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The demographics of pain after spinal cord injury: a survey of our model system.

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1 **TITLE:** THE DEMOGRAPHICS OF PAIN AFTER SPINAL CORD INJURY: A SURVEY OF OUR MODEL

2 SYSTEM

3

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20

21 **AUTHOR DISCLOSURES:** none

22

23 **Key Words:** neuropathic, nociceptive, spinal cord, pain, demographics

24 **ABSTRACT:**

25 **Study Design:** Survey

26 **Objectives:** Better understand the demographics of pain after spinal cord injury (SCI)

27 **Setting:** Academic Level 1 trauma center and SCI Model System

28 **Methods:** A survey including general demographic questions, questions of specific interest to
29 the authors, the standardized SCI Pain Instrument (SCIPI), International SCI Pain Data Set, Basic
30 form (ISCI-PDS:B), Patient Reported Outcomes Measurement Information System (PROMIS)
31 neuropathic 5a (PROMIS-Neur), and PROMIS nociceptive 5a (PROMIS-No).

32 **Results:** 81% of individuals with SCI experience chronic pain and 86% of individuals with pain
33 have neuropathic pain. 55% of individuals had shoulder pain. Females and those who recall
34 $\geq 5/10$ pain during initial hospital stay had significantly higher PROMIS-Neur scores.
35 Completeness of injury correlates inversely with degree of neuropathic pain. Those who recall
36 ≥ 5 pain during initial hospital stay and those who reported the worst or second worst pain as
37 being shoulder pain had significantly higher PROMIS-No scores. Lumbosacral injuries trended
38 towards higher PROMIS-No scores and had the highest PROMIS-Neur scores. Those with
39 tetraplegia were more likely to develop shoulder pain and those with shoulder pain had higher
40 PROMIS-No scores.

41 **Conclusions:** Chronic pain is almost universal in patients with SCI. Pain is more commonly
42 reported as neuropathic in nature and females reported more neuropathic pain than males.
43 Physicians should monitor for nociceptive shoulder pain, particularly in those with tetraplegia.
44 Patients with incomplete injuries or lumbosacral injuries are more likely to report higher levels
45 of neuropathic pain and pain levels should be monitored closely. Those with more neuropathic

46 and nociceptive pain recall worse pain at initial hospitalization. Better understanding pain
47 demographics in this population help screen, prevent and manage chronic pain in these
48 patients.

49 **Sponsorship:** none

50 **INTRODUCTION:**

51 Chronic pain limits activities, decreases quality of life, and leads to significant impairment in
52 individuals with spinal cord injury (SCI)[1–3]. Individuals with pain after SCI have a \$22,545
53 increased cost burden per year compared to their SCI peers without pain[4] and the difficulty in
54 treating this pain has been documented for years[5]. Pain after SCI is typically classified as
55 nociceptive (which includes visceral and musculoskeletal pain), at-level-neuropathic, and below
56 level neuropathic[6]. Neuropathic pain is generally regarded as the most frequent type of pain
57 after SCI[7], although this remains disputed, with studies having up to 59% of those with SCI
58 reporting musculoskeletal nociceptive pain [8]. The prevalence of chronic pain in this
59 population varies from 13-96% depending on the study[3,8–11] and of severe pain from 20-58%
60 [8,12]. The International Spinal Cord Injury Pain Classification System was developed in 2009,
61 but experts were unable to estimate the prevalence of pain after SCI due to the variability
62 between studies, suggesting the need for more and better data[6] which has since been
63 reiterated[7,13]. Some data suggests incomplete lesions result in more chronic pain
64 [8,11,14,15], though other studies paradoxically suggest complete lesions result in more
65 chronic pain[16–18]. A metanalysis recently found no difference between groups[13]. Many
66 studies suggest level of injury does not affect the prevalence of chronic pain, although others
67 have suggested lumbosacral injuries are more painful[19].

68

69 This confusion originates from the lack of consistently used and validated instruments to
70 measure pain. In a recent metanalysis of neuropathic pain after SCI that included 17 studies,
71 Burke et al. found only two studies used validated instruments to measure neuropathic

72 pain[20]. To further delineate and add to the body of literature surrounding chronic pain after
73 spinal cord injury, the authors of the current study developed a survey that included basic
74 demographic questions, instruments to measure neuropathic pain after SCI, and specific
75 questions assessing other types of pain that may be present in this population. Since pain is a
76 subjective finding notoriously difficult to measure, a survey with validated pain instruments is
77 one good way to assess the issues at hand and accurately evaluate the demographics
78 surrounding pain after SCI.

79

80

81 **METHODS:**

82 **Survey Development:**

83 The authors evaluated existing reviews and metaanalyses addressing the demographics of pain
84 after spinal cord injury[6,13,20]. We then interviewed experts in the areas of spinal cord injury
85 medicine, pain management, and survey statistics to solicit input on validated tools and
86 potential questions that could be answered by this work. Based on this preliminary work, we
87 developed a survey including general demographic questions, questions of specific interest to
88 the authors, the standardized Spinal Cord Injury Pain Instrument (SCIPI), International Spinal
89 Cord Injury Pain Data Set, Basic form (ISCIPDS:B), Patient Reported Outcomes Measurement
90 Information System (PROMIS) neuropathic 5a (PROMIS-Neur), PROMIS nociceptive 5a (PROMIS-
91 No), and PROMIS pain interference short form 8a (PROMIS-Int). The PROMIS instruments were
92 designed to compare groups of individuals to the general population of the United States. A
93 score of 50 represents the average population with a standard deviation of 10. The mean

94 PROMIS-Neur scores for surveyed population was 55.2 while the mean PROMIS-No score was
95 52.0. Of note, the level of completeness of injury (AIS classification) was self-reported and not
96 confirmed by physician examination or medical records review. The final survey consisted of a
97 possible 80 questions, although most combination of answers did not result in the participant
98 answering all 80 questions. A pilot test was conducted by the authors of the study as well as
99 others from within the department to evaluate question clarity and software functionality. The
100 goals of this survey were to a) collect demographic data as it relates to pain after SCI utilizing
101 standardized tools; b) assess demographic information of specific interest to the authors; and c)
102 compare multiple demographic parameters as they relate to measured outcomes using the
103 validated instruments. The survey was thoroughly examined and approved by the Thomas
104 Jefferson University Hospital institutional review board. We certify that all applicable
105 institutional and governmental regulations concerning the ethical use of human volunteers
106 were followed during the course of this research. A formatted copy of the survey is available
107 for review in appendix A.

108

109 **Survey Distribution:**

110 The survey was distributed via Survey Monkey to SCI consumer mailing lists maintained by
111 Thomas Jefferson University as part of the SCI model systems program. Each participant
112 received a link via email and completed the survey online. One patient was unable to
113 independently complete the survey online and therefore completed it over the telephone. A
114 reminder was sent six weeks after the initial invitation to participate. All survey responses
115 remained anonymous and repeat responses were discounted by cancelling any duplicate IP

116 addresses. There was no time limit to complete the survey. There were no incentives offered
117 for completing the survey. There were 705 individuals queried on the initial email and 711 on
118 the second email.

119

120 **Data Analysis:**

121 To answer study objectives, participant data were grouped into neuropathic (SCIPI ≥ 2) or
122 nociceptive (SCIPI < 2). For specific analyses—particularly in questions with multiple answers,
123 similar answers were grouped for analysis (i.e. multiple original age groups were combined to
124 form < 55 years of age and > 55 years of age). Data on level of injury, completeness of injury,
125 and other similar demographics were combined when no significant between group differences
126 was found. The data were analyzed using individual Chi-Square or t-tests for continuous data.
127 Fisher's Exact tests were used if expected values in categories fell below 5 in any cell. All data
128 was calculated using SPSS v.25 (Armonk, NY).

129

130 **RESULTS:**

131 One hundred seventy-one responses were received, giving a response rate of 24%. 81% of
132 respondents had chronic pain. As classified by the SCIPI, 86% of respondents with chronic pain
133 were classified as having neuropathic pain. The mean PROMIS-Neur scores for the surveyed
134 population was 55.2 while the mean PROMIS-No score was 52.0. Eighty-two percent of
135 participants report having experienced pain during their initial hospitalization after their injury,
136 81% reported having chronic pain since that time, and 66% reported their primary chronic pain
137 started immediately after their SCI. Most (56%) had constant and continuous pain that was

138 unpredictably intense (45%), continued on a daily basis (90%), and has gotten worse since initial
139 injury (54%). Seventy percent of individuals with chronic pain had at least three separate body
140 areas with pain. The median reported daily pain on the Stanford pain scale was 5/10 or “very
141 distressing.” The mode at initial injury was 3/10 or “tolerable” and the current mode of the
142 surveyed sample was 4/10 or “distressing.”

143

144 Seventy percent of the respondents were >55 years of age. There was no significant difference
145 in the development of nociceptive vs neuropathic pain as categorized by the SCIPI based on age
146 category ($\chi^2 = 0.942$). Seventy-five percent of respondents were male. There was no difference
147 between type of pain experienced (neuropathic versus nociceptive) when comparing males and
148 females ($\chi^2 = 0.341$), however, females mean neuropathic pain scores ($\bar{x} = 58.0$) was
149 significantly higher than the male mean neuropathic pain score as measured by the PROMIS-
150 Neur [$(\bar{x} = 54.0)$ ($T = -2.053$; $p = .043$)] (Table 1, Figure 1).

151

152 The most common mechanism of injury was motor vehicle accident (35%) followed by falls
153 (30%). Twelve percent were due to penetrating injuries. Penetrating injuries did not influence
154 the development of neuropathic or nociceptive pain on the SCIPI when compared to non-
155 penetrating injuries ($\chi^2=0.138$). However, those with penetrating injuries reported non-
156 significantly higher PROMIS-No [$(\bar{x} = 55.9)$ and PROMIS-Neur ($\bar{x} = 57.5$) scores compared to
157 their non-penetrating peers ($\bar{x} = 51.5$ and 55.1 ; $T = -1.692$ and $-.869$; $p = .094$ and $.387$) (Table
158 2).

159

160 Fifty-two percent of respondents had cervical spine injuries and most (68%) were incomplete
161 injuries as classified by the international standards for classification of spinal cord injury
162 (ISNCSCI) (grades B, C, D or E.) The breakdown of ASIA classification was as follows: 30% were
163 ASIA A, 19% were ASIA B, 20% were ASIA C, 20% were ASIA D, and 0.58 % (1 responder) was
164 ASIA E. There was no significant difference in pain type (neuropathic vs nociceptive) based on
165 ASIA classification ($\chi^2 = 0.112$). Those classified as ASIA C were more likely to be classified as
166 nociceptive pain by the SCIPI than those in other ASIA classifications (20.5 % in C vs 12.2%,
167 9.1%, 10.7% for A, B, and D respectively). Mean nociceptive pain scores, as measured by the
168 PROMIS-No, remained relatively stable across all ASIA classifications (A = 52.5, B = 51.0, C =
169 52.8, D = 50.2; $p=.691$; Table 3). However, subjects with progressively more incomplete injuries
170 had higher mean PROMIS-Neur scores and trended toward significance (A = 52.1, B = 55.0, C =
171 55.8, D = 57.7; $p=.161$; Figure 2). Subjects classified as motor incomplete (ASIA C & D) had
172 similar PROMIS-No scores ($\bar{x} = 51.8$) when compared to motor complete (AISA A & B) pain
173 scores ($\bar{x} = 52.0$). Although not statistically significant, those with motor incomplete injuries
174 reported higher PROMIS-Neur scores ($\bar{x} = 56.5$) than motor complete ($\bar{x} = 53.2$) with a trend
175 toward significance ($p=.061$).

176

177 There was no difference in reported pain type when grouping higher (cervical and thoracic) and
178 lower (lumbar and sacral) levels of injury ($\chi^2 = 0.767$). Lumbar and sacral injuries were
179 associated with higher PROMIS-Neur ($\bar{x} = 58.9$ vs $\bar{x} = 54.7$) and PROMIS-No ($\bar{x} = 56.7$ vs $\bar{x} =$
180 51.5) scores when compared to cervical and thoracic injuries. Although this trend was noted,

181 the difference was not significant for PROMIS-Neur (T = -1.476, p .143) but trended towards
182 significance for PROMIS-No (T = -1.977, P = .051).

183
184 Eighty-two percent of the surveyed population were >5 years from initial injury. Length of time
185 since injury did not significantly impact the type of pain ($\chi^2 = 0.726$), nor overall pain scores
186 experienced. There was, however, a trend that respondents with injuries >5 years old had
187 higher average PROMIS-Neur ($\bar{x} = 55.3$) and PROMIS-No ($\bar{x} = 52.8$) scores when compared to
188 injuries <5 years old ($\bar{x} = 54.4$ and $\bar{x} = 49.2$), though this difference was not significant (T = -
189 .376 , P = .708; T = -1.656, P =.101).

190
191 Similarly, patients with higher degrees of reported pain(>5) during their initial hospital stay did
192 not have significantly different breakdown of pain type (nociceptive vs neuropathic pain) when
193 compared to those with lower levels of reported pain ($\chi^2 = .320$). Participants recalling >5 on
194 the Stanford pain scale at initial hospital stay reported significantly higher PROMIS-Neur ($\bar{x} =$
195 56.35) than respondents with Stanford pain scales <4 at initial hospital stays ($\bar{x} = 52.1$) (T = -
196 2.114; p =.037) (Figure 3). Similarly, individuals who recall having >5 on the Stanford pain scale
197 during their initial hospital stay reported significantly higher PROMIS-No scores ($\bar{x} = 53.2$) than
198 those with <4 during their initial hospital stay ($\bar{x} = 48.8$) (T =-2.413; p =.018) (Figure 3).

199
200 Thirty-nine percent of respondents were employed to some degree, but there was no
201 significant difference in type of pain based on employment status ($\chi^2 = 0.957$). There was no

202 difference in PROMIS-No (\bar{x} = 52.4 vs \bar{x} = 51.4) or PROMIS-Neur (\bar{x} = 55.5 vs \bar{x} = 54.7 based on
203 employment status (T = -.429 , P = .668; T = -.632, P = .529).

204

205 Fifty-five percent of respondents reported shoulder pain. Those with tetraplegia were more
206 likely than those with paraplegia (thoracic, lumbar, or sacral injuries) to have shoulder pain
207 (p=.049). Respondents who reported having their worst or second worst pain affect their
208 shoulders had significantly higher PROMIS-No scores (\bar{x} = 54.3 vs \bar{x} = 50.6)(T =2.136; p =.030)
209 but not PROMIS-Neur scores (Table 4).

210

211 A summary of SCIPI groups and variables can be reviewed in Table 1. PROMIS-Neur and
212 PROMIS-No scores for each group can be reviewed in Table 2.

213

214 **DISCUSSION:**

215 Most individuals with SCI experience chronic pain regardless of mechanism of injury or ISNSCI
216 scores. The demographics of this survey population are generally consistent with the
217 population demographics of the those with SCI in the United States. Results of the current
218 study suggest that most individuals with SCI (81%) have chronic pain and most of those (86%)
219 experience neuropathic pain, which is within the range reported for most of the SCI pain
220 literature [7,10,13,14,21].

221

222 Neuropathic pain after SCI is likely a unique phenotype of neuropathic pain that originates from
223 disruption of spinal modulation pathways as opposed to similar ‘neuropathic’ conditions like a

224 peripheral nerve injury or post-stroke neuropathic pain[22]. Neuropathic pain manifests
225 differently at and below the level of injury. Neuropathic pain at the level of injury is likely
226 caused by injury to the nerve roots and spinal cord at that level as compared to neuropathic
227 pain below the level of injury, which is likely related to disruption of longer neuronal pathways
228 from the lesion[10,21].

229

230 Our results suggest that the completeness of the SCI correlates inversely with the degree of
231 neuropathic pain experienced—complete injuries had a lower mean pain score compared to
232 those with progressively more incomplete injuries (Table 2). This may be related to the way
233 descending modulation pathways in the spinal cord are disrupted by injury, creating
234 intermittent, incomplete, and abnormal transmission of signal across the damaged area of the
235 cord. A similar mechanism is proposed to explain why spasticity is worse in incomplete spinal
236 lesions[23]. As previously noted, level of completeness was recorded by patient report and not
237 confirmed with examination or medical record review as such measures are unlikely to
238 significantly impact the overall accuracy of the data collected. This population is knowledgeable
239 about their injuries and the aforementioned classification system. Given the frequency that
240 patients report such scores, there is a high degree of confidence in the accuracy of these
241 responses. Though, a small degree of error is introduced and may contribute to some
242 uncertainty in our final data analysis.

243

244 In addition to pain at and distal to the level of injury, patients with SCI often develop shoulder
245 pain, regardless of the level of injury. Those who rated the shoulder as their first or second

246 most painful area reported higher PROMIS-No scores than the rest of our population.
247 Individuals with paraplegia often develop nociceptive shoulder pain from overuse[24]. Years of
248 relying on the shoulder girdle for weight shifts, transferring, and mobility (propelling a manual
249 wheelchair) can lead to a spectrum of rotator cuff pathology. From acute tendonitis to chronic
250 complete rotator cuff tears, these injuries can all result in chronic shoulder pain[25].

251

252 In the current study, those with tetraplegia were significantly more likely than those with
253 paraplegia to report shoulder pain. Alternatively, individuals with higher cervical injuries (C3-5)
254 may develop shoulder pain secondary to spasticity and shoulder subluxation. In addition to
255 pain, a weak shoulder struggles to position the hand in space to perform activities of daily
256 living[26]. This abnormal scapular kinesis may lead to the entire spectrum of rotator cuff
257 pathology seen in paraplegia. Scapular dyskinesis is a well-known etiology of shoulder pain, but
258 may be secondary to other conditions[27,28]. Higher levels of injury may result in decreased
259 shoulder range of motion. This has been linked to increased shoulder pain in this
260 population[29]. Functional substitution of stronger muscle groups such as the trapezius may
261 lead to suboptimal positioning of the scapula further predisposing the shoulders to injury.
262 Taken in total, the current study suggests the shoulder is a common pain generator and the
263 shoulder pain experienced by both those with paraplegia and tetraplegia is more consistent
264 with nociceptive pain than neuropathic pain.

265

266 With regard to level of injury, lumbar or sacral injuries trended towards having more
267 nociceptive pain and also reported the highest PROMIS-Neur scores of any subgroup analyzed,

268 although the mean score was not significantly different from that of the cervical/thoracic
269 group. There is some literature that cauda equina injuries are particularly painful[14]. It is
270 suspected that both of these differences would have been significant if the number of subjects
271 was higher, as there were only 17 lumbar/sacral injuries in our sample.

272

273 Females reported significantly higher levels of neuropathic pain (PROMIS-neur), but not
274 nociceptive pain (PROMIS-no). However, there was a similar distribution of females and males
275 with neuropathic and nociceptive pain ($\chi^2 = 0.341$). As such, sex did not predispose patients to
276 developing neuropathic or nociceptive pain. It is possible this is not a true reflection of the
277 demographics of women with SCI as our sampled population was heavily skewed in favor of
278 males. It has been noted in prior studies, however, that women report more below-level
279 neuropathic pain after SCI in the past[30]. This phenomenon has also been noted with other
280 neuropathic conditions such as polyneuropathy[31]. Some suggest sex may be an important
281 factor in the modulation of pain[32,33]. Additionally, a review on prevalence of chronic pain
282 after SCI found sex to have a small impact on the experience of pain[13].

283

284 Understanding the trajectory of the pain course is of vital importance to those who treat SCI
285 related pain. The current study was not designed to track pain over time, however, there was a
286 correlation between the recollection of a painful acute hospital stay and current levels of
287 neuropathic and nociceptive pain. This may suggest that those with more pain at the onset of
288 injury will also experience more chronic pain. Alternatively, there could be recall bias where
289 those who develop more chronic pain recall always being in more pain. This distinction is

290 important as it may impact patient prognosis, goals and expectations. A longitudinal study
291 tracking pain severity over time would help elucidate this question.

292

293 The current study is not without limitations. This survey was distributed through our model
294 system database which covers the Delaware Valley and could introduce regional bias. There
295 were a number of statistical categories, mainly those assessing nociceptive pain, where our
296 sample size was small enough to introduce the possibility of Type II error. Additional studies
297 with larger samples size spanning a broader part of the country would be warranted to
298 eliminate the possibility of a regional bias, better understand how sex impacts pain in patients
299 with SCI, and compare the quality and severity of pain to the level of injury.

300

301 In summary, this survey suggests neuropathic pain is the predominate pain after spinal cord
302 injury. In our sample, 81% of individuals experience chronic pain and 86% of those with pain
303 are classified as having neuropathic pain. Overall, individuals with SCI report higher levels of
304 neuropathic and nociceptive pain compared to the general United States population. Those
305 who reported higher levels of current nociceptive and neuropathic pain were more likely to
306 report higher levels of pain during their initial hospital stay. Females were more likely to report
307 higher levels of neuropathic pain but not nociceptive pain than males. Incomplete injuries
308 trended toward producing a phenotype with more neuropathic pain and possibly nociceptive
309 pain than complete injuries and lumbar/sacral injuries trended toward producing a phenotype
310 with more nociceptive pain. Shoulder pain afflicted 55% of individuals surveyed. Those with
311 tetraplegia were more likely to develop shoulder pain than those with paraplegia and those

312 who reported their first or second worst pain to be shoulder pain had significantly higher
313 nociceptive pain scores. Understanding these pain demographics will enable physicians to
314 better predict complications, take down barriers to improvement, and optimize care for
315 patients with SCI.

316

317 **DATA ARCHIVING:** Data has been stored in a secured Survey Monkey account

318

319 **CONFLICT OF INTERESTS:** None

320

321 **REFERENCES:**

322 1. Craig A, Nicholson Perry K, Guest R, Tran Y, Dezarnaulds A, Hales A, et al. Prospective Study of
323 the Occurrence of Psychological Disorders and Comorbidities After Spinal Cord Injury Archives
324 of Physical Medicine and Rehabilitation. Arch Phys Med Rehabil [Internet]. 2015 [cited 2020 Sep
325 5];96:1426–60. Available from: <http://dx.doi.org/10.1016/j.apmr.2015.02.027>

326 2. Elliott TR, Frank RG. Depression following spinal cord injury [Internet]. Arch. Phys. Med.
327 Rehabil. W.B. Saunders; 1996 [cited 2020 Sep 5]. p. 816–23. Available from: [https://pubmed-
328 ncbi-nlm-nih-gov.proxy1.lib.tju.edu/8702378/](https://pubmed-ncbi-nlm-nih-gov.proxy1.lib.tju.edu/8702378/)

329 3. Finnerup NB, Jensen MP, Norrbrink C, Trok K, Johannesen IL, Jensen TS, et al. A prospective
330 study of pain and psychological functioning following traumatic spinal cord injury. Spinal Cord
331 [Internet]. Nature Publishing Group; 2016 [cited 2020 Aug 29];54:816–21. Available from:
332 www.nature.com/sc

333 4. Margolis JM, Juneau P, Sadosky A, Cappelleri JC, Bryce TN, Nieshoff EC. Health care resource

334 utilization and medical costs of spinal cord injury with neuropathic pain in a commercially
335 insured population in the United States. *Arch Phys Med Rehabil*. W.B. Saunders; 2014;95:2279–
336 87.

337 5. Kaplan LI, Grynbaum BB, Lloyd KE, Rusk HA. Pain and Spasticity in Patients with Spinal Cord
338 Dysfunction. *J Am Med Assoc*. American Medical Association; 1962;182:918–25.

339 6. Bryce TN, Biering-Sørensen F, Finnerup NB, Cardenas DD, Defrin R, Lundeborg T, et al.
340 International Spinal Cord Injury Pain Classification: Part I. Background and description. *Spinal*
341 *Cord*. Nature Publishing Group; 2012;50:413–7.

342 7. Van Gorp S, Kessels AG, Joosten EA, Van Kleef M, Patijn J. Pain prevalence and its
343 determinants after spinal cord injury: A systematic review. *Eur J Pain*. 2015;19:5–14.

344 8. Siddall PJ, McClelland JM, Rutkowski SB, Cousins MJ. A longitudinal study of the prevalence
345 and characteristics of pain in the first 5 years following spinal cord injury. *Pain* [Internet]. 2003
346 [cited 2020 Aug 29];103:249–57. Available from: www.elsevier.com/locate/pain

347 9. Cardenas DD, Bryce TN, Shem K, Richards JS, Elhefni H. Gender and minority differences in
348 the pain experience of people with spinal cord injury. *Arch Phys Med Rehabil* [Internet]. W.B.
349 Saunders; 2004 [cited 2020 Aug 29];85:1774–81. Available from: [https://pubmed.ncbi.nlm.nih-](https://pubmed.ncbi.nlm.nih.gov.proxy1.lib.tju.edu/15520972/)
350 [gov.proxy1.lib.tju.edu/15520972/](https://pubmed.ncbi.nlm.nih.gov.proxy1.lib.tju.edu/15520972/)

351 10. Siddall PJ, Taylor DA, Cousins MJ. Classification of pain following spinal cord injury. *Spinal*
352 *Cord* [Internet]. Nature Publishing Group; 1997 [cited 2020 Aug 29];35:69–75. Available from:
353 <https://www-nature-com.proxy1.lib.tju.edu/articles/3100365>

354 11. Beric A, Dimitrijevic MR, Lindblom U. Clinical Section Central dysesthesia syndrome in spinal
355 cord injury patients. *Pain*. 1988;34:190–16.

- 356 12. Bryce TN, Ragnarsson KT. Epidemiology and classification of pain after spinal cord injury.
357 Top Spinal Cord Inj Rehabil. Thomas Land Publishers Inc.; 2001;7:1–17.
- 358 13. Dijkers M, Bryce T, Zanca J. Prevalence of chronic pain after traumatic spinal cord injury: A
359 systematic review. J Rehabil Res Dev. 2009;46:13–30.
- 360 14. Siddall PJ, Loeser JD. Pain following spinal cord injury. Spinal Cord [Internet]. Nature
361 Publishing Group; 2001 [cited 2020 Aug 29];39:63–73. Available from: www.nature.com/sc
- 362 15. Davidoff G, Roth E, Guarracini M, Sliwa J, Yarkony G. Function-limiting dysesthetic pain
363 syndrome among traumatic spinal cord injury patients: a cross-sectional study. Pain.
364 1987;29:39–48.
- 365 16. Wagner Anke AG, Stenehjem AE, Kvalvik Stanghelle J. Pain and life quality within 2 years of
366 spinal cord injury. Paraplegia. Paraplegia; 1995;33:555–9.
- 367 17. Yap EC, Tow A, Menon EB, Chan KF, Kong KH. Pain during in-patient rehabilitation after
368 traumatic spinal cord injury. Int J Rehabil Res [Internet]. Lippincott Williams and Wilkins; 2003
369 [cited 2020 Dec 22];26:137–40. Available from: <https://pubmed.ncbi.nlm.nih.gov/12799608/>
- 370 18. Budh CN, Lund I, Ertzgaard P, Holtz A, Hultling C, Levi R, et al. Pain in a Swedish spinal cord
371 injury population. Clin Rehabil. Clin Rehabil; 2003;17:685–90.
- 372 19. Nepomuceno C, Fine PR, Richards S, Gowens H, Stover SL, Rantanuabol U, et al. Pain in
373 patients with spinal cord injury. Arch Phys Med Rehabil. 1979;60:605–9.
- 374 20. Burke D, Fullen BM, Stokes D, Lennon O. Neuropathic pain prevalence following spinal cord
375 injury: A systematic review and meta-analysis. Eur J Pain (United Kingdom). 2017;21:29–44.
- 376 21. Mahnig S, Landmann G, Stockinger L, Opsommer E. Pain assessment according to the
377 International Spinal Cord Injury Pain classification in patients with spinal cord injury referred to

378 a multidisciplinary pain center. *Spinal Cord* [Internet]. Nature Publishing Group; 2016 [cited
379 2021 Mar 13];54:809–15. Available from: [https://pubmed-ncbi-nlm-nih-](https://pubmed-ncbi-nlm-nih-gov.proxy1.lib.tju.edu/26754471/)
380 [gov.proxy1.lib.tju.edu/26754471/](https://pubmed-ncbi-nlm-nih-gov.proxy1.lib.tju.edu/26754471/)

381 22. Hatch MN, Cushing TR, Carlson GD, Chang EY. Neuropathic pain and SCI: Identification and
382 treatment strategies in the 21st century. *J. Neurol. Sci.* Elsevier B.V.; 2018. p. 75–83.

383 23. Finnerup NB. Neuropathic pain and spasticity: Intricate consequences of spinal cord injury.
384 *Spinal Cord* [Internet]. Nature Publishing Group; 2017 [cited 2020 Oct 31];55:1046–50.
385 Available from: <https://pubmed.ncbi.nlm.nih.gov/28695904/>

386 24. Hastings J, Goldstein B. Paraplegia and the shoulder [Internet]. *Phys. Med. Rehabil. Clin. N.*
387 *Am. Phys Med Rehabil Clin N Am*; 2004 [cited 2021 Mar 13]. p. 699–718. Available from:
388 <https://pubmed-ncbi-nlm-nih-gov.proxy1.lib.tju.edu/15219896/>

389 25. Dyson-Hudson TA, Kirshblum SC. Shoulder pain in chronic spinal cord injury, Part I:
390 Epidemiology, etiology, and pathomechanics [Internet]. *J. Spinal Cord Med.* American
391 Paraplegia Society; 2004 [cited 2021 Mar 13]. p. 4–17. Available from: [https://pubmed-ncbi-](https://pubmed-ncbi-nlm-nih-gov.proxy1.lib.tju.edu/15156931/)
392 [nlm-nih-gov.proxy1.lib.tju.edu/15156931/](https://pubmed-ncbi-nlm-nih-gov.proxy1.lib.tju.edu/15156931/)

393 26. Mayer NH, Esquenazi A. Muscle overactivity and movement dysfunction in the upper
394 motoneuron syndrome [Internet]. *Phys. Med. Rehabil. Clin. N. Am.* W.B. Saunders; 2003 [cited
395 2021 Mar 13]. p. 855–83. Available from: [https://pubmed-ncbi-nlm-nih-](https://pubmed-ncbi-nlm-nih-gov.proxy1.lib.tju.edu/14580042/)
396 [gov.proxy1.lib.tju.edu/14580042/](https://pubmed-ncbi-nlm-nih-gov.proxy1.lib.tju.edu/14580042/)

397 27. Wilson RD, Chae J. Hemiplegic Shoulder Pain [Internet]. *Phys. Med. Rehabil. Clin. N. Am.*
398 W.B. Saunders; 2015 [cited 2021 Mar 13]. p. 641–55. Available from: [https://pubmed-ncbi-nlm-](https://pubmed-ncbi-nlm-nih-gov.proxy1.lib.tju.edu/26522903/)
399 [nih-gov.proxy1.lib.tju.edu/26522903/](https://pubmed-ncbi-nlm-nih-gov.proxy1.lib.tju.edu/26522903/)

400 28. Benjamin Kibler W, Sciascia A, Wilkes T. Scapular dyskinesia and its relation to shoulder
401 injury [Internet]. *J. Am. Acad. Orthop. Surg.* J Am Acad Orthop Surg; 2012 [cited 2021 Mar 13].
402 p. 364–72. Available from: <https://pubmed-ncbi-nlm-nih-gov.proxy1.lib.tju.edu/22661566/>

403 29. Eriks-Hoogland IE, Hoekstra T, De Groot S, Stucki G, Post MW, Van Der Woude LH.
404 Trajectories of musculoskeletal shoulder pain after spinal cord injury: Identification and
405 predictors. *J Spinal Cord Med* [Internet]. Maney Publishing; 2014 [cited 2021 Mar 13];37:288–
406 98. Available from: <https://www.tandfonline.com/doi/abs/10.1179/2045772313Y.0000000168>

407 30. Werhagen L, Hultling C, Molander C. The prevalence of neuropathic pain after non-
408 traumatic spinal cord lesion. *Spinal Cord* [Internet]. *Spinal Cord*; 2007 [cited 2021 Mar
409 13];45:609–15. Available from: <https://pubmed-ncbi-nlm-nih-gov.proxy1.lib.tju.edu/17160075/>

410 31. Abraham A, Barnett C, Katzberg HD, Lovblom LE, Perkins BA, Brill V. Sex differences in
411 neuropathic pain intensity in diabetes. *J Neurol Sci* [Internet]. Elsevier B.V.; 2018 [cited 2021
412 Mar 13];388:103–6. Available from: [https://pubmed-ncbi-nlm-nih-
413 gov.proxy1.lib.tju.edu/29627001/](https://pubmed-ncbi-nlm-nih-gov.proxy1.lib.tju.edu/29627001/)

414 32. Pieretti S, Di Giannuario A, Di Giovannandrea R, Marzoli F, Piccaro G, Minosi P, et al. Gender
415 differences in pain and its relief. *Ann Ist Super Sanita* [Internet]. Istituto Superiore di Sanita;
416 2016 [cited 2021 Mar 13];52:184–9. Available from: [https://pubmed-ncbi-nlm-nih-
417 gov.proxy1.lib.tju.edu/27364392/](https://pubmed-ncbi-nlm-nih-gov.proxy1.lib.tju.edu/27364392/)

418 33. Sorge RE, Totsch SK. Sex Differences in Pain [Internet]. *J. Neurosci. Res.* John Wiley and Sons
419 Inc.; 2017 [cited 2021 Mar 13]. p. 1271–81. Available from: [https://pubmed-ncbi-nlm-nih-
420 gov.proxy1.lib.tju.edu/27452349/](https://pubmed-ncbi-nlm-nih-gov.proxy1.lib.tju.edu/27452349/)

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422 **FIGURE LEGENDS:**

423 **FIGURE 1:** Women report higher levels of neuropathic pain but not nociceptive pain after SCI

424 **FIGURE 2:** Neuropathic and Nociceptive pain scores based on ASIA level

425 **FIGURE 3:** Neuropathic and Nociceptive Pain scores based on recall of degree of pain during

426 initial hospitalization

427

428 **TABLES and FIGURES:**

429 **TABLES:**

430 Table 1: Categorical Variation in Pain Quality

	Sub-Group	Number of patients	Neuropathic Pain Group	Nociceptive Pain group	Chi Squared Value	Significance value
Age	<55	70	60	10	.005	.942
	>55	65	56	9		
Sex	Male	94	79	15	.908	.341
	Female	41	37	4		
Mechanism of Injury	Penetrating	14	14	0	3.402	.183
	Non-penetrating	117	98	19		
AISA Classification	A	41	36	5	8.930	.112
	B	22	20	2		
	C	39	31	8		
	D	28	25	3		
Completeness	Complete (ASIA A/B)	63	56	7	.767	.381
	Incomplete (AISA C/D)	67	56	11		
Level of Injury	Cervical or thoracic	118	101	17	.086	.770
	Lumbar or sacral	17	15	2		
Time Since Injury	≤5 years	24	20	4	.123	.726
	>5 years	108	93	15		
Degree of pain at initial stay	<5	37	30	7	.989	.320
	≥5	98	86	12		
Employment status	Yes	49	42	7	.003	.957
	No	86	74	12		

431 *Neuropathic and nociceptive pain groups derived from SCIPI (neuropathic = SCIPI ≥2; nociceptive = SCIPI <2).

432 ASIA = American Spinal Injury Association [Impairment Scale]

433

434
 435
 436 Table 2: Pain Severity

	Sub-Group	Mean Neuropathic			Mean Nociceptive		
		Pain Score	T-value	p-value	Pain Score	T-value	p-value
Age	<55	56.0	.906	.367	52.9	1.042	.300
	>55	54.3			51.1		
Sex	Male	54.0	-2.053	.043 [^]	52.0	.008	.994
	Female	58.0			52.0		
Mechanism of Injury	Penetrating	57.5	-.869	.387	55.9	-1.692	.094
	Non-penetrating	55.1			51.5		
Completeness	Complete (ASIA A/B)	53.2	-1.891	.061 [†]	52.0	.113	.910
	Incomplete (ASIA C/D)	56.6			51.8		
Level of Injury	Cervical or thoracic	54.7	-1.476	.143	51.5	-1.977	.051 [†]
	Lumbar or sacral	58.9			56.7		
Time Since Injury	≤5 years	54.4	-.376	.708	49.2	-1.656	.101
	>5 years	55.3			52.8		
Degree of pain at initial stay	<5	52.2	-2.144	.037 [^]	48.8	-2.413	.018 [^]
	≥5	56.4			53.3		
Employment status	Yes	54.7	-.429	.668	51.4	-.632	.529
	No	55.5			52.5		

437 *Neuropathic and nociceptive pain scores derived from neuropathic 5a (PROMIS-Neur), PROMIS nociceptive 5a
 438 (PROMIS-No) values. ASIA = American Spinal Injury Association [Impairment Scale]

439 [^]statistical significance (p <.05)

440 [†]trending towards statistical significance (p>.05 and <.10)

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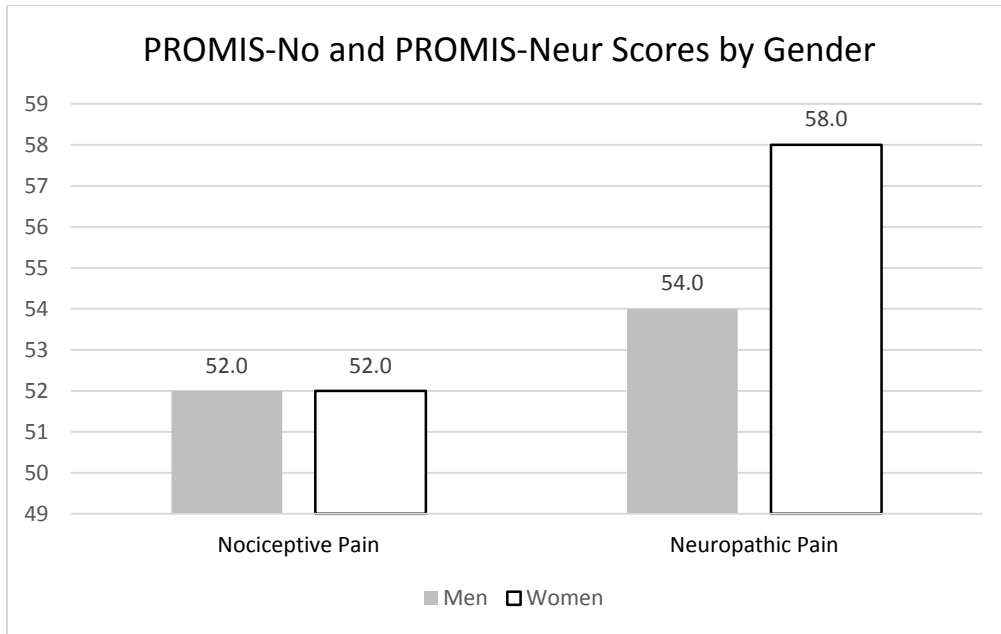
446 Table 3: Pain Severity by ASIA Classification

AISA Score		Mean Neuropathic	ANOVA	Mean Nociceptive	ANOVA
		Pain Score	Significance	Pain Score	Significance
	A	52.1	.161	52.5	.691
	B	54.9		51.0	
	C	55.8		52.8	
	D	57.7		50.2	

447 *Neuropathic and nociceptive pain scores derived from neuropathic 5a (PROMIS-Neur), PROMIS nociceptive 5a
 448 (PROMIS-No) values. ASIA = American Spinal Injury Association [Impairment Scale].

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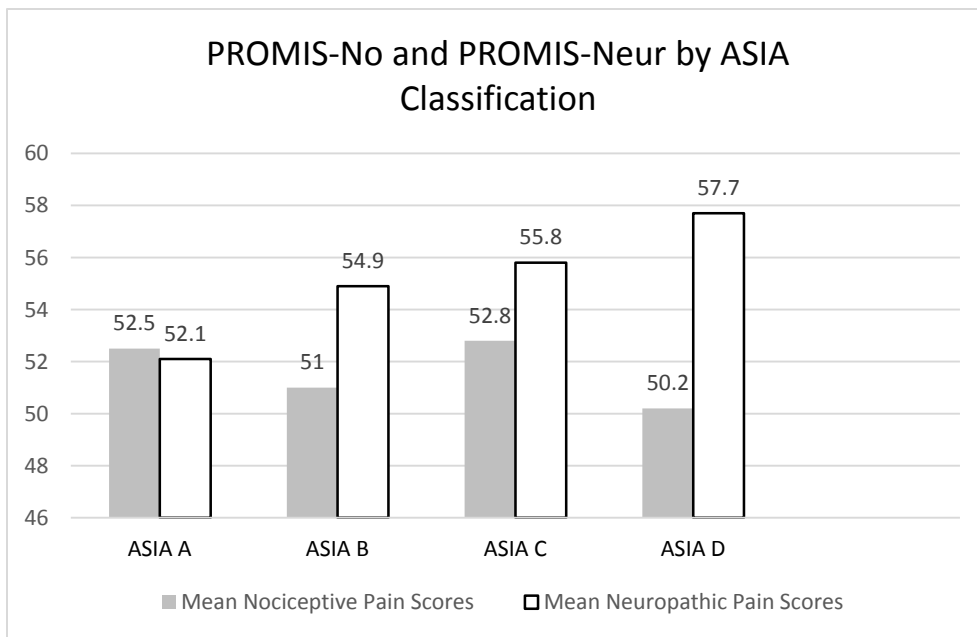
450 **FIGURE 1:**



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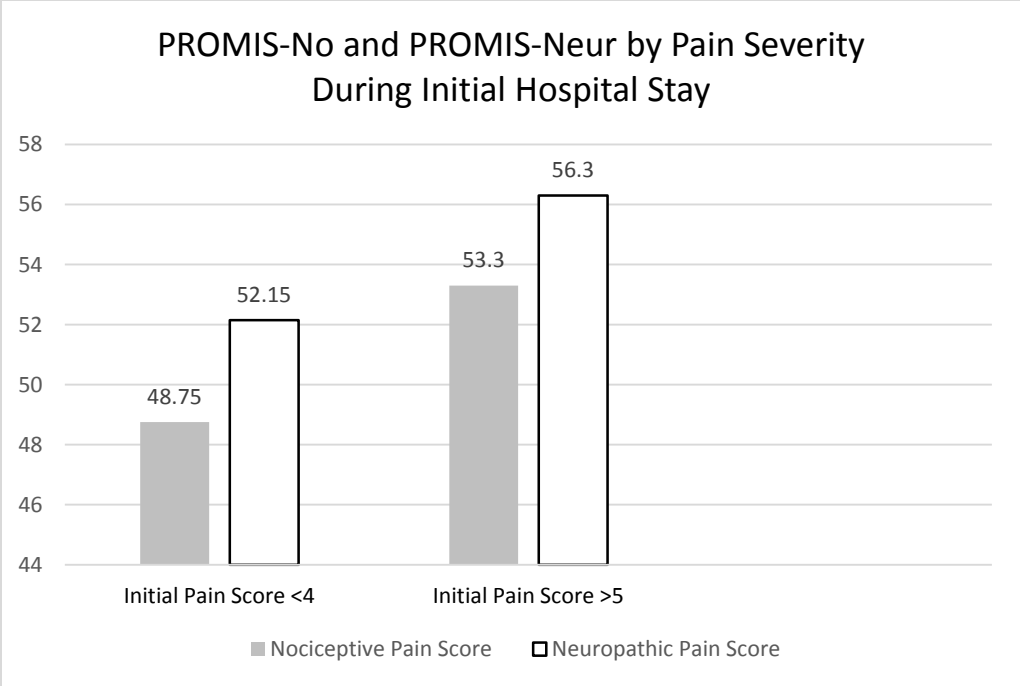
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453 **FIGURE 2:**



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455 **FIGURE 3:**



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FIGURE 1: Women report higher levels of neuropathic pain but not nociceptive pain after SCI

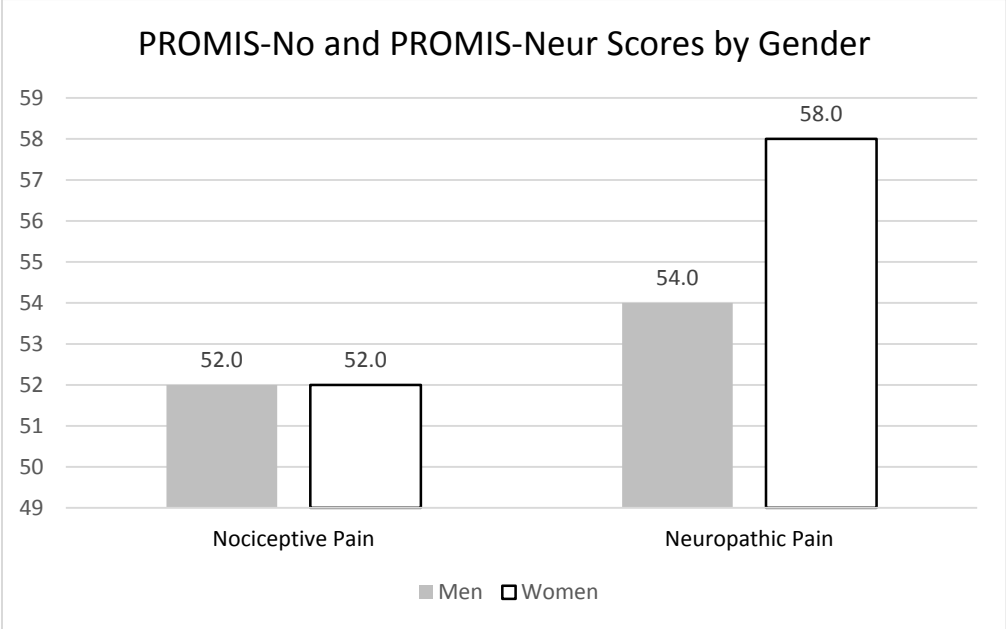


FIGURE2:

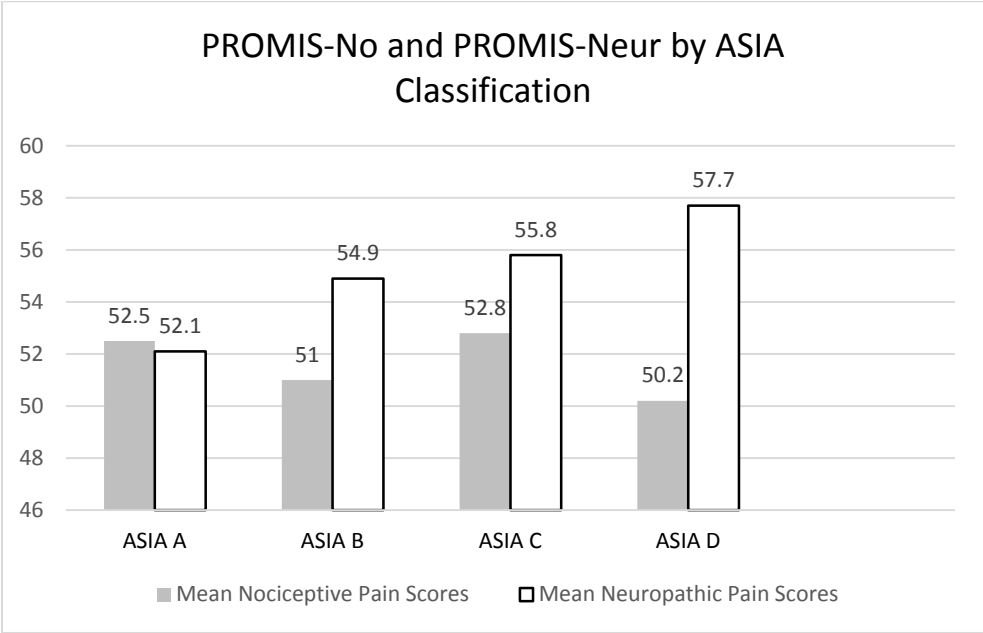
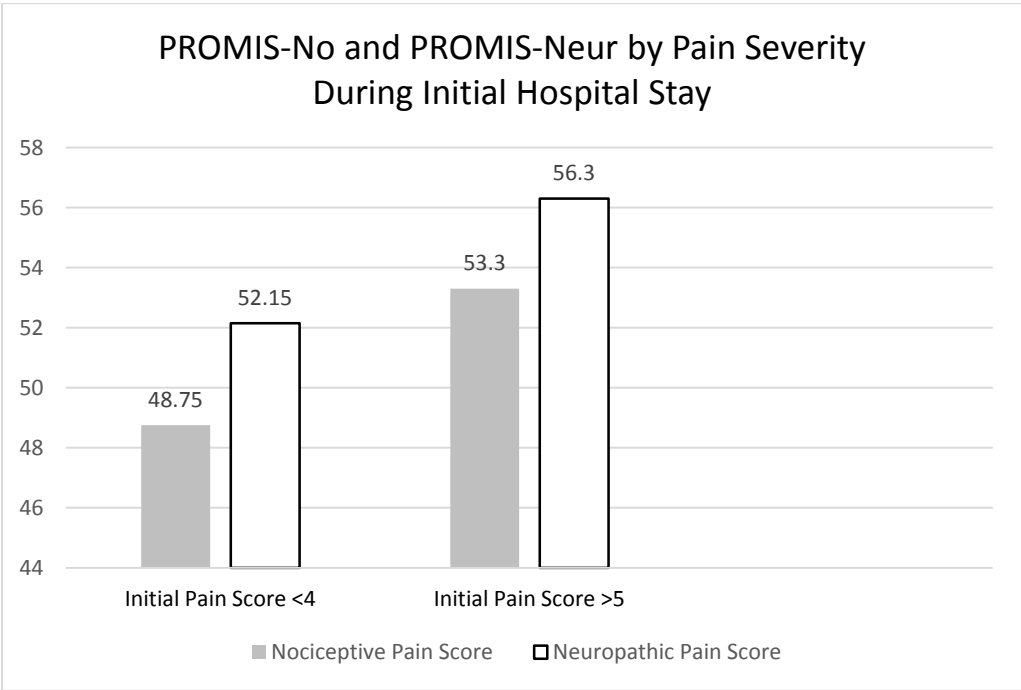


FIGURE 3:



TABLES:

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 ASIA = American Spinal Injury Association [Impairment Scale]

Table 2: Pain Severity

	Sub-Group	Mean Neuropathic			Mean Nociceptive		
		Pain Score	T-value	p-value	Pain Score	T-value	p-value
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