



Rotator Cuff Lesion in Wheelchair Users with Spinal Cord Injury: Does Time of Injury and Medullary Level Interfere? A Retrospective Evaluation

Lesão do manguito rotador em cadeirantes com lesão medular: O tempo de lesão e o nível medular interferem? Uma avaliação retrospectiva

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Abstract

Objective To describe magnetic resonance imaging (MRI) characteristics of shoulders from patients with spinal cord injury (SCI) and to correlate these findings with age, duration of SCI and neurological level.

Method The study sample included patients with thoracic SCI over 18 years of age, who were active wheelchair users and had undergone an MRI of the shoulder from January 2004 to December 2015.

Results We studied 41 shoulders (37 patients), including 27 men (65.9%) and 14 women (34.1%). At the time of MRI, the mean age was 41.9 years and the mean duration of SCI was 9.4 years. The analysis of the relationship between the duration of trauma and severity of the rotator cuff lesion (RCL), as well as between age and the severity of the shoulder injury showed a statistically significant difference ($p < 0.001$), with a positive association in both cases. No statistically significant difference ($p = 0.095$) was observed between the neurological level of the SCI and RCL.

Conclusion In this study, a progressive increase in the severity of the shoulder lesions can be noted with advancing age and a longer duration of SCI. However, level of the SCI does not seem to interfere with RCL.

Level of Evidence Level IV, case series.

Keywords

- ▶ magnetic resonance imaging
- ▶ shoulder
- ▶ spinal cord injuries
- ▶ wheelchairs

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Resumo

Objetivo Descrever as características de ressonância magnética (RM) dos ombros de pacientes com lesão medular (LM) e correlacionar esses achados com idade, duração de LM e nível neurológico.

Método A amostra do estudo incluiu pacientes maiores de 18 anos com LM torácica, que eram cadeirantes ativos e haviam sido submetidos a uma ressonância magnética do ombro de janeiro de 2004 a dezembro de 2015.

Resultados Foram estudados 41 ombros (37 pacientes), incluindo 27 homens (65,9%) e 14 mulheres (34,1%). Na época da ressonância magnética, a média de idade era de 41,9 anos e a duração média da LM era de 9,4 anos. A análise da relação entre a duração do trauma e a gravidade da lesão do manguito rotador (LMR), bem como entre a idade e a gravidade da lesão do ombro mostrou diferença estatisticamente significativa ($p < 0,001$), com associação positiva em ambos os casos. Não foi observada diferença estatisticamente significativa ($p = 0,095$) entre o nível neurológico da LM e da LMR.

Conclusão Neste estudo, pode-se notar um aumento progressivo da gravidade das lesões do ombro com o avanço da idade e uma maior duração da LM. No entanto, o nível da LM não parece interferir com a LMR.

Nível de Evidência Nível IV, série de casos.

Palavras-chave

- ▶ imagem de ressonância magnética
- ▶ ombro
- ▶ traumatismos da medula espinal
- ▶ cadeira de rodas

Introduction

In daily life, patients with spinal cord injury (SCI) require load-bearing use of the upper limbs for transfers and propulsion when using their wheelchairs. Consequently, joint pain and shoulder injuries are expected to occur over time.¹⁻⁴ The scapulothoracic and glenohumeral (GH) kinematics of activities, including transfers and lifting body weight in persons with SCI, have previously been investigated. These studies have shown that positional patterns are associated with a decrease in the subacromial space and the appearance of anterosuperior lesions of the rotator cuff.^{5,6}

The present study aims to describe the characteristics of the shoulders of wheelchair users with thoracic SCI who have been treated at our institution, by analyzing the shoulder magnetic resonance imaging (MRI) findings of these patients.

Materials and Methods

The present study is an observational, cross-sectional (case series) analysis of manual wheelchair patients with thoracic SCI, above 18 years of age, who underwent shoulder MRI, due to complaints of joint pain, from January 2004 to December 2015. We found 37 patients with a total of 41 shoulders. An electronic medical record analysis was performed to determine the sex, the age at the time of MRI, the cause of the SCI, the neurological level (according to American Spinal Injury Association criteria [ASIA]),⁷ the time elapsed from SCI up to the date of the MRI examination, and information on possible shoulder surgeries. All the MRIs were performed on 1.5 T equipment. All the images were simultaneously reviewed by two authors during the analysis of the medical records. They identified presence or absence of arthritis of the GH and acromioclavicular (AC) joints; type of acromion, classified

according to Bigliani et al.,⁸ and the presence or absence of bursitis. The tendons of the supraspinatus, infraspinatus, and subscapularis muscles were analyzed for the presence of tendinitis, partial or complete lesions. The fatty degeneration status of the muscle mass involved was evaluated according to the Goutallier classification.⁹

The collected data was inserted into Microsoft Excel spreadsheets (Microsoft Corp., Redmond, WA, USA), which were also used in the elaboration of graphs. Statistical analyses were completed using IBM SPSS version 21 for Windows (IBM Corp., Armonk, NY, USA). For sample's characterization, a descriptive analysis of the variables' results was made. The variability of the distribution of a quantitative variable was considered low if the coefficient of variation (CV) < 0.20 ; moderate if $0.20 \leq CV < 0.40$ and high if the CV ≥ 0.40 . Samples were tested for normality with the Shapiro-Wilk test, which did not reveal normality in the distributions of age and time of trauma. Given the absence of normality and the ordinal nature level of severity and neurological level of the lesion, the whole inferential approach was non-parametric. The association between two qualitative variables was made using the chi-squared test or, when it was inconclusive, a Fisher exact test was used. The measure used to estimate risk was the odds ratio (OR). In the analysis of the association between a quantitative and a qualitative variable, the comparison of two independent groups was performed by the Mann-Whitney test and more than two independent groups were compared using the Kruskal-Wallis test. The association between two quantitative variables was investigated by the correlation analysis, checking the scatter plot and calculating the Spearman order correlation coefficient. The significance of the correlation coefficients was evaluated by the correlation coefficient test. The correlation between two variables was

considered strong if the correlation coefficient had an absolute value > 0.7 and moderate if its absolute value was in the range between 0.3 and 0.7. All discussions about significance tests were performed considering a maximum significance level of 5% (0.050).

Results

Out of 41 shoulders, 14 (34.1%) belonged to female patients and 27 (65.9%) belonged to male patients; however, the difference between the proportions of men and women was not significant ($p = 0.064$, Binomial test); 25 cases (61.0%) were on the right side and 16 (39.0%) on the left side, and the difference between these proportions was not significant either ($p = 0.211$, binomial test). The age of participants ranged from 22 to 65 years, with an average of 41.9 years ($SD = 10.7$; $CV = 0.26$), and the time of SCI until performance of the MRI varied from 1 to 29 years, with a mean of 9.4 years ($SD = 9.1$; $CV = 0.97$). By the values of the CVs, it is observed that the sample was homogeneous with respect to age but heterogeneous to the time of injury. The main causes of the injuries were traffic accidents (29 cases; 70.7%) and falls from height (5 cases; 12.2%). The neurological level of the lesion was classified according to the ASIA classification. In summary, 17 cases (41.5%) were of high thoracic lesions (T2–T6), and 24 cases (58.5%) were of low thoracic lesions (T7–T12), and there was no statistically significant difference between these two proportions ($p = 0.533$; binomial test).

Each case of shoulder injury was categorized by us into 14 stages of severity, ranging from absence of lesion in the 3 muscles (less severe) to 2 complete and 1 partial tear (more severe), as shown in ►Table 1. In the descriptive analysis of the

MRI, GH arthritis was found in 9 shoulders (22%). In the AC joint, 28 shoulders (68.3%) were characterized with arthritis. Regarding subacromial bursitis, 33 shoulders (80.5%) had an inflammatory process. The shape of the acromion was type I in 16 (39.0%), type II in 23 (56.1%), and type III in 2 shoulders (4.9%). In the evaluation of the labral lesion, only 10 shoulders (24.4%) had lesions in some identified labral segments. When evaluating the tendons that compose the rotator cuff, excluding the teres minor tendon, it was found that the supraspinatus tendon was not affected in 16 shoulders (39.0%), presented tendinopathy in 14 (34.2%) and partial tear in 11 shoulders (26.8%). The supraspinatus tendon was not affected in 6 shoulders (14.6%), presented tendinopathy in 16 (39.0%), partial tear in 10 (24.4%), and complete tear in 9 shoulders (22.0%). In the cases of complete supraspinatus tear, the mean rupture size was 21.3 mm (standard deviation [SD] = 10.1 mm, $CV = 0.47$, high variability). In these cases, according to Goutalier classification, 1 (11.1%) was classified as grade 0, 1 (11.1%) as grade I, 4 (44.4%) as grade II, 1 (11.1%) as grade III and 2 shoulders (22.2%) as grade IV. Regarding the infraspinatus, 14 (34.2%) showed tendinopathy, 7 (17.1%) partial lesions, and only 2 shoulders (4.9%) presented complete tear, one with 15 mm and the other with 23 mm in size (mean 19.0 mm), and both were classified as grade I according to the Goutalier classification.

Correlation analysis was performed between the variables age (at the time of MRI), time of injury, neurological level of SCI, and level of severity of the lesion. Dispersion plots are shown in ►Fig. 1. The severity of shoulder lesion was found to be correlated with the age of participants and time of SCI, with moderate correlations as measured by the Spearman order correlation coefficient ($r = 0.544$ and $r = 0.452$, respectively). There was no correlation between neurological level of SCI and severity of RCL ($p = 0.095$).

Observing the p -values found in ►Table 2, it is possible to conclude that the condition of the supraspinatus tendon was associated with age ($p = 0.006$) and time of injury ($p = 0.038$). It can also be observed that the average age of the patients increases as the lesion in the supraspinatus increases, to the point that patients with complete tear were significantly older (mean 52.4 years). The infraspinatus condition was not associated with the age of participants ($p = 0.062$, Kruskal-Wallis test) but was associated with the time of injury ($p = 0.029$, Kruskal-Wallis test). It can be observed that the cases without lesions in the infraspinatus tendon were of patients with a significantly lower lesion time (mean of 5.4 years), and the average time of SCI increases as the infraspinatus complication increases, to the point that patients with complete lesion had a significantly longer lesion time (mean of 26.0 years). The condition of the subscapular tendon was not associated with the age of participants ($p = 0.050$, Kruskal-Wallis test) or with the time of injury ($p = 0.240$, Kruskal-Wallis test). In the general evaluation of the rotator cuff, considering the 3 muscles, 23 shoulders (56.1%) presented with some lesion in at least 1 of the 3 evaluated muscles, and 18 shoulders (43.9%) presented with no tears (►Table 2). There is a statistically significant difference between the age of the patients who did not have tears in the 3 muscles and the patients who presented with lesions in at least 1 muscle ($p = 0.023$, Mann-Whitney

Table 1 Distribution of frequencies of injury severity level

Injury severity level	Type of injury	Frequency	Percentage
0	0 T + 0 PT + 0 CT	3	7.3
1	1 T	6	14.6
2	2 T	8	19.5
3	3 T	1	2.4
4	1 PT	1	2.4
5	1 PT + 1 T	5	12.2
6	1 PT + 2 T	1	2.4
7	2 PT	1	2.4
8	2 PT + 1 T	5	12.2
9	3 PT	1	2.4
10	1 CT + 1 T	3	7.3
11	1 CT + 1 PT + 1 T	3	7.3
12	1 CT + 2 PT	1	2.4
13	2 CT + 1 T	1	2.4
14	2 CT + 1 PT	1	2.4

Abbreviations: CT, complete tear; PT, partial tear; T, tendinopathy.

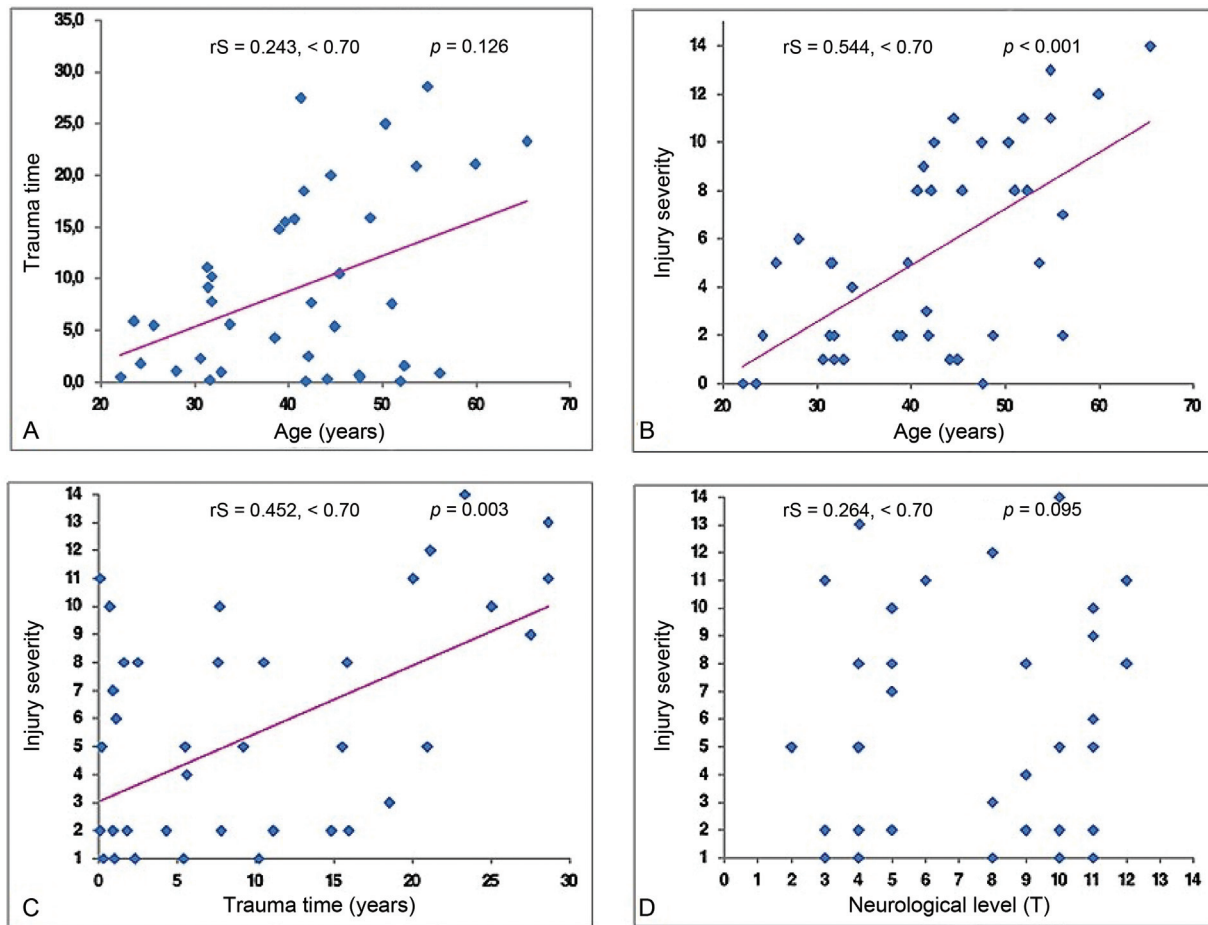


Fig. 1 Dispersion plots • (A) Trauma time (years) x age (years). There is a slight positive trend, but with points far removed from this trend line. In fact, the correlation between the two variables is weak ($rS = 0.243, < 0.70$) and not significantly different from zero ($p = 0.126$) • (B) Injury severity x age (years). There is a slight positive trend, but with points far removed from this trend line. In fact, the correlation between the two variables is significant ($p < 0.001$), indicating that as age increases the severity of the lesion tends to increase, but the correlation is not strong ($rS = 0.544, < 0.70$). • (C) Injury severity versus trauma time (years). It is possible to verify a slight positive trend, but with points very distant from this trend line. In fact, the correlation between the two variables is significant ($p = 0.003$), indicating that the trauma time increases, the severity of the lesion tends to increase, but the correlation is not strong ($rS = 0.452, < 0.70$) • (D) Injury severity x neurological level (T). There is no trend line, with weak correlation between the two variables ($rS = 0.264, < 0.70$) and not significantly different from zero (p -value = 0,095).

test). There was no statistically significant difference between the time of SCI in cases with no lesion in the 3 muscles and in cases with lesion in at least 1 muscle ($p = 0.057$, Mann-Whitney test). Glenohumeral arthrosis was significantly associated with time of injury ($p = 0.020$, Mann-Whitney test). The mean time of injury of the group that did not have GH arthrosis was 7.3 years, with standard deviation of 7.2 years, and median of 5.4 years. In the group that had GH arthrosis, the time of injury was significantly longer; with a mean of 16.9 years, standard deviation of 11.5 years, and median of 20 years. Glenohumeral arthrosis was significantly associated with the severity of the lesion in the cuff ($p = 0.003$, Mann-Whitney test). In the group without GH arthrosis, the median severity was 3, but in the group with arthrosis, the median severity was 10. Acromioclavicular arthrosis is significantly associated with the patient's age ($p < 0.001$, Mann-Whitney test). The mean age of the patient in the group without AC arthrosis was 33.8 years, with standard deviation of 10.0 years, and median of 31.4 years. In the group that had AC arthrosis, the age was significantly higher, with a mean of 45.7 years, standard

deviation of 8.8 years and median of 45.1 years. Bursitis was significantly associated with time of injury ($p = 0.022$, Mann-Whitney test), with a mean of 11.0 years, SD of 9.3 years, and median of 7.8 years.

Discussion

In a biomechanics study, Kulig et al.¹ demonstrated a 360% increase in vertical stress on the shoulder in manual wheelchair transfer and propulsion demands. Nevertheless, as Alves concluded,¹⁰ in these patients the pain may be related only to functional overload, and there is not always a relation with anatomical lesions.

We found a high prevalence of AC arthrosis in our sample, with 28 cases (68.3%), a pattern also observed in other studies.^{5,11} Eriks-Hoogland¹² found a high prevalence of AC arthrosis in both groups, wheelchair users and control sample; however, the severity of the arthrosis was higher in patients with SCI.

Morrow et al.,⁵ in a group of 10 manual wheelchair users, observed a 50% presence of supraspinatus lesions and noted

Table 2 Statistics of the age, time and neurological level distribution of the patients according to the situation of the supraspinatus, infraspinatus and subscapular muscles

Muscle	Muscle situation	Age statistics (years)				p-value	Trauma time statistics				p-value	Neurological level statistics			p-value
		Medium	Average	SD	CV		Medium	Average	SD	CV		Minimum	Medium	Maximum	
Supraspinatus	No lesion	33.3	34.0	10.4	0.31	0.006	0.8	2.3	2.7	1.17	0.038	3	5	9	0.135
	Tendinopathy	38.8	38.7	9.4	0.24		5.4	7.5	6.9	0.92		2	6	12	
	Partial tear	41.7	42.6	9.3	0.22		8.4	9.7	8.2	0.85		4	10	12	
	Complete tear	51.9	52.4	7.3	0.14		21.1	17.2	11.4	0.66		3	10	12	
Infraspinatus	No lesion	39.3	39.1	11.0	0.28	0.062	5.4	6.9	7.6	1.10	0.029	3	10	12	0.323
	Tendinopathy	42.0	40.5	8.8	0.22		6.0	7.6	7.4	0.96		2	6	12	
	Partial tear	45.4	46.9	8.9	0.19		10.5	14.8	10.8	0.73		4	6	12	
	Complete tear	60.1	60.1	7.5	0.13		26.0	26.0	3.8	0.14		10	11	12	
Subscapular	No lesion	36.1	36.7	9.2	0.25	0.050	5.4	5.3	4.5	0.84	0.240	3	5	12	0.109
	Tendinopathy	41.9	43.3	9.4	0.22		15.8	12.0	11.1	0.92		2	10	12	
	Complete tear	51.9	47.8	11.6	0.24		9.8	12.0	10.1	0.84		3	8	12	
All three muscles	No lesion	38.8	37.5	9.6	0.25	0.023	4.8	5.9	5.9	1.00	0.057	2	6	12	0.161
	At least one lesion	45.4	45.4	10.5	0.23		9.2	12.2	10.3	0.85		3	9	12	

Abbreviations: CV, coefficient of variation; SD, standard deviation.

that 60% had a lesion in at least one of the rotator cuff tendons. In our population, the findings were similar, with 46% having lesions in the supraspinatus, and 56% in at least one of the tendons.

For those who presented partial or complete tears, the mean age and time of SCI were 7.9 and 6.3 years greater, respectively, when compared with the group without tears. Both variables showed a positive correlation with the severity of the lesion, with statistical significance (►**Fig. 1**), as found by other authors.¹¹ The present study, however, was not able to show whether one of these factors was more important for rotator cuff lesion, as both had a weak correlation. In the analysis of the relationship between spinal injury time and the status of the tendons of the cuff, the supraspinatus and infraspinatus showed a difference between groups, while the subscapularis showed no difference. This finding allows us to hypothesize that, unlike the supra and the infraspinatus, the work performed in propulsion of the wheelchair does not generate overload in the subscapularis.

Kulig et al.¹³ performed a study to analyze the effect of the level of SCI on shoulder joint kinetics during manual wheelchair propulsion, finding an increased upper vertical force in the quadriplegic group, which could lead subacromial structures to an increased risk of compression. This parameter was not significantly different between the high (T1–T9) and low (T10–L3) paraplegic groups. Our sample contained only patients with thoracic injury (T2–T12), and, in agreement with published works, we did not find statistically significant differences between the severity of the rotator cuff lesion in the groups with high thoracic level (T1–T6) and low thoracic level (T7–T12) injuries. Both observations indicate that the differences in the postural balance capacity caused by the level of SCI do not act as a significant overload factor in the shoulder joint.

Conclusion

In the present study, a progressive increase in the severity of the shoulder lesion was observed as age becomes more advanced and with a longer time from the onset of the SCI. However, the level of the thoracic injury apparently does not interfere with the rotator cuff lesion.

Conflict of Interests

The authors have no conflict interests to declare.

References

- 1 Kulig K, Rao SS, Mulroy SJ, et al. Shoulder joint kinetics during the push phase of wheelchair propulsion. *Clin Orthop Relat Res* 1998; (354):132–143
- 2 Jung HJ, Sim GB, Jeon IH, Kekatpure AL, Sun JH, Chun JM. Reconstruction of rotator cuff tears in wheelchair-bound paraplegic patients. *J Shoulder Elbow Surg* 2015;24(04): 601–605
- 3 Samuelsson KA, Tropp H, Gerdle B. Shoulder pain and its consequences in paraplegic spinal cord-injured, wheelchair users. *Spinal Cord* 2004;42(01):41–46
- 4 Barbetta DC, Lopes AC, Chagas FN, et al. Predictors of musculo-skeletal pain in the upper extremities of individuals with spinal cord injury. *Spinal Cord* 2016;54(02):145–149
- 5 Morrow MM, Van Straaten MG, Murthy NS, Braman JP, Zanella E, Zhao KD. Detailed shoulder MRI findings in manual wheelchair users with shoulder pain. *BioMed Res Int* 2014;2014:769649
- 6 Boninger ML, Dicianno BE, Cooper RA, Towers JD, Koontz AM, Souza AL. Shoulder magnetic resonance imaging abnormalities, wheelchair propulsion, and gender [published correction appears in *Arch Phys Med Rehabil* 2004;85(1):172. *Arch Phys Med Rehabil* 2003;84(11):1615–1620
- 7 American Spinal Injury Association. International standards for neurological classification of spinal cord injury (ISNCSCI). [Accessed 20 May 2019] from: http://asia-spinal-injury.org/wp-content/uploads/2016/02/International_Std_Diagram_Work-sheet.pdf
- 8 Bigliani LU, Ticker JB, Flatow EL, Soslowsky LJ, Mow VC. The relationship of acromial architecture to rotator cuff disease. *Clin Sports Med* 1991;10(04):823–838
- 9 Goutalier D. Pathologie de la coiffe des rotateurs. In: *Encyclopédie Médico Chirurgicale*. Paris:: Elsevier Masson; 1997:350
- 10 Alves AP, Terrabuio Junior AA, Pimenta CJ, Medina GI, Rimkus CdeM, Cliquet Júnior A. Clinical assessment and magnetic resonance imaging of the shoulder of patients with spinal cord injury. *Acta Ortop Bras* 2012;20(05):291–296
- 11 Haffner DL, Hoffer MM, Wiedbusch R. Etiology of children's spinal injuries at Rancho Los Amigos. *Spine* 1993;18(06):679–684
- 12 Eriks-Hoogland I, Engisch R, Brinkhof MW, van Drongelen S. Acromioclavicular joint arthrosis in persons with spinal cord injury and able-bodied persons. *Spinal Cord* 2013;51(01): 59–63
- 13 Kulig K, Newsam CJ, Mulroy SJ, et al. The effect of level of spinal cord injury on shoulder joint kinetics during manual wheelchair propulsion. *Clin Biomech (Bristol, Avon)* 2001;16(09): 744–751