The Effects of Respiratory Exercises on Respiratory Functions and the Quality of Life in Patients with Thoracal Spinal Cord Injury

Özlem Gültekin, Kadriye Öneş, Halil Harman, Ebru Yılmaz Yalçınkaya
İstanbul Physical Theraphy and Rehabilitation Training and Research Hospital, İstanbul

ABSTRACT

Objective: *The present study aims to investigate the effects of respiratory rehabilitation programs on respiratory function, chest expansion, and the quality of life among patients with thoracal level spinal cord injury (SCI); as well as examine the relation between the changes in these parameters and lower and upper thoracal vertebra injury level, duration of the disorder and spasticity.*

Material and Method: *Twenty nine patients, who have been admitted to our rehabilitation hospital for the last 9 months, for SCI with a neurological lesion level T1-T12 vertebra were included in the study. The patients were categorized into lower and upper thoracal SCI. Patients were administered a respiratory functions test (RFT) and quality of coughing both prior to and following six week respiratory rehabilitation program. St. George's Respiratory Questionnaire (SGRQ), Short Form 36 (SF-36) and Functional Independence Measure (FIM) scores were calculated.*

Results: *It was found that following a thoracal SCI, respiratory functions and coughing quality were affected more severely for patients who had a higher thoracal level. Patients with thoracal SCI showed statistically significant improvement after the respiratory rehabilitation in their RFT.*

Conclusions: *Respiratory functions in thoracal SCI patients were affected seriously. The improvement in patients' respiratory functions may lead to an increase in their quality of life and functional independence.*

Key Words: *Spinal cord injury, exercises, rehabilitation*
Nobel Med 2013; 9(3): 82-87

TORAKAL SEVİYELİ MEDULLA SPİNALİS YARALANMALI HASTALARDA SOLUNUM EGZERSİZLERİNİN SOLUNUM FONKSİYONLARINA VE YAŞAM KALİTESİNE ETKİLERİ

ÖZET

Amaç: Bu çalışmada torakal seviyede medulla spinalis yaralanması (MSY) olan hastalarda solunum rehabilitasyon programının solunum fonksiyon testleri, göğüs ekspansiyonu ve yaşam kalitesi üzerine etkisinin araştırılması, bu parametrelerdeki değişimlerin üst ve alt torakal vertebra yaralanma seviyesi, hastalık süresi ve spastisite ile ilişkilerinin araştırması amaçlanmıştır.

Materyal ve Metod: Çalışmaya rehabilitasyon hastanemize yatırılarak tedavi edilen nörolojik lezyon seviyesi T1-T12 vertebra arasında olan MSY'li 29 hastayı alınmıştır. Hastaları nörolojik lezyon düzeyine göre üst ve alt torakal gruplara ayrıldı. Altı haftalık solunum rehabilitasyon programı öncesi ve sonrasında hastaların solunum fonksiyon testleri (SFT) ve göğüs ekspansiyon ölçümleri yapıldı, öksürük kalitesi değerlendirildi ve St. George's Respiratory Questionnaire (SGRQ), Kısa form-36 (SF-36) ve Fonksiyonel Bağımsızlık Ölçütü (FIM) skorlarını hesaplandı.

Bulgular: MSY sonrası torakal vertebra seviyeli hastalarda solunum fonksiyonlarının ve öksürük kalitesinin etkilendiği bu etkilenmenin üst torakal seviyede daha fazla olduğu saptandı.

Sonuç: Sonuç olarak torakal seviyeli MSY olan hastalarda solunum fonksiyonları önemli oranda etkilenmektedir. Solunum fonksiyonlarının iyileştirilmesi hastanın yaşam kalitesi ve bağımsızlığını artırılmasını sağlayabilir.

Anahtar Kelimeler: Spinal kord yaralanması, egzersiz, rehabilitasyon **Nobel Med 2013; 9(3): 82-87**

INTRODUCTION

Respiratory system complications due to spinal cord injury (SCI) are the leading causes of death both in the acute and the chronic phases. During the acute phase of SCI, the ratios of pulmonary complications are 65% of torachal vertebra level. The frequency of pulmonary complications increases with age, level of injury and complete tetraplegia.[1] The present study aims to investigate the effects of respiratory rehabilitation programs on respiratory function tests, chest expansion, and the quality of life among thoracal level SCI patients.

MATERIAL AND METHOD

Study design: Twenty nine inpatients who have been admitted to our center between October 2006 and June 2007 were included in the study. The inclusion criteria were T1-T12 neurological level, less than 1 year duration period and 15-65 years of age.

Patients with chest deformities as kyphosis, scoliosis, pectus excavatum, pectus carinatum, a history of cardiopulmonary system disorders prior to the SCI, posterior-anterior (PA) lung graphy, acute lung disease findings in electrocardiography (ECG) and physical examinations, hypertension and cardiac pathologies, instable clinical picture, stage 3-4 compression injuries, neuromuscular diseases other than SCI, and uncooperative patients were excluded from the study.

Material and Method: The demographics, etiological factors, disease and rehabilitation durations, comorbid disorders, premorbid life style, medications, and the use of spinal orthesis were questioned. The neurological levels of the patients were evaluated using the ASIA (American Spinal Injury Association) Scale.

The pulmonary complications following the SCI were investigated. A respiratory system examination was conducted to determine the respiration type, pattern, respiration per minute, respiratory sounds, presence of tracheostomy following the injury and the effectiveness of coughs. Patients with a loud cough, who can cough twice or more with one inhalation and can clean their secretions were evaluated as coughing effectively. Patients with a soft cough, who can cough once with one inhalation and can clean some of their secretions, were evaluated as partially effective; and patients who can sigh or clean their throats and need assistance to clean their secretions were evaluated as non-effective.

Patients' respiratory function tests were conducted using a Chest graph HI-101 spirometer device, in a straight up sitting position with their noses clamped. Tests were repeated three times for each patient and the best result was recorded. Spinal orthosis were removed during testing to avoid the potential effects on chest and abdominal movements. A current-volume curve was obtained using the spirometer device, and vital capacity (VC), forced vital capacity (FVC), forced expiratory volume 1 (FEV1), FEV1/FVC, forced expiratory flow (FEF) 25-75 and peak expiratory flow (PEF) values were measured.

Routine laboratory (sedimentation, hemoglobin, full urine, blood electrolyte, urea, creatinine, alkaline phosphate) analysis was carried out. Lung graphy and ECG findings were evaluated. St. George's Respiratory Questionnaire (SGRQ) form, which is used in the evaluation of life quality of patients with lung diseases, was administered. This form is a questionnaire that has a high sensitivity and specificity especially in evaluating the daily quality of life and dyspnea.[2]

For the purposes of the evaluation of quality of life, all patients were administered the Short-form 36 (SF-36) questionnaire before and after the exercise program. There is a wide range of use in clinical and research settings.[3]

The functional independence levels of patients were evaluated using the Functional Independence Measure (FIM).[4]

Patients were divided into two groups based on their lesion levels. The first group included patients with a lesion level of T1-6 vertebras, and the second group included patients with T7-12 vertebras.

All patients were evaluated by using respiratory function tests (RFT), and were administered to a rehabilitation program. Besides this program, they were given exercises for 6 weeks, 3 days per week, one hour per day. These exercises were segmental respiration, pursed lips breathing (PLB), diaphragmatic respiration, air-shifting techniques and incremental weight upper extremity and shoulder region exercises RFT measures were taken at the completion of the rehabilitation program. SGRQ, FIM scores were re-measured. The post-rehabilitation scores were compared with the pre-rehabilitation scores for all of the scales.

Analysis: Besides the descriptive analysis (mean values and standard deviations), quantitative data was analyzed by using Student's t-test, Kruskal Wallis test, and Mann Whitney U tests. Group comparisons were conducted by using a Wilcoxon sign test. Qualitative data was compared by using a Chi-square test. Level of significance was set a p-value of 0.05. →

Table 1: Demographic features of the patients					
Demographics		**All patients (N=29) n (%)**	**Patients with an upper thoracal injury (N=9) n (%)**	**Patients with a lower thoracal injury (N=20) n (%)**
Age (Mean±SD)		37.45±12.86	34.89±10.32	38.60±13.94
Gender	**Female**	13 (45%)	4 (44%)	9 (45%)
	Male	16 (55%)	5 (56%)	11 (55%)
Marital Status	**Married**	7 (24%)	2 (22%)	5 (25%)
	Single	22 (76%)	7 (18%)	15 (75%)

Table 2: Occupations of the patients			
Occupation	**All patients (N=29) n (%)**	**Upper thoracal group (N=9) n (%)**	**Lower thoracal group (N=20) n (%)**
Student	3 (10%)	1 (11%)	2 (10%)
Housewife	6 (21%)	0 (0%)	6 (30%)
Driver	2 (7%)	0 (0%)	2 (10%)
Workmen	12 (41%)	7 (78%)	5 (25%)
Farmer	4 (14%)	0 (0%)	4 (20%)
Blue collar	2 (7%)	1 (11%)	1 (5%)

Table 3: Etiology of the spinal cord injury (SCI)			
SCI etiological factors	**All patients (N=29) n (%)**	**Upper thoracal group (N=9) n (%)**	**Lower thoracal group (N=20) n (%)**
Traffic accidents	8 (27.6%)	3 (33.3%)	5 (25%)
Falling	10 (34.5%)	1 (11.1%)	9 (45%)
Shot-gun wounds	4 (13.8%)	2 (22.2%)	2 (10%)
Tumor	2 (6.9%)	2 (22.2%)	0 (0%)
Other	5 (17.2%)	1 (11.1%)	4 (20%)

The conducted study was approved by the local ethical committee and all the patients were informed about the study and they signed informed consent form.

RESULTS

The mean age value for 29 patients was 37.45 (17-62) years. The demographic data of the patients is presented in Table 1.

There was no statistically significant difference in the duration of disease between the two groups [group 1 (3.83±1.82 months), group 2 (3.05±1.75 months)] ($p>0.005$).

The most commonly observed occupational group among the patients was workmen (41.4%) (Table 2). The most common SCI etiology cause was observed to be falling from a height (34.5%) followed by traffic accidents (27.6%) (Table 3).

The examination of the patients according to the ASIA categorisation showed that 20 patients (69%) had complete SCI, and 9 patients (31%) had incomplete SCI. Of the patients with an upper thoracal injury, 7 (78%) had complete, 2 (22%) had incomplete; and of the patients with a lower thoracal injury, 13 (65%) had complete and 7 (35%) incomplete injuries.

The pre-rehabilitation anamnesis of 29 patients showed that 14 patients (48.27%) had developed post SCI lung complications. 9 patients (77.7%) in group 1 and 6 (30%) of the patients in group 2 had developed lung complications prior to the rehabilitation.

When the patients were grouped into two regarding the duration of the disease; there were 14 patients with a disease duration of three months or less, and 15 patients with a disease duration of longer than three months. When RFT scores was analyzed , only the VC scores of patients with a duration of longer than three months was significantly higher at the beginning of the treatment ($p<0.05$).

When the respiratory patterns of the patients were evaluated, (13.7%), a restrictive pattern in 12 patients (41.3%) was observed (Table 4).

A statistically significant difference was observed in all of the parameters between pre-rehabilitation and post-rehabilitation RFT values ($p<0.05$) (Table 5).

When the RFT mean values were compared between group 1 and 2, it was found that at the beginning of the treatment, group 2 had better values in their FEV1, PEF, and FEF25 scores ($p<0.05$). Group 2 showed a significant improvement after the exercise program in their MMF (maximum expiratory mean flow, FEF25-75), FEF50, and FEF75 scores ($p<0.05$). When the RFT values were compared between patients with and without spasticity, the only statistically significant difference was observed in the pre-exercise values of FEF 75 ($p<0.05$).

Respiratory symptoms of the patients were; 12 patients complained (41.37%) day-time naps, 10 (34.48%) complained snoring, 10 (34.48%) complained coughing, 6 (20.68%) complained fatigue. For both of the patient groups, a statistically significant improvement was observed in the cough quality ($p<0.05$).

For group 1, an increase was observed in physical functions, general health, social functions, emotional role strength, and mental health scores after the exercise, however the improvement in these scores was not statistically significant ($p>0.05$). For group 2, physical function, vitality, social function scores showed an improvement after the exercise, however→

this difference was not statistically significant, either ($p>0.05$). When all of the patients were evaluated, physical function, pain, vitality, social functions scores showed an improvement after the exercise; however the only statistically significant improvement was observed in the social function scores ($p<0.05$).

When the pre and post exercise SGRQ scores of all the patients were analyzed, impact on daily life activities (DLA) and total scores showed a positive and statistically significant improvement ($p<0.05$) (Table 6).

When the pre and post treatment FIM scores were compared, a statistically significant increase was observed for all of the patients ($p<0.05$). When this improvement was separately compared for group 1 and 2, there was no significant difference between the two groups of patients ($p>0.05$) (Figure 1).

DISCUSSIONS

SCI has an impact on a variety of systems and limits the individual's life activities for long periods of time. It is mostly impacting young adults. It is reported that at the time of the injury the average age for these patients is 37.6 and 80% of them are male.[5] Chen et al. conducted a study with 1649 patients in 1996. In this study the mean age of the patients was 36.5 and 79% of them were male.[6] The present study showed that the mean age of the patients at the time of the injury was 37.45 (17-62) and 55% of these patients were male. A retrospective study by Ones et al. conducted with 194 patients showed that 32.47% of the patients had non-traumatic, 67.53% of the patients had traumatic etiological factors. Motor vehicle accidents was the leading cause (36.64%), followed by falling from a height (34.35%).[7] In the current study, falling from a height was the leading cause of injury (34.5%), followed by car accidents (27.6%).

In patients with SCI, inspiratory and expiratory muscle group failure and paradoxal chest wall movement may lead to the development of atelectasia, pneumonia, and respiratory failure due to ventilator. In addition to these, disruption in sympathetic innervations (between T1-T6 vertebras) and increase in the parasympathetic innervations may lead to increase in bronchial tonicity and congestion in the upper respiratory tracts. A study conducted by Jackson et al. with 261 patients showed that there were a total of 544 respiratory system complications in 175 patients.[8] This study showed that 67% of the SCI patients had respiratory complications during the acute phase and the rehabilitation phase. Axen et al. followed 36 tetraplegic patients for a period of 10 months after their injuries. They reported that the vital

Table 4: Respiratory patterns

Respiratory patterns	Upper thoracal Group n (%)	Lower thoracal group n (%)	All patients n (%)
Obstructive	0 (0%)	4 (20%)	4 (13.7%)
Restrictive	5 (55.5%)	7 (35%)	12 (41.3%)
Mixed	3 (33.3%)	3 (15%)	6 (20.6%)
Normal	1 (11%)	6 (30%)	7 (24.1%)

Table 5: Pre and post rehabilitation respiratory functions test values of all patients

Respiratory functions measures		Mean±SD	p values
Vital capacity	Pre-R	68.58±19.57	0.000*
	Post-R	75.24±17.99	
Forced vital capacity	Pre-R	64.02±18.24	0.000*
	Post-R	72.58±17.20	
FEV 1	Pre-R	69.88±17.81	0.000*
	Post-R	80.80±17.97	
FEV %		110.97±7.03	
Peak expiratory flow	Pre-R	68.45±24.05	0.000*
	Post-R	89.89±26.59	
Maximum expiratory mean flow	Pre-R	85.70±19.55	0.000*
	Post-R	107.04±27.37	
FEF %25	Pre-R	70.51±22.47	0.001*
	Post-R	91.71±27.23	
FEF %50	Pre-R	79.4±19.04	0.002*
	Post-R	98.44±25.60	
FEF %75	Pre-R	96.06±29.31	0.004*
	Post-R	121.28±34.71	

*p<0.01, FEV: Forced expiratory volume, FEF: Forced expiratory flow

capacity increased from 45% to 58%. The increase in VC was especially significant in the first three months, and they reported that this was due to the progress in the shoulder and upper extremity muscles and the increase in the neural support of the diaphragm.[9]

Bluechardt et al. conducted a study with 12 patients with a motor complete injury (above L1 neurologic L1 level) and reported a gradual increase in FEV1 and FVC values. The improvements in the performance of the diaphragm, reflex activity in the inter-costal muscles, and in the accessory muscles in the neck contribute to this restoration in the FEV1 and FVC values.[10] In the present study, it was found that the pre-exercise VC values of patients with a disease duration longer than three months was significantly higher than patients with a disease history of 3 months or less. This finding concurs with other findings from the literature. Spasticity increases the stability of the thorax because of the reflex intercostals muscle activity, therefore helps the diaphragm to effectively change place in the lung. The current study's findings show a significant difference in the MMF, FEF50, and FEF75 values in the group →

Table 6: St. George's respiratory questionnaire (SGRQ)

		Upper thoracal group	Lower thoracal group	p value	All patients
		Mean±SD	Mean±SD		Mean±SD
Symptom	Pre	14.75±10.26	12.48±8.95	0.347	13.84±8.1
	Post	16.51±10.06	10.58±7.35	0.467	13.33±7.49
	Pre-Post	0.36	0.19	0.19	
Activity	Pre	11.4±13.23	7.17±7.23	0.219	8.78±9.95
	Post	6.66±9.48	3.81±5.13	0.812	4.84±6.63
	Pre-Post	0.18	0.35	0.35	
Impact on DLA	Pre	8.32±9.86	4.12±5.35	0.732	5.32±7.09
	Post	4.49±5.01	3.01±3.44	0.703	3.17±3.79
	Pre-Post	0.12	0.07	0.02*	
Total	Pre	10.32±9.28	6.61±4.46	0.345	7.83±6.62
	Post	8.14±5.67	4.78±2.61	0.838	5.74±0.17
	Pre-Post	0.06	0.007*	0.001*	

*p <0.01

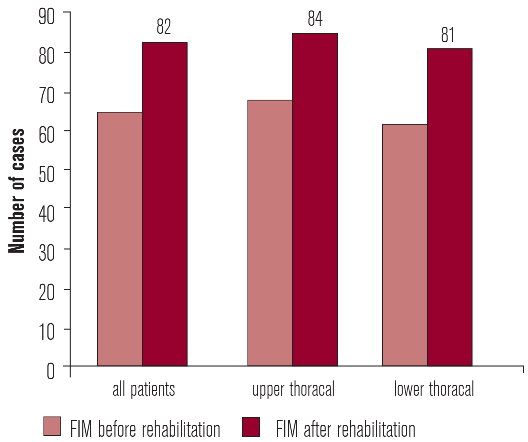

Figure 1: Functional independent measure (FIM) score before and after rehabilitation

with spasticity, and this supports the positive impact of spasticity on respiratory functions.

Sutbeyaz et al. conducted a study with 20 SCI patients with an injury level of T6-T12, and found a restrictive respiratory pattern in 25% of the patients, obstructive a respiratory pattern in 20% of the patients, and a mixed (restrictive+obstructive) pattern in 15% of the patients.[11] The present study found a restrictive respiratory pattern in 41.3% of the patients, an obstructive respiratory pattern in 13.7% of the patients, and a mixed respiratory pattern in 20.6% of the patients. All patients with a normal respiratory pattern, except for one, had a lower thoracal vertebra level.

Silva et al. conducted a controlled study with 12 SCI patients on the thoracal vertebra level, and observed a statistically significant decrease in the FVC and FEV1 values and the endurance of respiratory muscles of the patient groups. They, also, observed an improvement in the FVC values and the endurance of the respiratory muscles at the end of the 6-week exercise program.[12] In a controlled study conducted by Liaw et al. with tetraplegic patients, a change in patients' VC, TLC, ventilation per minute and FEV1 values was observed after the respiratory muscle training given to the patients within the first six months after the injury.[13] The present study showed that there was a significant increase in the VE, FVE, FEV1, PEF, MMF, FEF25, FEF50, and FEF75 values of the patients after the 6 week respiration rehabilitation of the patients. Ventilation exercises have a positive impact on patients' respiratory functions by increasing the power and endurance of the respiratory muscles. The findings of the current study were in accordance with the findings in the literature.

Rote et al. conducted a study with 52 acute cervical and upper thoracic injury SCI patients and concluded that muscle strength is more important factor than muscles tonicity in pulmonary function tests.[14] Baydur et al. found a significant relation between the FEV1/FVC values and the level of injury in the study they conducted with 74 tetraplegic and paraplegic patients.[15] In the present study, when the respiratory function tests were compared for the upper and lower thoracal level injury patients FEV1, PEF and FEF25 values showed significantly better results in the lower thoracal group. Lower thoracal level patients' FEV1 scores were better than the upper thoracal group, which is a finding that concurs with other findings in the literature.

Following a SCI, dyspnea is most common in upper level injuries.[16] Ayas et al. investigated the relation between dyspnea and some specific activities in a study conducted with 130 cervical and thoracic SCI patients. They found that dyspnea prevelance increased with the increase in the level of damage.[17] The present study found the respiratory system symptoms to be as follows: 41.37% of the patients had day time naps, 34.48% had snoring, 34.48% had coughing, 20.68% had fatigue, 3.44% had phlegm, and 3.44% had dyspnea. We believe the difference in the ratios of the present study and other studies in the literature, is due to the fact that, the present study, mostly included the patients with a lower thoracic injury.

As the innervations of the cough-related muscles come from differenet levels, lesion level has an effect on the effective coughing patterns of the patients.[18] The abdominal muscles, which are needed for an effective coughing pattern, are a clavicular part of the intercostals and muscle pec toralis major. The innervations span of these muscles is below the T6 vertebra level. Only the upper parts of mucle pectoralis major and intercostals muscles innerve from the level higher than T6. Therefore, it is →

expected for SCI patients with an upper thoracal injury to have less functional cough patterns than patients with lower thoracal injury.[19] The present study found that 41.37% of all patients had functional coughing patterns at the end of the six week exercise program. There was a statistically significant improvement in the coughing capacity of the patients. This shows that, at the completion of the exercise, the muscle strength of intercostals and abdominal muscles increase, which helps the patient to develop a functional coughing pattern.

One major aim of the rehabilitation programs is the improvement of the quality of life. Especially for the tetraplegic patients, the high rate of respiratory complications has a drastic impact on the quality of life. Jain et al. conducted a 5-year study with 356 SCI patients, and found that low quality of life scores were related to chronic coughing, chronic phlegm, permenant wheezing, dyspnea following daily life activities, low FEV1 and low FVC scores.[19] The present study found an increase in physical functions, pain, vitality, social functions scores for all of the patients, however only the social functions scores showed a statistically significant increase ($p<0.05$).

In the present study, decline in respiratory functions and the effects of this decline on quality of life was evaluated using the SGRQ, which is specifically designed for lung diseases. There was a statistically significant difference for all of the patients in their post-exercise SGRQ total scores and impact on daily life scores. However, when the upper and lower thoracal injury groups and the pre-post exercise scores were compared, no significant difference was observed. It was observed that patients' complaints of dyspnea during daily life activities had decreased, and therefore they were more comfortable in carrying out the activities.

CONCLUSION

The respiratory functions of the SCI patients are severely impacted, which may lead to an increase in mortality and morbidity. Respiratory rehabilitation programs help the increase in the volume and the capacity of the lungs and chest expansion; which leads to a decrease in the pulmonary complications and an increase in the quality of life. Therefore it is important to start the respiratory rehabilitation in the early phases of the disease and to show the needed importance throughout the treatment period.

C **CORRESPONDING AUTHOR:** Ebru Yılmaz Yalçınkaya Cennet mah. Barboros cad. No:11/16 Küçükçekmece, İstanbul, Turkey ebru_yilmaz@hotmail.com

✔ **DELIVERING DATE:** 11 / 12 / 2012 • **ACCEPTED DATE:** 12 / 04 / 2013

REFERENCES

1. Peterson WP, Kirshblum S. Pulmonary Management of Spinal Cord Injury .In: Delisa JA. Spinal Cord Medicine 2002; 134-154.
2. Jones PW, Quirk FH, Baveystock CM, Little JP. Self complete measure of health status for chonic airway limitation. St. George's Respiratory Questionnaire. Am Rev Respir Dis 1992; 145: 1321-1327.
3. Andresen EM, Allan RM. Health-Related Quality of Life Outcomes Measures. Arch Phys Med Rehabil 2000; 81: 30-45.
4. Lundgren-Nilsson A, Tennant A, Grimby G, Sunnerhagen KS. Cross-diagnostic validity in a generic instrument: an example from the Functional Independence Measure in Scandinavia. Health Qual Life Outcomes 2006; 4: 55.
5. Alvarez SE, Peterson M, Lunsford BR. Respiratory treatment of the adult patient with spinal cord injury. Phys Ther 1981; 61: 1737-1745.
6. Chen D, Nussbaum SB. Gastrointestinal disorders. In: Delisa JA (edi). Spinal Cord Medicine 2002; 155-161.
7. Ones K, Yilmaz E, Beydogan A, Gultekin O, Caglar N. Comparison of functional results in non-traumatic and traumatic spinal cord injury. Disabil Rehabil 2007; 29: 1185-1191.
8. Jackson AB, Groomes TE. Incidence of respiratory complications following spinal cord injury. Arch Phys Med Rehabil 1994; 75: 270-275.
9. Axen K, Pineda H, Shnfenthal H. Diaphragmatic function following cervical cord injury. Neurolly mediated improvement. Arch Phys Med Rehabil 1985: 66: 139-144.
10. Bluechardt MH, Wiens M, Thomas SG, Plyley MJ. Repeated measurement of pulmonary function following spinal cord injury. Paraplegia 1992; 30: 768-774.
11. Sutbeyaz ST, Koseoglu BF, Gokkaya NK. The combined effects of controlled breathing techniques and ventilatory and upper extremity muscle exercise on cardiopulmonary responses in patients with spinal cord injury. Int J Rehabil Res 2005; 28: 273-276.
12. Silva AC, Neder JA, Chiurciu MV, et al. Effect of aerobic training on ventilatory muscle endurance of spinal cord injured men. Spinal Cord 1998; 36: 240-245.
13. Liaw MY, Lin MC, Cheng PT. Resisitif inspiratory muscle training its effectivines is acute servical cord injury. Arch Phys Med Rehabil 2000; 81: 752-756.
14. Roth EJ, Lu A, Primack S, et al. Ventilatory function in cervical and high thoracic spinal cord injury. Relationship to level of injury and tone. Am J Phys Med Rehabil 1997; 76: 262-267.
15. Baydur A, Adkins RH, Milic-Emili J. Lung mechanics in individuals with spinal cord injury: effects of injury level and posture. J Appl Physiol 2001; 90: 405-411.
16. Robert B, Antony DM, Jeannete DH. Respiratory dysfunction and management spinal cord injury. Respiratory Care 2006; 51: 853-870.
17. Ayas NT, Garshick E, Lieberman SL, et al. Breathlessness in spinal cord injury depends on injury level. J Spinal Cord Med 1999; 22: 97-101.
18. Wang AY, Jaeger RJ, Yarkony GM, Turba RM. Cough in spinal cord injured patients: the relationship between motor level and peak expiratory flow. Spinal Cord 1997; 35: 299-302.
19. Jain NB, Brown R, Tun CG, Gagnon D, Garshick E. Determinants of forced expiratory volume in 1 second (FEV1), forced vital capacity (FVC), and FEV1/FVC in chronic spinal cord injury. Arch Phys Med Rehabil 2006; 87: 1327-1333.