDD. Using alternative measures representing similar constructs (pain intensity, pain interference, and depression) in a chronic SCI pain sample, this study proposes to replicate and extend the work begun by Klapow and colleagues (1993). Based on measures of pain intensity, pain interference, and depression, the present study uses multivariate clustering procedures to examine the existence of homogeneous SCI pain subgroups. Three homogeneous SCI pain subgroups, including low pain (low levels of pain intensity, pain interference, and depression), positive adaptation to pain (high levels of pain intensity, low levels of pain interference and depression), and chronic pain syndrome (high levels of pain intensity, pain interference, and depression) are proposed to be present in a chronic SCI pain sample. Thus, the primary objective of this study is to identify pain subgroups in a chronic SCI pain sample.

Methods

Data Collection and the Study Sample

Data collected for the present study came from SCI individuals admitted into one of the 16 funded Department of Education Model Spinal Cord Injury Systems of Care across the United States, which provide data to the National Spinal Cord Injury Statistical Center (NSCISC) database at the University of Alabama at Birmingham. The NSCISC database primarily includes those with traumatic SCI who were admitted into one of the Model Systems within 60 days of injury. Data collection currently occurs for Years 1, 5, 10 post-

injury, and every 5 years thereafter. A broad range of information is collected, including demographics, medical and physical aspects of injury, and psychosocial factors, as well as acute care, rehabilitation experiences, and treatment outcomes (DeVivo, Go, & Jackson, 2002; Stover, DeVivo, & Go, 1999). All measures are self-report collected typically by telephone by trained data collectors from each Model System site, or in person in a small percentage of cases during follow-up examinations.

For the present study, an item from the Medical Outcomes Survey Short Form (SF)-12 was chosen a priori as the primary pain interference measure. Study participants were excluded from the present study if they did not complete or endorse the SF-12, as well as provide complete data on other measures during the follow-up evaluation. Only those participants who were at least 2 years post-injury were included to eliminate early adjustment factors on depression.

Study Sample

Among 2,380 SCI individuals, 1,969 potential sample members endorsed having pain during the past 4 weeks prior to the follow-up evaluation. After eliminating respondents with incomplete scores on pain interference and depression measures, the final sample consisted of 1,334 persons with SCI. Participants ranged in age from 10 to 88 years ($M = 29.3$; $SD = 11.6$ years) at time of injury and 20 to 90 years ($M = 44.5$; $SD = 11.9$) at follow-up. Seventy-nine percent were male and predominantly Caucasian (82%), with 15% of the sample being African American. The majority of participants were single (54%) compared to those married (33%) or divorced (8%) at injury with an observable increase in divorce (20%) at follow-up. Study participants reported completion of high school (57% at injury and 51% at follow-up) and more than high school (14.9% at injury and 38% at follow-up). The most common cause of SCI was motor vehicle accidents (51%). Approximately half had paraplegia and half had tetraplegia. Fifty-six percent were reported to have complete injuries.

Measures

Sociodemographic Characteristics—Sociodemographic characteristics included age (at injury and follow-up), gender, race, traumatic etiology, marital status (at injury and follow-up), education (at injury and follow-up), and occupational status. Traumatic etiology of SCI was separated into five categories (e.g., vehicular, violence, sports, falls/flying objects, and other).

Impairment—Impairment was assessed in accordance with the International Standards for Neurological Classification of Spinal Cord Injury (American Spinal Injury Association, 1996). The study sample was divided into two categories to represent level of lesion (e.g., paraplegia and tetraplegia) and further subdivided to represent complete and incomplete injuries.

Pain Intensity—The Numerical Rating Scale (NRS; Jensen, Karoly, & Braver, 1986) provides a subjective estimate of overall pain intensity, which can be administered using a telephone. Respondents were asked to evaluate their typical level of pain intensity during the

past 4 weeks on a 0 to 10 scale with “10 being pain so severe you could not stand it” and “0 being no pain.” Although validity coefficients are not available for the measures of pain intensity and pain interference, previous research has found support for the stability and construct validity of these scales (Cardenas, Bryce, Shem, Richards, & Elhefni, 2004).

Pain Interference—A single item from the Medical Outcomes Survey Short Form 12 (MOS SF-12; Ware, Kosinski, & Keller, 1995) of the MOS SF-36 assessed the impact of pain on behavior. Specifically, the pain item measures pain interference with work inside and outside the home, “During the past 4 weeks, how much did pain interfere with your normal work including both work outside the home and housework?” All responses are recorded on a 5-point Likert scale ranging from ‘not at all’ to ‘extremely’. If the respondent does not work inside or outside the home, they are asked, “During the past 4 weeks, how much did pain interfere with your usual activities?”

Severity of Depression—The Brief Patient Health Questionnaire (BPHQ; Spitzer, Kroenke, & Williams, 1999) is a self-report measure designed to assess the presence and severity of depressive symptoms. The BPHQ (or PHQ-9) consists of ten items assessing a variety of depressive symptoms, including lack of interest or pleasure in activities, decreased mood, sleeplessness, tired or lack of energy, poor appetite or overeating, negative self-evaluation, lack of concentration, lethargy or restlessness, suicidal ideation or other self-destructive behavior, and depressive symptom interference with home, work, or social roles, over the last 2 weeks. Besides evaluating the severity of depressive symptoms, a summation score is derived that correlates with the Diagnostic and Statistical Manual of Mental Disorders (DSM) for a diagnosis of Major Depressive Syndrome. Overall, the BPHQ has shown good internal consistency (Cronbach $\alpha = .87$) among persons with SCI, with generally strong item scale correlations (Bombardier, Richards, Krause, Tulsky, & Tate, 2004). Construct validity was also demonstrated through significant relationships with satisfaction with life and subjective health, as well as greater difficulty in daily role functioning among persons with SCI.

Statistical Procedures

Statistical analyses were performed using the SPSS for Windows Version 11.5 statistical package (SSPS Inc., Chicago, IL). Descriptive statistics (means, standard deviations, ranges, frequencies, percentages) were calculated for the relevant variables. One-way analyses of variance (ANOVAs) were conducted between study participants with missing and non-missing data to determine if the sample was representative of individuals in the NSCISC database. Chi-square (χ^2) analyses were utilized to determine group differences on gender, race, marital status, traumatic etiology, as well as level and completeness of injury.

Pearson product-moment correlations were performed to determine relationships between pain intensity, pain interference, and depression. Based on scores of pain intensity, pain interference, and depression, Ward’s method, a hierarchical clustering procedure, was used to determine the number of clusters within the study sample (Ward, 1963). K-means clustering, a non-hierarchical clustering procedure, was performed to assign individuals to clusters once the number of clusters was established (Engelman & Hartigan, 1981). It has

been suggested that the normal distribution of variables does not always demonstrate the presence of multiple subgroups within a population (Morris & Fletcher, 1988). Consequently, standard scores (Z scores) were calculated on the total scores of the three outcome variables (pain intensity, pain interference, and depression) to control for scaling differences on each outcome measure.

A primary challenge that must be addressed when performing any cluster analysis involves the determination of the correct number of clusters. However, it has been suggested that the number of clusters can be determined from the progression of distances following the formation of clusters (Morey et al., 1983, as cited in Jamison et al., 1988). The first step in hierarchical cluster analysis involves establishing distance patterns from observations (Ward, 1963). Ward's method generates a series of clusters that represent homogeneous subgroups through sequential aggregation of similar characteristics obtained from psychometric measures. Thus, Ward's method was used to compute distance patterns and determine the appropriate number of clusters for the K-means clustering procedure.

K-means clustering was performed for the classification of cluster subgroups. The K-means clustering procedure uses a nonhierarchical, partitioning method of clustering that compares subjects from each cluster and reassigns incorrect assignments of subjects to a more suitable cluster, thereby decreasing within-cluster variance and increasing between-cluster variance (Hartigan, 1975; Morris et al., 1981). Specifically, the K-means clustering procedure clusters cases based on Euclidian distance between each case and the mean of cases in each cluster. Based on predetermined clusters, this procedure computes new means for each cluster and cases are reassigned based on closeness to derived cluster centers. Cases are assigned iteratively based on initial starting values of the predetermined cluster solution. During the partitioning procedure, incorrect or misclassified cases are reassigned through consecutive iterations for a more accurate cluster assignment. If the cluster solution is stable, then few changes should be observed between the initial and final cluster centers. Thus, the initial and final cluster centers were examined to determine the stability of the cluster solution.

Several statistical tests were used to provide evidence for the robustness, consistency, and validity of the hypothesized pain subgroups in the SCI population. The total sample was divided into a split-half random sample. K-means clustering was used with the two subsamples to determine the presence of similar cluster subgroups from previous analyses. T-tests were used to assess possible differences on the outcome measures between the two subsamples. A one-way ANOVA was used to compare measures of pain intensity, pain interference, and depression across the SCI pain subgroups.

A TwoStep Cluster procedure (using Schwarz's Bayesian Information Criterion and Akaike's Information Criterion) was also performed to compute Euclidian distance patterns and demonstrate the maximum number of clusters. K-means was performed for the classification of the SCI pain subgroups. Since the K-means clustering procedure is non-parametric, it does not require that variables have a multivariate normal distribution. As an additional step to verify the discriminant validity of the clusters and their centers, the total sample was again divided into random split-half samples. The TwoStep clustering procedure was used

with the two subsamples to determine the optimal cluster solution and examine values for cluster means.

Results

Demographic Characteristics and Relationships Between Variables

A preliminary analysis was performed between study participants with missing and non-missing data to determine if the sample was representative of individuals in the NSCISC database who experience chronic pain. Comparisons were based on age, gender, race, marital status, education, traumatic etiology, and level and completeness of injury (Table 1). The study sample was similar with respect to gender and level and completeness of injury compared to those who were not included in subsequent analyses ($p > .05$). Study participants, however, were significantly different with respect to age ($F[1, 1967] = 5.80, p < .05$), race ($\chi^2[2] = 24.03, p < .001$), marital status ($\chi^2[4] = 84.33, p < .001$), education ($\chi^2[2] = 40.16, p < .001$), and traumatic etiology ($\chi^2[4] = 23.57, p < .001$). The study sample was disproportionate with regard to race and traumatic etiology; that is, fewer African Americans and individuals reporting violence as cause of injury were represented in the study sample. Study participants were also more likely to have a higher level of education than those excluded from the study. Therefore, there were some differences in the samples, possibly related to whether or not the participant or potential participant was from the majority culture, or to measures indicating lifestyle differences.

Pearson product-moment correlations were undertaken to examine possible relationships between pain, pain interference, and depression. A significant positive relationship was revealed between pain intensity and depressive symptoms ($r = .31, p < .001$) suggesting that greater pain is associated with elevated depressive symptoms. As one might expect, results also indicated a significant relationship between pain intensity and pain interference ($r = .56, p < .001$), and greater pain interference was related to elevated depressive symptoms ($r = .43, p < .001$). Thus, results indicated a strong relationship between these three dimensions with considerable shared variance.

Description and Characteristics of SCI Cluster Profiles

Standard score means were calculated for measures of pain, pain interference, and depression (Figure 1). Both the K-means clustering procedure and Ward's method supported a four-cluster solution. Cluster 1 represented SCI individuals ($N = 528$) termed 'Low Pain' who reported low levels of pain intensity, pain interference, and depression. Cluster 2 characterized SCI individuals ($N = 350$) with high levels of pain intensity, but low levels of pain interference and depression described as having 'Positive Adaptation to Pain.' Cluster 3 comprised SCI individuals ($N = 288$) with high levels of pain intensity and pain interference but low levels of depression, which were classified as having 'Minimal Distress.' Finally, Cluster 4 corresponded to SCI individuals ($N = 168$) with high levels of pain intensity, pain interference, and depression categorized as having a 'Chronic Pain Syndrome.'

As already mentioned, the K-means clustering procedure uses iterative partitioning to sharpen cluster assignments based on case similarities to cluster centroids. In the current

iterative procedure, few changes were observed and cluster solutions achieved stability at 5 iterations. The K-means clustering procedure generated subgroups that were consistent with cluster profiles from past research. Cluster groupings were of reasonable size and stable. However, results are not sufficient to conclude that the cluster subgroups are consistent, valid, or clinically meaningful in an SCI population. Thus, the cluster subgroups were evaluated with follow-up tests to address these concerns.

The study sample was divided into a random split-half sample for replication and validation of the accepted cluster subgroups. K-means clustering was performed on each subsample ($N = 667$) following the same process as described above (Figure 2). Clustering coefficients indicated that the four-cluster solution was the most homogeneous solution in each subsample. Consistent with previous results, the number of cluster solutions and characteristics corresponded with those in the total sample. T-tests showed no significant differences between the NRS, SF-12, and BPHQ. Consequently, results supported the robustness and validity of the overall sample cluster solution.

Means and standard errors for pain intensity, pain interference, and depression measures for SCI pain subgroups are shown in Table 2. Clustering procedures, like Ward's method, use algorithms to create cluster solutions that decrease within-cluster variance and increase between-cluster variance. If cluster groupings are true clusters, they should be present using multiple methods. A TwoStep Cluster procedure was performed to determine the maximum number of clusters. Both Schwarz's Bayesian Information Criterion and Akaike's Information Criterion indicated the presence of four clusters. K-means clustering was performed for the classification of the four clusters. When the TwoStep clustering procedure was also performed with random split-half samples, each subsample produced results consistent with a four-cluster solution being the optimal solution and produced similar values for cluster means.

Discussion

Consistent with previous research, significant relationships were found between pain, pain interference, and depression, respectively. The present study has also been successful in replicating Klapow and colleagues' (1993) empirical classification of homogeneous pain subgroups within another chronic pain population, specifically the SCI population. The following subgroups were present in the SCI population: (1) 'Low Pain' ($N = 528$; low levels of pain intensity, pain interference, and depression), 'Positive Adaptation to Pain' ($N = 350$; high levels of pain intensity with low levels of pain interference and depression), 'Chronic Pain Syndrome' ($N = 168$; high levels of pain intensity, pain interference, and depression). This finding lends support to the robustness of the chronic pain grouping characteristics proposed by Klapow et al. (1993). Unlike a CLBP population, however, another SCI pain group emerged referred to as 'Minimal Distress' ($N = 288$; high levels of pain intensity and pain interference with low levels of depression). One possible explanation for this finding may be that not all persons with pain and pain interference experience greater depressive symptoms. Indeed, some persons with pain intensity and pain interference may have better coping skills than their counterparts in the chronic pain syndrome group.

Tests of reliability and discrimination among SCI pain subgroups were positive. Clustering procedures on a random split-half sample supported the consistency of the four SCI pain subgroups. In addition, SCI pain subgroups could be discriminated reliably on the outcome measures. Thus, results support the reliability of the four SCI pain subgroups and discriminant differences between each subgroup.

Chronic pain has been recognized as a multidimensional experience involving biological, psychological, and social systems. Persons with chronic pain who have been diagnosed with similar pain syndromes often respond differently to identical interventions (Turk, 1999). A primary reason for poor treatment outcomes may be the fact that the pain experience involves a multitude of dimensions requiring comprehensive treatment planning for maximum effectiveness. Based on recent reports advocating better treatment alternatives (Ravenscroft, Ahmed, & Burnside, 2000) and negative reports concerning treatment satisfaction (Murphy & Reid, 2001), many individuals with SCI consider current treatments for SCI-related pain as ineffective and un-satisfactory. An empirical classification of SCI pain subgroups may be important for treatment planning. If a single pain population has multiple subgroups whose members share similar characteristics, we would probably anticipate different interventions for better response to treatment. However, the benefits of identifying homogeneous pain subgroups within chronic pain population's has yet to be understood and implemented in treatment planning for chronic pain. Such knowledge may be instrumental in research and guiding treatment selection. Among the SCI pain subgroups, for example, a greater understanding of chronic pain in the SCI population might be reached from thorough comparisons between SCI members in the low pain and chronic pain syndrome subgroups. A thorough examination of more adaptive SCI pain subgroups may provide insight into positive characteristics associated with better rehabilitative outcomes.

Focused intervention programs clearly have the potential to be more effective for health care consumers and less expensive for health care providers (Strong, Ashton, & Stewart, 1994). Cognitive and behavioral strategies, including education, distraction, relaxation training, imagery, problem-solving, coping self-statements, cognitive restructuring, activity scheduling, and verbal reinforcement, have gained recognition as possible treatments for pain management. We can only speculate about effective treatment alternatives for members of the different SCI pain subgroups. For example, persons with low pain, positive adaptation to pain, and minimal distress may not require extensive psychotherapy that targets depressive symptoms. If someone has low pain, treatment may not be necessary. Regardless, they may desire a treatment plan combining education and maintenance of coping skills to continue their low pain. After all, SCI-related pain has often been reported to continue throughout life (Rose et al., 1988), with remission occurring among only a few cases with early onset (Pollock, 1951 as cited in Britell & Mariano, 1991). Members of the positive adaptation to pain and minimal distress subgroups may require a greater emphasis on physical treatment (e.g., electrotherapy, massage therapy, hydrotherapy, neural therapy) rather than a primary psychotherapy or counseling approach. A member of the chronic pain syndrome group may benefit from a combination of pain-control strategies (e.g., pharmacotherapy, biofeedback, exercise, psychotherapy). Besides more focused intervention plans, treatment organization might also be enhanced to reach a larger number of SCI health care consumers for a fraction of the cost of alternative pain management approaches. For

example, the separation of SCI individuals into pain subgroups represents a novel organizational approach to pain management, specifically group therapy. However, intervention trials must be performed to determine the effectiveness of such treatment approaches.

Several important limitations should be considered when evaluating the results from the present study. A sampling bias may have been produced with the removal of participants with incomplete data from the study. A large percentage (32%) of the original participants reporting pain had missing information on a variety of measures and were excluded from the study. The study sample was not completely representative of individuals in the National SCI Database, which in turn, is essentially a nationwide convenience sample, not a population-based sample, and does not necessarily represent characteristics of the entire SCI population.

Although statistical methods are available for the estimation and replacement of missing values, only persons with complete data were considered for our analyses. Such methods are frequently the best choice for small samples when the loss of participants is not acceptable. For a large sample size, the elimination of SCI participants with missing values may be a lesser problem, which may actually reduce the likelihood of sampling bias. Considering the exploratory nature of the present study, we thought the simplest and best choice was to eliminate SCI individuals with incomplete data for a pure sample of chronic pain sufferers.

Chronic pain has been defined as pain existing for at least 6 months or longer. As already mentioned, pain intensity was assessed using the NRS at follow-up, which evaluates the duration of pain on a 0 to 10 scale over the past 4 weeks. As such, it might be argued that this may not be a chronic pain population. However, considerable evidence indicates that SCI-related pain does not relent after onset and persists throughout life (Britell & Mariano, 1991; Rose, Robinson, Ells, & Cole, 1988). Therefore, it seemed reasonable to consider the current sample as members of a chronic SCI pain population.

Like non-SCI pain conditions, chronic pain is clearly associated with pain interference and depression among persons with SCI. Based on measures of pain, pain interference, and depression, evidence supports the presence of distinguishable, homogeneous subgroups of persons with SCI suffering from pain, which may be important for clinicians to consider in pain management and research. Future research is required to learn more about the (a) generalization of SCI pain subgroups across samples (e.g., clinical and community-based SCI samples and heterogeneous pain conditions); (b) the contribution of physiological, psychological, and social factors in predicting group membership (e.g., etiology, coping, social support); and (c) health outcomes (e.g., treatment efficacy and health care consumption).

References

- Anke AG, Stenehjem AE, Stanghelle JK. Pain and life quality within 2 years of spinal cord injury. *Paraplegia*. 1995; 33:555–559. [PubMed: 8848308]
- ASIA. International Standards for Neurological Classification of Spinal Injury Patients (Revised). American Spinal Injury Association; Chicago, IL: 2000.

- Beck AT, Ward CH, Mendelson M, Mock J, Erbaugh J. An inventory for measuring depression. *Archives of General Psychiatry*. 1961; 4:561–571. [PubMed: 13688369]
- Beric A. Post-spinal cord injury pain states. *Pain*. 1997; 72:295–298. [PubMed: 9313269]
- Bombardier CH, Richards JS, Krause JS, Tulsy D, Tate DG. Symptoms of major depression in people with spinal cord injury: implications for screening. *Archives of Physical Medicine & Rehabilitation*. 2004; 85:1749–1756. [PubMed: 15520969]
- Bradley LA, Prokop CK, Margolis R, Gentry WD. Multivariate analyses of the MMPI profiles of low back pain patients. *Journal of Behavioral Medicine*. 1978; 1:253–272. [PubMed: 158659]
- Bradley LA, Van der Heide LH. Pain-related correlates of MMPI profile subgroups among back pain patients. *Health Psychology*. 1984; 3:157–174. [PubMed: 6242143]
- Britell CW, Mariano AJ. Chronic pain in spinal cord injury. *Archives of Physical Medicine & Rehabilitation*. 1991; 5:71–82.
- Burke DC. Pain in paraplegia. *Paraplegia*. 1973; 10:297–313. [PubMed: 4697003]
- Cairns DM, Adkins RH, Scott MD. Pain and depression in acute traumatic spinal cord injury: origins of chronic problematic pain? *Archives of Physical Medicine & Rehabilitation*. 1996; 77:329–335. [PubMed: 8607754]
- Cardenas DD, Bryce TN, Shem K, Richards JS, Elhefni H. Gender and minority differences in the pain experience of people with spinal cord injury. *Archives of Physical Medicine & Rehabilitation*. 2004; 85:1774–1781. [PubMed: 15520972]
- Davidoff G, Roth E, Guarracini M, Sliwa J, Yarkony G. Function-limiting dysesthetic pain syndrome among traumatic spinal cord injury patients: a cross-sectional study. *Pain*. 1987; 29:39–48. [PubMed: 3588000]
- DeVivo MJ, Go BK, Jackson AB. Overview of the national spinal cord injury center database. *Journal of Spinal Cord Injury Medicine*. 2002; 25:335–338.
- DeVivo, MJ. Epidemiology of traumatic spinal cord injury. In: Kirshblum, S.; Campagnolo, DI.; DeLisa, JA., editors. *Spinal Cord Medicine*. Lippincott Williams and Wilkins; Philadelphia, PA: 2002. p. 69-81.
- Elliott TR, Frank RG. Depression following spinal cord injury. *Archives of Physical Medicine & Rehabilitation*. 1996; 77:816–823. [PubMed: 8702378]
- Elliott TR, Harkins SW. Psychosocial concomitants of persistent pain among persons with spinal cord injury. *NeuroRehabilitation*. 1991; 1:7–16.
- Gilson BS, Gilson JS, Bergner M, Bobbit RA, Dressel S, Pollard WE, Vesselagg M. Sickness Impact Profile: Development of an outcome measure of health care. *American Journal of Public Health*. 1976; 65:1304–1310. [PubMed: 1200192]
- Go, BK.; DeVivo, MJ.; Richards, JS. The epidemiology of spinal cord injury. In: Stover, SL.; Whiteneck, GG.; DeLisa, JA., editors. *Spinal cord injury: Clinical outcome from the model systems*. Aspen; Gaithersburg, MD: 1995. p. 21-51.
- Hays RD, Wells KB, Sherbourne CD, Rogers W, Spritzer K. Functioning and well-being outcomes of patients with depression compared with chronic general medical illnesses. *Archives of General Psychiatry*. 1995; 5:11–19. [PubMed: 7811158]
- Hartigan, JA. *Clustering Algorithms*. John Wiley; New York: 1975.
- Jamison RN, Rock DL, Parris WCV. Empirically derived Symptom Checklist-90 subgroups of chronic pain patients: A cluster analysis. *Journal of Behavioral Medicine*. 1988; 11:147–157. [PubMed: 3172188]
- Jensen MP, Karoly P, Braver S. The measurement of clinical pain intensity: A comparison of six methods. *Pain*. 1986; 27:117–126. [PubMed: 3785962]
- Johnson RL, Gerhart KA, McCray J, Menconi JC, Whiteneck, GG. Secondary conditions following spinal cord injury in a population-based sample. *Spinal Cord*. 1998; 36:45–50. [PubMed: 9471138]
- Johnson S. Hierarchical clustering schemes. *Psychometrika*. 1967; 32:241–254.
- Katz PP, Yelin EH. Life activities of persons with rheumatoid arthritis with and without depressive symptoms. *Arthritis Care and Research*. 1994; 7:69–77. [PubMed: 7857996]

- Keefe FJ, Bradley LA, Crisson JE. Behavioral assessment of low back pain: Identification of pain behavior subgroups. *Pain*. 1990; 40:153–160. [PubMed: 2137905]
- Keefe FJ, Lefebvre JC, Kerns RD, Rosenberg R, Beaupre P, Prochaska J, Prochaska JO, Caldwell DS. Understanding the adoption of arthritis self-management: Stages of change profiles among arthritis patients. *Pain*. 2000; 87:303–313. [PubMed: 10963910]
- Klapow JC, Slater MA, Patterson TL, Doctor JN, Atkinson JH, Garfin SR. An empirical evaluation of multidimensional clinical outcome in chronic low back pain patients. *Pain*. 1993; 55:107–118. [PubMed: 8278203]
- Lasfargues JE, Custis D, Morrone F, Carswell J, Nguyen T. A model for estimating spinal cord injury prevalence in the United States. *Paraplegia*. 1995; 33:62–68. [PubMed: 7753569]
- Mariano AJ. Chronic pain and spinal cord injury. *Clinical Journal of Pain*. 1992; 8:87–92. [PubMed: 1633387]
- Melzack R. The McGill pain questionnaire: Major properties and scoring methods. *Pain*. 1975; 1:272–299.
- Morris R, Blashfield R, Satz P. Neuropsychology and cluster analysis: Potentials and problems. *Journal of Clinical Neuropsychology*. 1981; 3:79–99. [PubMed: 7276198]
- Morris RD, Fletcher JM. Classification in neuropsychology: a theoretical framework and research paradigm. *Journal of Clinical Experimental Neuropsychology*. 1988; 10:640–658. [PubMed: 3066798]
- Murphy D, Reid DB. Pain treatment satisfaction in spinal cord injury. *Spinal Cord*. 2001; 39:44–46. [PubMed: 11224014]
- Nepomuceno C, Fine PR, Richards JS, Gowens H, Stover SL, Rantanuaboli U, Houston R. Pain in patients with spinal cord injury. *Archives of Physical Medicine & Rehabilitation*. 1979; 60:605–609. [PubMed: 518270]
- Putzke JD, Richards JS, DeVivo MJ. Quality of life after spinal cord injury caused by gunshot. *Archives of Physical Medicine & Rehabilitation*. 2001; 82:949–954. [PubMed: 11441384]
- Putzke JD, Richards JS, Hicken BL, Ness TJ, Kezar L, DeVivo M. Pain classification following spinal cord injury: the utility of verbal descriptors. *Spinal Cord*. 2002; 40:118–127. [PubMed: 11859438]
- Putzke JD, Richards JS, Hicken BL, DeVivo MJ. Interference due to pain following spinal cord injury: important predictors and impact on quality of life. *Pain*. 2002; 100:231–242. [PubMed: 12467994]
- Rappaport NB, McAnulty DP, Waggoner CD, Brantley PJ. Cluster analysis of Minnesota Multiphasic Personality Inventory (MMPI) profiles in a chronic headache population. *Journal of Behavioral Medicine*. 1987; 10:49–60. [PubMed: 3586001]
- Ravenscroft A, Ahmed YS, Burnside IG. Chronic pain after SCI. A patient survey. *Spinal Cord*. 2000; 38:611–614. [PubMed: 11093322]
- Richards JS, Meredith RL, Nepomuceno C, Fine PR, Bennett G. Psycho-social aspects of chronic pain in spinal cord injury. *Pain*. 1980; 8:355–366. [PubMed: 7402693]
- Rintala DH, Loubser PG, Castro J, Hart KA, Fuhrer MJ. Chronic pain in a community-based sample of men with spinal cord injury: prevalence, severity, and relationship with impairment, disability, handicap, and subjective well-being. *Archives of Physical Medicine & Rehabilitation*. 1998; 79:604–614. [PubMed: 9630137]
- Rose M, Robinson JE, Ellis P, Cole JD. Pain following spinal cord injury: results from a postal survey. *Pain*. 1988; 34:101–102. [PubMed: 3405616]
- Rudy TE, Kerns RD, Turk DC. Chronic pain and depression: toward a cognitive-behavioral mediation model. *Pain*. 1988; 35:129–140. [PubMed: 3237427]
- Sanders SH, Brena SF. Empirically derived chronic pain patient subgroups: The utility of multidimensional clustering to identify differential treatment effects. *Pain*. 1993; 54:51–56. [PubMed: 8378103]
- Siddall PJ, Taylor DA, McClelland JM, Rutkowski SB, Cousins MJ. Pain report and the relationship of pain to physical factors in the first 6 months following spinal cord injury. *Pain*. 1999; 81:187–197. [PubMed: 10353507]
- Spitzer RL, Kroenke K, Williams JBW. Validation and utility of a self-report version of PRIME-MD: The PHQ Primary Care Study. *JAMA*. 1999; 282:1737–1744. [PubMed: 10568646]

- SPSS. SPSS for Windows, Release 11.5.0. SPSS Inc.; Chicago, IL: 2002.
- Summers JD, Rapoff MA, Varghese G, Porter K, Palmer RE. Psychosocial factors in chronic spinal cord injury pain. *Pain*. 1991; 47:183–189. [PubMed: 1762813]
- Stover SL, DeVivo MJ, Go BK. History, implementation, and current status of the national spinal cord injury database. *Archives of Physical Medicine & Rehabilitation*. 1999; 80:1365–1371. [PubMed: 10569429]
- Strong J, Ashton R, Stewart A. Chronic low back pain: Toward an integrated psychosocial assessment model. *Journal of Consulting and Clinical Psychology*. 1994; 62:1058–1063. [PubMed: 7806715]
- Swimmer GI, Robinson ME, Geisser ME. Relationship of MMPI cluster type, pain coping strategy, and treatment outcome. *The Clinical Journal of Pain*. 1992; 8:131–137. [PubMed: 1385994]
- Tabachnik, BG.; Fidell, LS. *Using Multivariate Statistics*. Harper and Row Publishers; New York: 1989.
- Talo S, Forssell H, Heikkonen S, Puukka P. Integrative group therapy outcome related to psychosocial characteristics in patients with chronic pain. *International Journal of Rehabilitation Research*. 2001; 24:25–33. [PubMed: 11302461]
- Turk DC. The role of psychological factors in chronic pain. *Acta Anaesthesiologica Scandinavica*. 1999; 43:885–888.
- Turk DC, Rudy TE. Towards a comprehensive assessment of chronic pain patients. *Behavioral Research Therapy*. 1987; 25:237–249.
- Turk DC, Rudy TE. Toward an empirically derived taxonomy of chronic pain patients: Integration of psychological assessment data. *Journal of Consulting and Clinical Psychology*. 1988; 56:233–238. [PubMed: 3372831]
- Turk DC, Rudy TE. The robustness of an empirically derived taxonomy of chronic pain patients. *Pain*. 1990; 43:27–35. [PubMed: 2148974]
- Turner JA, Cardenas DD, Warm CA, McClellan CB. Chronic pain associated with spinal cord injuries: a community survey. *Archives of Physical Medicine & Rehabilitation*. 2001; 82:501–509. [PubMed: 11295011]
- Ward J. Hierarchical grouping to optimize an objective function. *American Statistical Association*. 1963; 58:236–244.
- Ware, JE.; Kosinski, M.; Keller, SD. *SF-12: How to score the SF-12 Physical and Mental Health Summary Scales*. 2nd ed. The Health Institute: New England Medical Center; Boston, Mass: 1995.
- Warm CA, Turner JA, Marshall HM, Cardenas DD. Treatments for chronic pain associated with spinal cord injuries: many are tried, few are helpful. *Clinical Journal of Pain*. 2002; 18:154–163. [PubMed: 12048417]
- Williamson GM, Schulz R. Pain, activity restriction, and symptoms of depression among community-residing elderly adults. *Journal of Gerontology*. 1992; 47:367–372.
- Williamson GM, Schulz R. Activity restriction mediates the association between pain and depressed affect: a study of younger and older adult cancer patients. *Psychology & Aging*. 1995; 10:369–378. [PubMed: 8527058]
- Williamson GM. Extending the activity restriction model of depressed affect: evidence from a sample of breast cancer patients. *Health Psychology*. 2000; 19:339–347. [PubMed: 10907652]

Figure 1. Standard score means on measures of pain intensity, pain interference, and depression for the SCI pain subgroups.

Figure 2.
Standard score means on measures of pain intensity, pain interference, and depression for the two random SCI pain subgroup samples.

Table 1

Comparison of Group Characteristics

Characteristic	Selected Sample	Not Selected
Age ($\bar{x}$)	44.5 (11.9)	45.0 (13.4)
Gender		
Male	1,052 (79)	513 (81)
Female	282 (21)	122 (19)
Race *		
Caucasian	1,096 (82)	409 (72)
African-American	198 (15)	127 (23)
Other	40 (3)	30 (5)
Traumatic Etiology *		
Vehicular	676 (51)	275 (44)
Violence	175 (13)	128 (20)
Sports	174 (13)	71 (11)
Falls/flying objects	254 (19)	122 (19)
Other, unclassified	51 (4)	39 (6)
Marital Status *		
Single	505 (38)	260 (41)
Married	498 (37)	189 (30)
Divorced	269 (20)	111 (18)
Other	62 (5)	36 (6)
Education *		
Less than high school	151 (11)	127 (22)
High school	681 (51)	297 (50)
More than high school	502 (38)	166 (28)
Level, completeness of injury		
Paraplegia, incomplete	230 (18)	100 (16)
Paraplegia, complete	434 (33)	207 (34)
Tetraplegia, incomplete	352 (26)	158 (26)
Tetraplegia, complete	308 (23)	149 (24)

Data for age are means (SD). All other data are n (%).

* $p < .001$

Table 2

Means and Standard Errors of Pain Intensity, Pain Interference, and Depression Measures for the SCI Pain Groups

Measures	SCI Pain Groups			
	Positive Adaptation			Chronic Pain
	Low Pain (N = 528)	to Pain (N = 350)	Minimal Distress (N = 288)	Syndrome (N = 168)
Pain Intensity (NRS)	2.60 ($\pm$ 0.05)	6.21 ($\pm$ 0.08)	6.92 ($\pm$ 0.11)	7.08 ($\pm$ 0.16)
Pain Interference (SF-12)	0.44 ($\pm$ 0.03)	0.36 ($\pm$ 0.03)	2.75 ($\pm$ 0.04)	2.66 ($\pm$ 0.09)
Depression (BPHQ)	2.31 ($\pm$ 0.13)	2.69 ($\pm$ 0.16)	3.78 ($\pm$ 0.18)	15.46 ($\pm$ 0.32)