



# Upper extremity musculoskeletal pain during rehabilitation in persons with spinal cord injuries using manual wheelchairs

Bo Ra Kang<sup>a</sup>, Dong Hee Cho<sup>b</sup>, Han Seung Kim<sup>b</sup>, Si-Nae Ahn<sup>c</sup>

<sup>a</sup>Department of Occupational Therapy, Yonseimadu Hospital, Goyang, Republic of Korea

<sup>b</sup>Department of Rehabilitation Medicine, Yonseimadu Hospital, Goyang, Republic of Korea

<sup>c</sup>Department of Occupational Therapy, Cheongju University, Cheongju, Republic of Korea

**Objective:** The purpose of this study was to investigate the relationship between physical features, strength, function, and upper extremity musculoskeletal pain during rehabilitation of manual wheelchair users with spinal cord injuries.

**Design:** Cross-sectional study.

**Methods:** The degree and frequency of upper extremity musculoskeletal pain were measured in persons with spinal cord injuries using manual wheelchairs with the use of questionnaires. The pain scores of the hand, wrist, and shoulder joints were calculated by multiplying the seriousness and frequency of pain. We collected data on the manual muscle test, Spinal Cord Independent Measure-III, and the Body Mass Index. Statistical analysis was performed by descriptive analysis and Pearson's correlation analysis.

**Results:** A total of 47 patients participated in this study and the neurological level of the injuries ranged from C2 to S5. Pain in the shoulder joints was the most common in persons with tetraplegia and paraplegia. Pain was experienced as mild to moderate, and occurred one or more times a week. Of the 32 persons with paraplegia, the most common area of complaint was the shoulder. Of the 15 persons with paraplegia, the shoulder joints were the most common site of pain. The independence levels of the persons with spinal cord injuries were highly correlated to muscle strength levels ( $p < 0.05$ ).

**Conclusions:** This study investigated upper extremity musculoskeletal pain during rehabilitation of manual wheelchair users with spinal cord injuries and the relationship between physical features, strength, and function. In most persons with spinal cord injuries, pain and frequency of shoulder joints were high and pain levels were also related to functional levels.

**Key Words:** Pain, Paraplegia, Spinal cord injury, Tetraplegia

## Introduction

Recently, the incidence of spinal cord injuries has been increasing due to various accidents, mainly occupation-related accidents [1]. Most patients with spinal cord injury suffer from quadriplegia and paraplegia. Spinal cord injury results in loss of sensory and motor abilities due to neurological damage, which negatively affects the quality of life [1-4]. Furthermore, upper extremity function influences not

only activities of daily living but also ambulation [5].

Generally, the use of wheelchairs by persons with spinal cord injuries can improve day-to-day activities and social participation [6]. However, at least half of those with spinal cord injuries have pain in both shoulders for more than one year [7]. The pain suffered by those with spinal cord injuries usually occurs in the performance of daily living activities, such as propelling a wheelchair, ambulation, reaching their arms vertically, or handling a task that requires lots of force

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Corresponding author: Si-Nae Ahn (ORCID <https://orcid.org/0000-0001-8497-6331>)

Department of Occupational Therapy, Cheongju University, 298 Daesung-ro, Cheongju 28503, Republic of Korea

Tel: 82-43-229-7980 Fax: 82-43-229-7980 E-mail: [otlovesn@gmail.com](mailto:otlovesn@gmail.com)

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in the hands [8-10]. In those with spinal cord injuries, upper extremity musculoskeletal pain is predominant in daily activities, and this pain negatively affects quality of life and patient independence. Therefore, addressing the complaints of pain during rehabilitation can have a significant impact on patient progress and duration of rehabilitation.

Various studies have been conducted on persons with spinal cord injuries in terms of manual wheelchair usage, upper extremity musculoskeletal pain, activities of daily living, and physical examination [11-13]. Brian and colleagues described maximal upper limb torque values and the torque of agonist/antagonist in individuals with paraplegia [11]. Pentland and colleagues [12] showed that manual wheelchair usage in persons with long-term paraplegia was associated with upper limb pain and independence in activities of daily living. Samuelsson *et al.* [13] described the consequences of shoulder pain on daily activities in paraplegic manual wheelchair users with spinal cord injuries. However, previous studies on the complaints of pain in these patients are insufficient.

During the rehabilitation period, musculoskeletal pain due to spinal cord injury can significantly influence the patients' progress and time of rehabilitation [14,15]. In previous studies, those with spinal cord injury were not satisfied with their hands, wrists, and elbows, and all joint pain occurred more than three times per week [16]. However, there was a correlation between upper extremity musculoskeletal pain and functional levels, but the current analysis is insufficient.

The ratio of a patient's upper extremity musculoskeletal pain during activities of daily living has been reported to be as high as 70%, which can negatively affect the quality and independence of a patient's life [10]. Therefore, knowledge about the cause and degree of pain will not only help to predict the condition of the patient but also help with the treatment and pain prevention. This study also assumed that upper extremity pain in persons with spinal cord injury had the greatest effect on activities of daily living. Since daily life activities vary greatly depending on the environment and circumstances of the target, various analyzes should be conducted on various topics and environment.

The purpose of this study was to evaluate the degree of upper limb musculoskeletal pain, characteristics of lesions, and correlation of muscle strength and function. We hypothesized that those with quadriplegia are expected to have greater upper limb musculoskeletal pain, whereas persons with greater muscle strength and better function are ex-

pected to have less upper limb musculoskeletal pain of manual wheelchair users.

## Method

### Participants

Forty-seven participants who were hospitalized in Gyeonggi-do, Yonsei-madu Hospital from October 17, 2018 to January 26, 2018 were included in this study. Participants were classified as A, B, C, or D according to the impairment scale of the American Spinal Injury Association (ASIA).

The inclusion criteria were as follows; (1) patients who used a manual wheelchair, (2) patients who did not have complications, such as fractures or pressure ulcers, (3) patients without cognitive impairments with an MMSE-K score of 24 points or more, and (4) patients who understood the purpose and agreed to participate in the study. The exclusion criteria were as follows; (1) patients with a progressive disease, (2) patients with psychiatric problems, (3) injury duration of 6 months or more, and (4) patients who did not use a manual wheelchair.

A total of 47 patients participated in this study. The Figure 1 demonstrates the neurological level of the injuries ranging from C2 to S5. The general characteristics of participants are summarized in Table 1. All participants used a manual wheelchair. All participants had been in rehabilitation for more than 6 months after the onset. The duration of the onset was 24 patients (51.1%) between 6 months and 1 year, 13 patients (27.7%) between 1 and 2 years and 10 patients (21.3%) for more than 2 years.

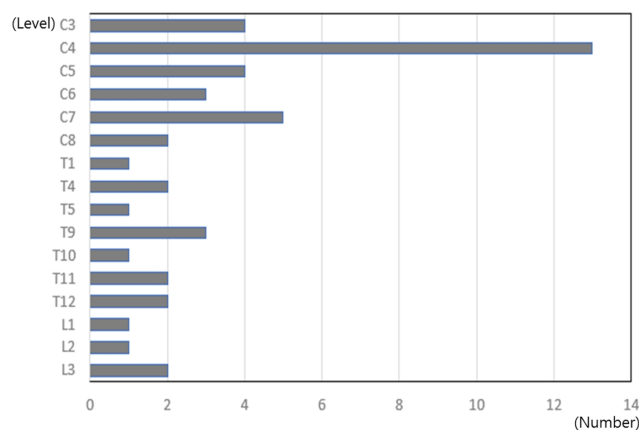


Figure 1. Distribution of level.

**Table 1.** General characteristics of participants (N=47)

Classification	Value	Mean (SD)
Sex		
Male	32 (68.1)	
Female	15 (31.9)	
Onset (y)		
Less than 1	24 (51.1)	
1 to 2	13 (27.7)	
2 or over	10 (21.3)	
Lesion		
Tetraplegia	32 (68.1)	
Paraplegia	15 (31.9)	
ASIA		
A	13 (27.7)	
B	4 (8.5)	
C	14 (29.8)	
D	16 (34.0)	
Age (y)		54.11 (16.66)
Height (cm)		167.32 (9.98)
Weight (kg)		64.09 (10.83)
BMI (kg/m <sup>2</sup> )		22.84 (2.87)
MMT		41.26 (16.91)
SCIM-III		36.00 (20.94)

Values are presented as n (%) or mean (SD).

ASIA: American Spinal Injury Association, BMI: body mass index, MMT: manual muscle test, SCIM-III: Spinal Cord Independent Measure-III.

### Experimental procedure

The study method was approved by the Institutional Review Board of Cheongju University (IRB No. 1041107-201812-HR-030-01) and informed consent was obtained. The characteristics (level and completeness) of lesions and general characteristics were evaluated by doctors in accordance with international standards on the classification of nerves in persons with spinal cord injuries.

According to a previous study by van Drongelen *et al.* [16], this study measured pain that the participants responded via a quantified survey when they experienced intramuscular pain in the wrists, elbows, and shoulders. A score of 0 was given when they felt no musculoskeletal pain in each joint, and a 1 when they experienced pain in each joint. Furthermore, the participants were asked how often they experienced the pain and how severe it was. The severity of pain was measured using the Likert scale, which ranges from 1 to 5, and the pain was subjectively measured from minor to extremely severe. To measure the frequency of pain, a score of 1 was assigned when patients experienced pain less than once a week; 2, when they experienced pain 2

or 3 times a week; and 3, when they experienced pain more than 3 times a week. The total score of the upper limb pain was calculated from the score of each joint according to severity and frequency of pain.

### Measurement

For the measurement of strength, the strength of six muscle groups (wrist extensor, elbow flexor, elbow extensor, shoulder internal rotator, shoulder external rotator and shoulder abductor) was measured through a standardized manual muscle test (MMT). The scale for the MMT ranges from 0 to 5 points with the following criteria: a score of zero is a state without muscle contraction, a score of one is touched and there is visible muscle contraction, a score of 2 indicates a state with active motion through the entire range of motion (ROM) from which gravity has been removed, a score of 3 indicates active motion through the entire ROM, a score of 4 indicates the ability to do full ROM against resistance, and a score of 5 indicates the ability to do full ROM with maximum resistance [17]. The scores for each muscle group were then summed to determine the MMT score.

The Spinal Cord Independent Measure-III (SCIM-III) was used for daily activity assessment. The score can range from 0 to 100 points, across three subdomains; self-care scores from 0 to 20, respiration and sphincter management scores from 0 to 40, and mobility scores from 0 to 40. The questionnaire contained 19 items, covering all the three subdomains [18].

Body Mass Index (BMI) is widely used and is calculated with the body weight divided by the height in square meters (m<sup>2</sup>). According to the criteria of the World Health Organization, competent adults can be classified as underweight, normal weight, overweight or obese [19]. BMI was positively correlated in patients with spinal cord injury [20].

### Data analysis

The IBM SPSS Statistics ver. 22.0 software (IBM Co., Armonk, NY, USA) was used for statistical analysis. Among the general characteristics of patients, such as age, height, weight, and BMI, were described by descriptive statistics. The onset with spinal cord injuries, ASIA scale, and the level of damage were described with percentages. Statistical analysis was performed by descriptive analysis and Pearson's correlation analysis. Statistical significance was set at 0.05.

## Results

### Descriptive pain according to classification of lesion

In this study, classification of lesions was analyzed according to the complaint rate of descriptive pain (Table 2). Among the tetraplegic patients, 28 patients (87.5%) complained of pain in the right shoulder joint and 27 patients (84.4%) complained of pain in the left shoulder joint. Likewise, among the persons with paraplegia, the greatest area of complaint caused by pain was the shoulder joint. Eleven patients (73.3%) had right and left shoulder joint pain. In addition, the upper extremity joints with the highest severity and frequency of pain were the shoulder joints in all participants.

Table 3 shows the results of the analysis of the difference

in pain of the upper limb joint according to the ASIA level. There was no statistically significant difference in the severity and frequency of pain according to the classification of the ASIA level. However, the severity of the pain was different in the left shoulder joint, and the frequency of the pain was different in the left elbow joint. Overall, shoulder pain was higher than other joints.

### Relationship between muscle pain, lesion, MMT, SCIM-III, BMI, and age with tetraplegia

Table 4 shows the correlation analysis results of participants with tetraplegia. In the case of tetraplegia, muscle pain and other factors were negatively correlated but were not statistically significant ( $p>0.05$ ). The highest correlation among these factors was lesion and MMT scores ( $r=0.706$ ,

**Table 2.** Descriptive pain data

(N=47)

Pain	Hand wrist		Elbow		Shoulder	
	Left	Right	Left	Right	Left	Right
Complaint rate						
TP (n=32)	27 (84.4)	26 (81.3)	26 (81.3)	25 (78.1)	27 (84.4)	28 (87.5)
PP (n=15)	10 (66.7)	10 (66.7)	9 (60.0)	9 (60.0)	11 (73.3)	11 (73.3)
Seriousness	1.55 (1.27)	1.51 (1.21)	1.00 (0.96)	1.00 (0.96)	1.83 (1.45)	1.89 (1.22)
Frequency	1.30 (1.02)	1.32 (1.04)	0.94 (0.73)	1.00 (0.86)	1.57 (1.05)	1.66 (1.03)

Values are presented as n (%) or mean (SD) (score of seriousness and frequency).

TP: tetraplegia, PP: paraplegia.

**Table 3.** Pain data of upper limb joint according to ASIA level

(N=47)

Pain	ASIA level				F (p)
	A (n=13)	B (n=4)	C (n=14)	D (n=16)	
Seriousness					
Wrist-R	1.69 (1.37)	1.50 (1.29)	1.78 (1.18)	1.12 (1.08)	0.868 (0.465)
Wrist-L	1.76 (1.48)	1.50 (1.00)	1.92 (1.43)	1.06 (0.85)	1.375 (0.263)
Elbow-R	0.92 (0.49)	0.75 (0.50)	1.14 (1.02)	1.00 (1.26)	0.212 (0.887)
Elbow-L	1.15 (0.89)	1.50 (1.00)	1.15 (1.23)	0.62 (0.61)	1.444 (0.243)
Shoulder-R	2.15 (1.21)	2.25 (1.15)	2.00 (1.24)	1.50 (1.15)	0.895 (0.451)
Shoulder-L	2.69 (1.70)	1.25 (1.25)	1.71 (1.32)	1.37 (1.14)	2.533 (0.070)
Frequency					
Wrist-R	1.69 (1.18)	1.00 (0.81)	1.21 (0.97)	1.18 (1.04)	0.798 (0.502)
Wrist-L	1.69 (1.10)	1.50 (1.00)	1.28 (0.99)	0.93 (0.92)	1.404 (0.255)
Elbow-R	1.00 (0.57)	0.75 (0.50)	1.14 (0.86)	0.93 (1.12)	0.257 (0.856)
Elbow-L	1.07 (0.64)	1.50 (1.10)	1.07 (0.82)	0.56 (0.51)	2.771 (0.053)
Shoulder-R	1.84 (0.89)	1.75 (1.25)	1.78 (1.05)	1.37 (1.08)	0.617 (0.608)
Shoulder-L	2.00 (1.15)	1.25 (0.95)	1.61 (0.96)	1.25 (1.00)	1.398 (0.257)

Values are presented as mean (SD).

ASIA: American Spinal Injury Association, R: right, L: left.

**Table 4.** Correlations between the joint pain, lesion, MMT, SCIM-III, and BMI with tetraplegia (N=32)

Assessment	Lesion	MMT	SCIM-III	BMI	Age
Joint pain	-0.208	-0.182	-0.177	-0.140	-0.028
Lesion		0.706*	0.418**	0.225	-0.031
MMT			0.671*	0.268	0.127
SCIM-III				0.347	0.122
BMI					-0.060

Values are Pearson's correlation coefficients.

MMT: manual muscle test, SCIM-III: Spinal Cord Independent Measure-III, BMI: body mass index.

\* $p < 0.05$ , \*\* $p < 0.01$ .

**Table 5.** Correlations between the joint pain, lesion, MMT, SCIM-III, and BMI with paraplegia (N=15)

Assessment	Lesion	MMT	SCIM-III	BMI	Age
Joint pain	-0.103	0.004	0.244	0.261	-0.013
Lesion		-0.215	0.193	-0.011	0.259
MMT			0.556*	-0.212	0.072
SCIM-III				0.280	0.057
BMI					0.036

Values are Pearson's correlation coefficients.

MMT: manual muscle test, SCIM-III: Spinal Cord Independent Measure-III, BMI: body mass index.

\* $p < 0.05$ .

$p < 0.05$ ), followed by MMT and SCIM-III ( $r = 0.671$ ,  $p < 0.05$ ).

#### Relationship between muscle pain, lesion, MMT, SCIM-III, BMI, and age with paraplegia

Table 5 shows the results of the correlation analysis of the participants with paraplegia. Muscle pain, lesions, MMT, SCIM-III, BMI, and age were negatively correlated but were not statistically significant ( $p > 0.05$ ). With paraplegia, statistically significant correlations were found only in MMT and SCIM-III scores among these factors ( $r = 0.556$ ,  $p < 0.05$ ).

## Discussion

The purpose of this study was to examine upper limb musculoskeletal pain during rehabilitation of manual wheelchair users with spinal cord injuries, as well as the relationship between features, strength, and function. We collected data on the severity of pain, lesions, MMT, SCIM-III, BMI variables from persons with spinal cord injuries and then determined their relevance. Among these factors, pain in the shoulder joints was the most common in persons with tetraplegia and paraplegia. Pain was mild to moderate and occurred more than once a week. van Drongelen *et al.* [16] measured pain in the same way as in this study. According to previous stud-

ies, those with tetraplegia reported more complaints in their hands, wrists, and elbows when compared to those with paraplegia, and pain in all joints occurred three or more times a week. The results of previous studies were different from those of the present study because pain is related to the physical condition and psychological state of a person. Therefore, pain is difficult to evaluate because it is subjective, and is not a physical measurement.

In persons with tetraplegia, there was no significantly correlation between muscle pain and other factors. However, there was a positive correlation between lesions and MMT scores, and MMT and SCIM-III scores in those with tetraplegia. In those with paraplegia, there was no significantly correlation between muscle pain and other factors. However, there were correlations between MMT and SCIM-III scores in persons with paraplegia. Pain is defined as a disagreeable sensation and emotional experience associated with damage, or is explained in relation to such damage [21].

Measures of pain used in this study have not been validated or used in previous studies. Similar to previous studies, a questionnaire was used to determine a participant's pain characteristics [22]. This study examined the presence or absence of pain in each joint in the upper extremity, and

investigated the severity and frequency of overall pain. In previous studies, shoulder pain as well as upper extremity pain were significantly correlated with functional outcomes [16]. However, there were no significant correlations between pain and functional outcomes in both the tetraplegia and paraplegia groups in this study. The differences in these results were due to the subjectiveness of pain, which was likely to be influenced by general and demographic characteristics of the participants.

The shoulder flexor and extensor tendons are used mainly for strengthening of spinal cord injured persons. However, in this study, the muscles of the rotator cuff of the upper arm, which stabilizes the shoulder bones, were measured. The muscles of the rotator cuff of the upper limb are frequently used but can be painful, as well as the abdominal muscles in spinal cord injured patients. Further studies are needed to investigate the pain in the shoulder flexor and extensor muscles that are frequently used by spinal cord injuries and perform strength training.

Nevertheless, it was clear that people suffering from spinal cord injuries, whether tetraplegia or paraplegia, often have chronic pain that can have an important influence on their quality of life. However, there were some limitations to this study. The recruitment of the subjects was performed in one institution, and it was difficult to generalize them to all persons with spinal cord injuries because the number of subjects was low. Furthermore, because pain was evaluated only on a nominal scale, there was a limit to the analysis. In future studies, more subjects should be recruited, pain should be assessed on an ordinal scale, and various analyses should be performed.

In conclusion, we presented methods to evaluate pain in manual wheelchair users with spinal cord injuries, in addition to discussing the recent advances in the considering of underlying related factors, and current evidence-based treatments of pain in these patients.

## Conflict of Interest

The authors declared no potential conflicts of interest with respect to the authorship and/or publication of this article.

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