Spinal Cord (1999) 37, 58–61

http://www.stockton-press.co.uk/sc

Relationship between shoulder muscle strength and functional independence measure (FIM) score among C6 tetraplegics

Toshiyuki Fujiwara[1], Yukihiro Hara[2], Kazuto Akaboshi[2] and Naoichi Chino[2]

[1]*Keio University Tsukigase Rehabilitation Center, 380-2 Tsukigase, Amagiyugashima, Tagata, Shizuoka, 410-3215;* [2]*Department of Rehablitation Medicine, Keio University School of Medicine, 35 Shinanomachi, Shinjyuku-ku, Tokyo, 160-0016, Japan*

The degree of disability varies widely among C6 tetraplegic patients in comparison with that at other neurological levels. Shoulder muscle strength is thought to be one factor that affects functional outcome. The aim of this study was to examine the relationship between shoulder muscle strength and the Functional Independence Measure (FIM) motor score among 14 complete C6 tetraplegic patients. The FIM motor score and American Spinal Injury Association (ASIA) motor score of these patients were assessed upon discharge. We evaluated muscle strength of bilateral scapular abduction and upward rotation, shoulder vertical adduction and shoulder extension by manual muscle testing (MMT). The total shoulder strength score was calculated from the summation of those six MMT scores. The relationships among ASIA motor score, total shoulder strength score and FIM motor score were analyzed. The total shoulder strength score was significantly correlated with the FIM motor score and the score of the transfer item in the FIM. In the transfer item of the FIM, the total shoulder strength score showed a statistically significant difference between the Independent and Dependent Group. Shoulder muscle strength appears to be an important factor in the functional abilities of those with C6 complete tetraplegia. Functional variation depends on the strength of shoulder muscles, especially among C6 tetraplegics.

Keywords: spinal cord injuries; functional independence measure (FIM); shoulder muscles; American Spinal Injury Association (ASIA) motor score; tetraplegia

Introduction

The neurological level of lesion is a primary factor for predicting functional outcome in spinal cord injuries. The degree of disability varies widely among C6 complete tetraplegic patients in comparison with injuries at other neurological levels.[1–7] As for activities of daily living (ADL) in tetraplegic patients, shoulder muscles play a key role in pushing-up motion, reaching action and trunk support. Some studies reported that *serratus anterior* muscle, upper part of *pectoralis major* muscle and *latissimus dorsi* muscle might play important roles in ADL, especially in transfer motion.[7–10] There are many measurements of upper extremity function among tetraplegics, but few evaluate shoulder function. Zancolli's classification mainly evaluates forearm function for recostructive surgery.[11] The American Spinal Injury Association (ASIA) classification includes evaluation of the strength of *deltoid* muscle but not of other muscles of the shoulder girdle.[12]

We propose that the strength of the *serratus anterior* muscle, upper part of *pectoralis major* muscle and *latissimus dorsi* muscle may greatly influence the ADL among C6 complete tetraplegic patients. The aim of this study was to examine the relationship between the strength of those three shoulder muscles and the Functional Independence Measure (FIM)[13] motor score among patients with C6 complete tetraplegia.

Subjects

Subjects were 14 C6 complete tetraplegic patients (two females and 12 males) discharged from the National Murayama Hospital during a 3-year period from 1995 to 1997, with a mean age of 30.7 years (range 13–62 years). Neurological level and impairment scale were determined according to the standard of ASIA[12] Mean length of time from injury was 462.0 days (169–1080).

Method

FIM motor score and ASIA motor score of all subjects were assessed on discharge by two physiatrists. The information of activities of daily living was gathered from observation and interview with patients, therapists and nurses. Same physiatrists evaluated

Correspondence: Dr T Fujiwara

muscle strength for bilateral scapular abduction and upward rotation, shoulder vertical adduction and shoulder extension by manual muscle testing (MMT).[14] The total shoulder strength score was defined as the sum of those six MMT scores: (1) We examined relationships among the ASIA motor score, total shoulder strength score and FIM motor score; (2) Among FIM items we focused on the bed-wheel chair transfer item and examined the relationships of this item to the ASIA motor score and total shoulder strength score; (3) According to the FIM score for bed-wheelchair transfer, we classified the subjects into two groups: Independent and Dependent. The subjects in the Independent Group had scored 6 or more points in bed-wheelchair transfer, while the Dependent Group scored below 6 points. A score of 6 or higher indicates the ability for the patient to make the transfer without assistance. A score below 6 points indicates the need for such assistance. Age, ASIA motor score and total shoulder strength score of each group were analyzed. Statistical analysis was performed using the Spearman's rank correlation test and Mann-Whitney test.

Results

Mean FIM motor score was 53.2 (25–72), mean ASIA motor score was 20.1, (15–24), and mean total shoulder strength score was 24.6 (20–28).

ASIA motor score–FIM motor score
The ASIA motor score moderately correlated with the FIM motor score. Spearman's rank correlation coefficient was 0.73 ($P<0.01$) (Figure 1). Although five subjects had the same ASIA motor score (22 points), the FIM motor scores ranged widely among these patients (47 to 72).

Total shoulder strength score–FIM motor score
Figure 2 shows the relationship between the total shoulder strength score and the FIM motor score. The total shoulder strength score correlated significantly with the FIM motor score. Spearman's rank correlation coefficient was 0.95 ($P<0.001$). Five subjects had a total shoulder strength score of 28 points, whereas their FIM motor scores were all over 60 points (64–72).

We performed statistical comparison of correlation coefficients of the total shoulder strength score with the FIM motor score and of the ASIA motor score with the FIM motor score. There was a statistically significant difference in those two correlation coefficients ($P<0.05$).

ASIA motor score–transfer item score
Figure 3 shows the relationship between the ASIA motor score and FIM transfer score. The ASIA motor score correlated with the FIM transfer score, and the Spearman's correlation coefficient was 0.64 ($P<0.01$).

Total shoulder strength score–transfer item score
Figure 4 shows the correlation of the total shoulder strength score with the FIM transfer score. The total

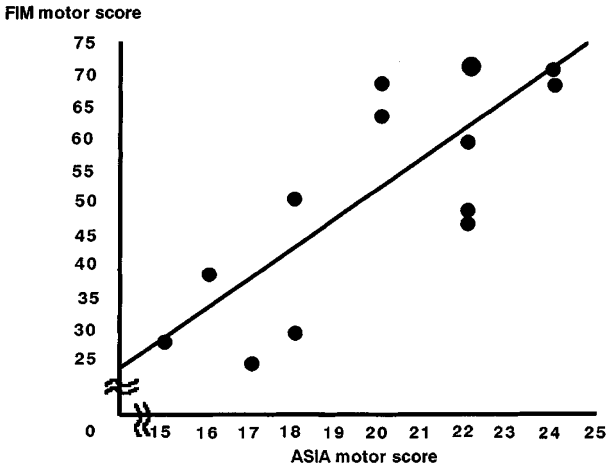

Figure 1 Relationship between ASIA motor score and FIM motor score: The ASIA motor score moderately correlated with the FIM motor score. Spearman's rank correlation coefficient was 0.73 ($P<0.01$). Small closed circle indicated one subject and larger closed circle two subjects

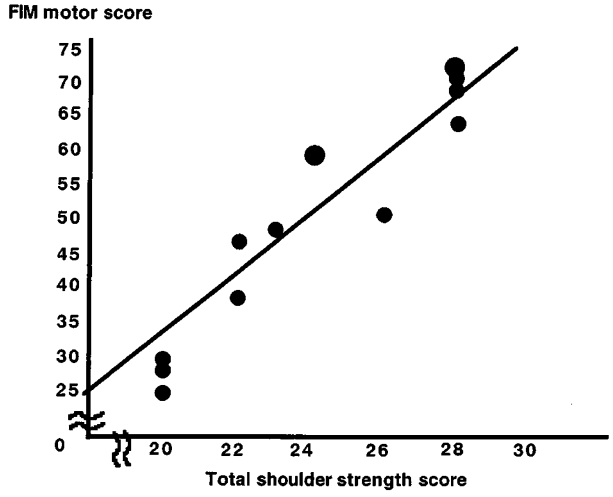

Figure 2 Relationship between total shoulder strength score and FIM motor score: The total shoulder strength score significantly correlated with the FIM motor score. Spearman's rank correlation coefficient was 0.95 ($P<0.001$). Small closed circle indicated one subject and larger closed circle two subjects

shoulder strength score significantly correlated with the FIM transfer score. The Spearman's correlation coefficient was 0.93 ($P<0.001$). There was a statistically significant difference between correlation coefficient of the total shoulder strength score and that of the ASIA motor score with the FIM transfer score. $P<0.05$).

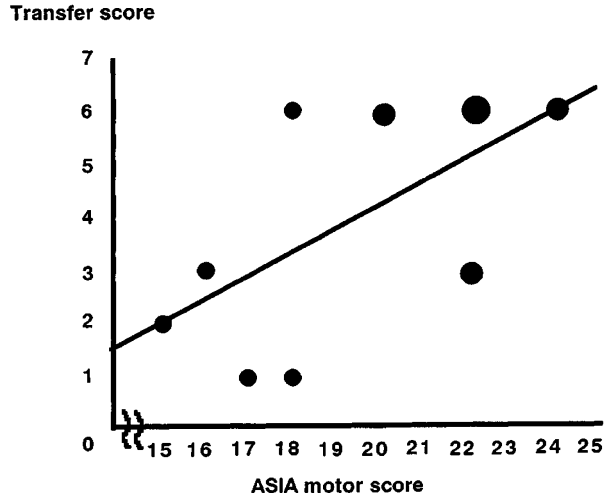

Figure 3 Relationship between ASIA motor score and Bed-Wheelchair transfer item score of FIM: The ASIA motor score moderately correlated with the FIM transfer score. Spearman's rank correlation coefficient was 0.64 ($P<0.01$). Small closed circle indicated one subject, medium circle did two subjects and large one did three subjects

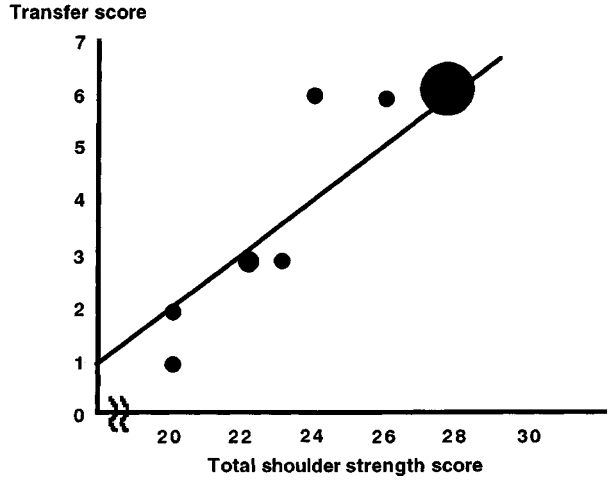

Figure 4 Relationship between total shoulder strength score and Bed-Wheelchair transfer score of FIM: The total shoulder strength score significantly correlated with the FIM transfer score. Spearman's rank correlation coefficient was 0.93 ($P<0.001$). Small closed circle indicated one subject, medium circle did two subjects and large one did seven subjects

Transfer independent and dependent groups

The Independent Group included eight subjects and the Dependent Group 6 subjects. The two females were included in the Dependent Group. The mean age of the Independent Group was 26.8 (13–47) and that of the Dependent Group was 35.8 (16–62), a difference which was not significant.

The mean ASIA motor score for the Independent Group was 21.5 (18–24) and that for the Dependent Group was 18.3 (15–22), which was not statistically significant. (Figure 5).

The mean total shoulder strength score for the Independent Group was 27.2 and that for the Dependent Group was 21.1 (Figure 6). These values indicated a statistically significant difference ($P<0.05$).

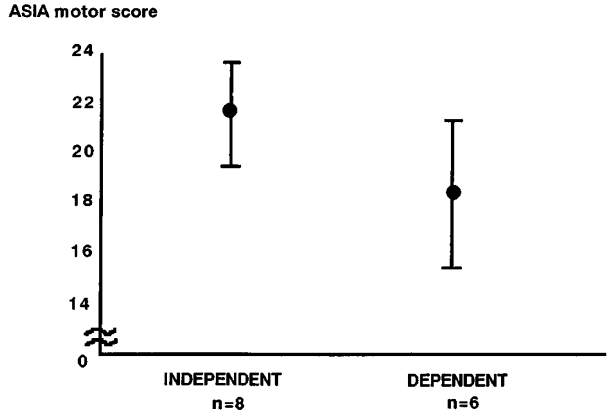

Figure 5 Mean ASIA motor score of transfer independent group and dependent group: The mean ASIA motor score for the independent group was 21.5 and that for the dependent group was 18.3. No statistically significant difference was found. (Mann-Whitney test)

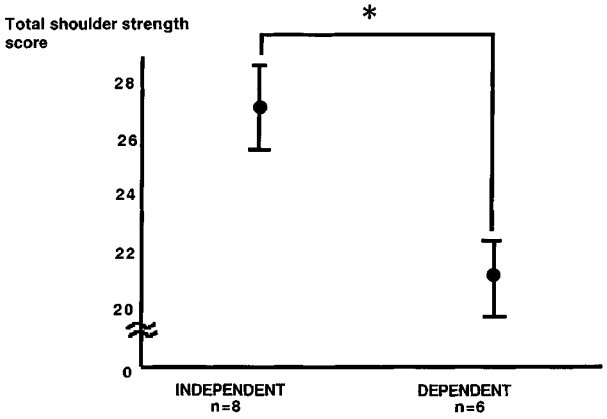

Figure 6 Mean total shoulder strength score of transfer independent group and dependent group: The mean total shoulder strength score for the independent group was 27.2 and for the dependent group was 21.1. *These values indicated a statistically significant difference ($P<0.05$). (Mann-Whitney test)

Discussion

Predicting functional outcome is an important issue in rehabilitation of spinal cord injuries. Neurological level, completeness of paralysis, spasticity, age and sex have some affect on functional outcome. Many authors agree that the neurological level is the most important factor for predicting functional outcome.[1,3,7] C5 tetraplegic patients are independent only in eating and with indoor wheelchair locomotion,[3,7] while C7 tetraplegics are almost independent with self-care items, transfer and wheelchair locomotion.[2,7] Subjects with C5 and C7 neurological level injuries generally tend to have consistent functional abilities which are determined by their neurological level. However, some patients with spinal cord lesions at C6 can achieve total independence in self-care and transfer tasks while others cannot. The degree of disability varies widely among C6 complete tetraplegic patients in comparison with that in other levels of injuries.[1–4]

In general, there are wide differences in the FIM motor score despite the same neurological level (C6) and similar ASIA motor scores. Compared with the total shoulder strength score, the ASIA motor score roughly reflected the FIM motor score and FIM transfer item score. The correlation coefficient between total shoulder strength score and FIM motor score was higher than that between the ASIA motor score and FIM motor score.

In the transfer item of the FIM, there was a statistically significant difference in the total shoulder strength score between the Independent and the Dependent Groups. The total shoulder strength score reflects the strengths of *serratus anterior* muscle, upper part of *pectoralis major* muscle and *latissimus dorsi* muscle. The ASIA motor score includes only the strength of the *deltoid* muscle among the shoulder girdle muscles. In transfer and push-up motions, tetraplegic patients need to lift and move their bodies by the upper extremities. It is supposed that the muscles in the shoulder girdle, especially the *serratus anterior* muscle, upper part of *pectoralis major* muscle and *latissimus dorsi* muscle, play a key role in those motions.[7–10] The *serratus anterior* muscle is innervated from C5 to C7, the upper part of *pectoralis major* from C5 to C7, and the *latissimus dorsi* muscle from C6 to C8.[15] Therefore, these muscles are partially innervated among C6 tetraplegics according to neurological anatomy. Shoulder muscle strength could reflect the degree of disability among C6 complete tetraplegics, and functional variation depend on the degree of strength in these muscles.

Our findings are based on new spinal cord injury subjects just post-rehabilitation. We must wonder whether over time, say 4–10 years post injury, the influence of shoulder muscle strength on function changes or is superseded by other less physical factors (eg depression, social support, lifestyle, employment, etc).

We concluded that these three shoulder muscles play an important role in functional independence, especially in relation to transfer tasks among C6 complete tetraplegics. Total shoulder strength score is correlated with the functional level which C6 complete tetraplegic patients have already achieved. The predictive aspect of total shoulder strength score is still to be done.

References

1 Ota *et al*. Functional assessment of patients with spinal cord injury: measured by the motor score and the Functional Independence Measure. *Spinal Cord* 1996; **34:** 531–535.
2 Yarkony GM, Roth EJ, Heinemann AW, Lovell L. Rehabilitation outcomes in C6 tetraplegia. *Paraplegia* 1988; **26:** 177–185.
3 Yarkony GM, Roth EJ, Lovell L, Heinemann AW. Rehabilitation outcomes in complete C5 quadriplegia. *Am J Phys Med Rehabil* 1988; **67:** 73–76.
4 Marino RJ, Rider-Foster D, Maissel G, Ditunno JF Jr. Superiority of motor level over single neurological level in categorizing tetraplegia. *Paraplegia* 1995; **33:** 510–513.
5 Menter RR *et al*. Impairment, Disability, Handicap and Medical Expenses of persons aging with Spinal Cord Injury. *Paraplegia* 1991; **29:** 613–619.
6 Welch RD, Lobley SJ, O Sullivan SB, Freed MM. Functional Independence in Quadriplegia: Critical levels. *Arch Phys Med Rehabil* 1986; **67:** 235–240.
7 Formal CS, Cawley MF, Steins SA. Spinal cord injury rehabilitation. 3 Functional outcomes. *Arch Phys Med Rehabil* 1997; **78:** s59–64.
8 Perry J. Normal Upper Extremity kinesiology. *Physical Therapy* 1978; **58:** 265–278.
9 Allison GT, Singer KP, Marshall RN. Muscle activation patterns during transfers in individuals with spinal cord injury. *Australian Journal of Physiotherapy* 1995; **41:** 169–173.
10 Reyes ML *et al*. Electromyographic analysis of shoulder muscles of men with low-level paraplegia during a weight relief raise. *Arch Physic Med Rehabil* 1995; **76:** 433–439.
11 Zancolli E. Structural and Dynamic Bases of Hand Surgery. 2nd edn, 229–262, Lippincott, Philadelphia, 1979.
12 Dituno JF Jr, Young W, Donovan WH, Creasey G. The international standards booklet for neurological and functional classification of spinal cord injury. *Paraplegia* 1994; **32:** 70–80.
13 Data management service (of the uniform data system for medical rehabilitation and the center for functional assessment research): Guide for use of the uniform data set for medical rehabilitation. ver. 3.0. The Buffalo General Hospital/State University of New York at Buffalo, 1990.
14 Daniels L, Worthingham C. Muscle Testing - Techniques of Manual Examination. WB Saunders Co, Philadelphia, 1986.
15 Jenkins DB. Hollinshead's Functional Anatomy of the Limbs and Back. 6th edn. WB Saunders Co, Philadelphia, 1991.