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The Effect of Breathing Exercises on Respiratory Functions and Quality of Life in Patients After Cervical or Thoracic Level Spinal Cord Injury

Servikal veya Torakal Düzey Omurilik Yaralanması Sonrası Hastalarda Solunum Egzersizlerinin Solunum Fonksiyonları ve Yaşam Kalitesi Üzerine Etkisi

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ABSTRACT Objective: The aim was to investigate the effects of breathing exercises on respiratory function, functional status, and the quality of life in patients with cervical or thoracic level spinal cord injury (SCI) and to compare the changes in these parameters in 2 groups. **Material and Methods:** Thirty two patients with a neurological lesion level of C4-T12, who have been admitted to our rehabilitation hospital were included in the study. The patients were divided into 2 groups as cervical and thoracic injury. After the assessment of pulmonary functions, breathing exercises 3 times a day for 20 minutes, in addition to neurological rehabilitation were given to all patients for 4 weeks. At the end of 4 weeks, pulmonary function tests were repeated. The results were compared with the baseline data. Quality of life was assesed with the short form-36 (SF-36). Functional status was evaluated with SCI measure III (SCIM III). **Results:** Pulmonary functions were increased significantly at the end of the rehabilitation program ($p<0.05$). However, the improvement in the respiratory parameters were higher in the thoracic injury group than those in the cervical group ($p<0.05$). A statistically significant improvement was found in SCIM III evaluation of both groups. A statistically significant improvement was found in the social function domain scores of SF-36 in the thoracic injury group ($p<0.05$). **Conclusion:** As a result, breathing exercises accompaning the conventional rehabilitation program provided improvement in the pulmonary function of the groups. Moreover, social functions were improved in the patients with thoracic injuries.

Keywords: Spinal cord injuries; breathing exercises; quality of life

ÖZET Amaç: Servikal veya torakal seviye omurilik yaralanması [spinal cord injury (SCI)] olan hastalarda solunum egzersizlerinin solunum fonksiyonu, fonksiyonel durum ve yaşam kalitesi üzerine etkilerini araştırmak ve 2 grupta bu parametrelerdeki değişiklikleri karşılaştırmak amaçlanmıştır. **Gereç ve Yöntemler:** Rehabilitasyon hastanemize başvuran nörolojik lezyon düzeyi C4-T12 olan 32 hasta çalışmaya dâhil edildi. Hastalar servikal ve torakal yaralanma olarak 2 gruba ayrıldı. Solunum fonksiyonları değerlendirildikten sonra tüm hastalara 4 hafta süreyle günde 3 kez 20 dk solunum egzersizleri ve nörolojik rehabilitasyon verildi. Dört hafta sonunda solunum fonksiyon testleri tekrarlandı. Sonuçlar temel verilerle karşılaştırıldı. Yaşam kalitesi kısa form-36 [short form-36 (SF-36)] ile değerlendirildi. Fonksiyonel durum, SCI ölçüm III (SCIM III) ile değerlendirildi. **Bulgular:** Rehabilitasyon programı sonunda solunum fonksiyonları anlamlı olarak arttı ($p<0,05$). Ancak solunum parametrelerindeki iyileşme torakal yaralanma grubunda servikal gruba göre daha yüksekti ($p<0,05$). Her iki grubun SCIM III değerlendirmesinde istatistiksel olarak anlamlı bir iyileşme saptandı. Torakal yaralanmalı grupta SF-36'nın sosyal fonksiyon alanı puanlarında istatistiksel olarak anlamlı bir iyileşme saptandı ($p<0,05$). **Sonuç:** Sonuç olarak, konvansiyonel rehabilitasyon programına eşlik eden solunum egzersizleri, grupların solunum fonksiyonlarında iyileşme sağladı. Ayrıca torakal yaralanmalı hastalarda sosyal fonksiyonlarda düzelme sağlandı.

Anahtar Kelimeler: Omurilik yaralanması; solunum egzesizleri; yaşam kalitesi

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Spinal cord injury (SCI) is one of the most severe conditions of disability that a person can experience. Especially traffic accidents, traumas such as gunshot injuries, falling from height, and work accidents are the causes of spinal injuries.[1] Pulmonary complications occur in 50-67% of persons with SCI.[2] Loss of strength in the limb muscles and weakness of the respiratory muscles may cause inadequate respiratory function after SCI. Early recovery in pulmonary functions may help prevent respiratory complications.[3-5]

Impairment in the respiratory muscle functions is associated with the level of the SCI.[6] Complete injuries above the level of the cervical third vertebra (C3), causes paralysis of all respiratory muscles, which requires mechanical ventilation and respiratory support. Respiratory muscles, including the diaphragm, scalens, and intercostals are partially protected in the injuries of the lower cervical vertebrae. Because of the functions of all expiratory muscles innervated from the thoracic and lumbar vertebrae are impaired, the clearance of the secretion is reduced. Due to dysfunctional cough, complications such as respiratory failure, pneumonia, and atelectasis may develop and eventually lead to increased mortality and morbidity. Hypoventilation, and ventilation perfusion disorder may occur due to immobilization. As a result, dyspnea, reduced exercise capacity, and limited functional capacity might develop.

It is well known that SCI patients with cervical level have a great risk in terms of respiratory complications.[6-8] However, there are limited data on respiratory complications in the patients with the injuries at thoracic vertebrae. Studies on pulmonary functions are mostly focused on the level above T1.[3,4,7-9] Therefore, this study was conducted to investigate the effects of breathing exercises on pulmonary functions, functional status, and quality of life in patients with cervical or thoracic level SCI, and to compare the results in these 2 different injury level groups.

MATERIAL AND METHODS

Thirty two patients >18 years with cervical or thoracic level SCI were included in this study. İstanbul Dr. Sadi Konuk Training and Research Hospital Ethics Committee (date: Jun 1, 2016, no: KAEK/2016.06.01) gave its approval to the study protocol. The Declaration of Helsinki's guiding principles were followed in conducting the study. A written informed consent was obtained from each patient.

Disease duration was <1 year and patients between the ages of 18-65 were included in the study. Neurological levels as evaluated with the American Spinal Injury Association Impairment Scale were between C4-T12. Exclusion criteria were uncontrolled hypertension, having neuromuscular disease other than SCI, having stage 3-4 pressure wounds, being clinically unstable, having cardiac rhythm disorders, having traumatic brain injury, and having tracheostomy.

Demographic characteristics were recorded. Pulmonary complications were questioned. The patients were divided into 2 groups according to their lesion levels. Those with lesion levels between C4-C8 were included in Group 1, and those between T1-T12 consisted Group 2. The patients included in the study consisted of 16 (50%) cervical and 16 (50%) thoracic level SCI. Pulmonary functions were assessed by pulmonary function tests (PFT). PFT were performed in the upright position with the SPIROBANK II spirometer device and a nose clamp was used. The test was repeated 3 times for each patient and the best result was recorded. Forced expiratory volume in 1 second (FEV_1), forced vital capacity (FVC), FEV_1/FVC, maximal middle expirium flow rate (FEF25-75), peak ekspiratory flow (PEF) values were measured by drawing the current-volume curve with the spirometer device.

All the patients had breathing exercises 3 times a day for 20 minutes for 4 weeks, in addition to neurological rehabilitation. Respiratory exercises were consisted of abdominal breathing, pursed lip breathing, segmental breathing, nose fast rapid and low volume breathing, resistant breathing with Triflo Breathing (Rabir Triflo Breathing Exercise Device, Turkey) exercise tool.

1) Diaphragm (abdominal breathing) Exercise

The person lies in supine position, one hand is on his abdomen and the other is on his chest. When the person breathes, the abdomen should swell with

the diaphragm movement and there should be no movement in the chest at this time. This exercise helps strenght the diaphragm.

2) Pursed Lip Breathing

This exercise is performed after a diaphragm breathing, the air is slowly released by contracting the lips.

3) Segmental Breathing

This exercise is performed by placing the hands symmetrically on the upper anterior surface of the chest and then on the sides of the chest, it is aimed to breathe the hand-held areas by breathing.

4) Nose fast rapid and low volume breathing

5) Resistant breathing with Triflo Breathing exercise tool

a) Triflo is held flat, deep breathing balls are lifted and left after holding for 3 seconds.

b) Triflo is inverted, deep breaths are released after the balls are lifted up and held for 3 seconds.

Each exercise is applied 10 sets of 3 times a day (10:30 to 16:00 21:00) and 1 minute rest is given between each exercise. If dizziness occurs, exercise is not continued, and exercise is not allowed after eating. At the end of 4 weeks, patients' respiratory functions were re-evaluated with pulmonary function test.

SHORT FORM-36

The quality of life was evaluated at the beginning and end of the study with the short form-36 (SF-36). SF-36 is frequently used in clinical trials to determine general health status and monitorize the outcome of medical care. It consists of 8 scales and 36 items extracted from the long forms of the Medical Outcome Study. It has been adapted for the Turkish people.[10] Higher scores indicate good health whereas lower scores show bad health.

SPINAL CORD INJURY MEASURE III (SCIM III)

Functional status was evaluated with SCIM III. SCIM III is the most sensitive and reliable scale that evaluates daily life performance in patients with SCI.[11,12] There are 3 sub-scales (self-care, breathing and sphincter, mobility) and 19 items which are scored between 0 and 100. Higher scores represent higher level of independence. SCIM III was given twice, at the beginning and end of the study. It has been adapted for the Turkish people.[13]

STATISTICAL ANALYSIS

The results obtained were evaluated with SPSS for Windows 19.00 (SPSS Inc., Chicago, Illinois) program. The Student t-test and Mann-Whitney U test were used to compare quantitative data. Descriptive statistical methods were used for the calculation of mean and standard deviation. The Wilcoxon sign test was used for in-group comparisons. For the comparison of qualitative data, chi-square test was used. The results were evaluated in the 95% confidence interval and the significance level was $p<0.05$. The power analysis of the study is 0.80 when the Type 1 error rate is calculated with 0.05.

RESULTS

Patient characteristics were presented at Table 1.

Eight (25%) patients were female and 24 (75%) were male. Group 1 consisted of 16 patients, 13 were male and 3 were female, whereas, there were 16 patients. Group 2, 1 was female and 11 were male. There was no statistically significant difference between the groups in terms of gender distribution ($p>0.05$). The most common etiology was traffic accident and the second most common cause was falling from height in the groups.

Nineteen (59%) patients had post-injury respiratory complications at the admittion to hospital. Six (37.5%) patients in Group 1 had respiratory complications at admission, whereas, 13 (81.3%) patients had respiratory complications at the beginning of rehabilitation. Comparison of baseline PFT values those with post-treatment test scores was presented in Table 2.

The SCIM III score comparisons of the patients before and after rehabilitation are shown in Table 3. A statistically significant difference was observed after treatment ($p<0.001$).

Baseline and posttreatment SF-36 are shown in Table 4. A statistically significant improvement was found in the social function val-

TABLE 1: Demographic and clinical characteristics.

	Cervical group meant±SD	Thoracic group mean±SD	p value
Age (years) (meant±Sd)	42.56±14.81	37.37±14.72	0.3
Height (cm) (meant±Sd)	169.50±10.27	171.75±8,47	0.496
Weight (kg) (meant±Sd)	74.06±13.23	71.50±16.12	0.545
BMI (kg/m²) (meant±Sd)	25.80±4.27	24.23±5.25	0.228
Time post injury (months) (meant±Sd)	6.00±3.30	4.31±3,13	0.166
Sex (female/male)	3/13	1/11	>0.05
Pulmoner complication (%)	37.5	81.3	
Current smokers (%)	25	50	
Injury severity			
AIS A (%)	12.50	37.5	
AIS B (%)	31.3	50	
AIS C (%)	18.8	6.3	
AIS D (%)	37.5	6.3	

SD: Standard deviation; BMI: Body mass index.

TABLE 2: Comparison of pre-treatment and post-treatment PFT values between groups.

	Group 1 Mean±SD		95% CI	p value	Group 2 Mean±SD		95% CI	p value
	Pre-tr.	Post-tr.						
FVC (%)	60.6±19.2	65.6±14.8	(-11.94, -3.17)	0.031	63.7±15.2	85.6±5.7	(-31.22, -71)	0.001
FEV_1 (%)	64.1±21.2	70.5±17.7	(-15.7, -2.26)	0.023	68.2 ±12.7	90.3± 8	(-38.21, -6.2)	0.001
FEV_1/FVC (%)	109.9±9.3	110.1±13.9	(-8.78, 3.67)	0.372	112 ± 8.7	109.1±7.7	(-13.63, 7.96)	0.6
PEF (%)	54.2±22	69.1±17.6	(-20.46, -1.98)	0.001	56 ± 12.3	74.1±11.1	(-36.41, -7.75)	0.002
FEF 25-75%	67.5±2.5	83.6±32.3	(-42.2, -6.4)	<0.001	74.7±17.9	89.3±16	(-50,0, -4.0)	<0.001

Group 1: Cervical spinal cord injury; Group 2: Thoracic spinal cord injury; Pre-tr: Pre-treatment; Post-tr.: Post- treatment; PFT: Pulmoner function test; FVC: Forced vital capacity; FEV_1: Forced expiratory volume in 1 second; PEF: Peak expiratory flow; FEF 25-75%: Maximal middle expirium flow rate; SD: Standard deviation; p value<0.05 significant; CI: Confidence intervals.

TABLE 3: Comparison of SCIM III values.

	Group 1 (mean±SD)			Group 2 (mean±SD)		
	Pre-tr	Post-tr	p value	Pre-tr	Post-tr	p value
SCIM III	31.4±25.4	36.6±24.82	0.001	41.3±10.9	48.5±9.7	0.001

Group 1: Cervical spinal cord injury; Group 2: Thoracic spinal cord injury; Pre-tr: pre-treatment; Post-tr: Post- treatment; SCIM III: Spinal cord injury measure III; SD: Standard deviation; p<0.05 significant.

ues of the thoracic injury group when compared with the baseline values in the thoracic group (p<0.05).

DISCUSSION

Nineteen (59%) patients had post-injury respiratory complications at admission to the rehabilitation hospital in this study. 37.5% (n=6/16) patients had respiratory complications with cervical injury at the admission. However, respiratory complications were detected in 13 (81.3%) patients with thoracic injuries at admission. Respiratory complication rate in cervical group was compatible with the literature. The rate of respiratory complications in the thoracic injury group was higher in our study compared to other

TABLE 4: SF-36 Comparison of the pre- and post-treatment quality of life scores.

	Group 1 Mean±SD			Group 2 Mean±SD		
	Pre-tr.	Post-tr.	p value	Pre-tr.	Post-tr.	p value
PF	17±2.16	17±2.16	1.00	19.9±4.5	19.9±4.5	1.000
PD	28±0	28±0	1.00	28±0	28±0	1.000
Pain	34.3±12.4	36.2±12.6	0.109	46± 6.9	47.1±6	0.167
GH	3.2±7	31.7±2.6	0.498	31.7±1.1	31.9±1.6	0.317
Vitality	41.5±1.8	42±0	0.317	42±0	42±0	1.000
SF	23.2±12	23.1±11.9	0.317	29.1±3	30.5±3.1	0.046*
ED	25.4±5.3	24.3±3.4	0.317	23.7±0	23.7±0	1.000
PH	35.6±3.5	36.4±1.5	0.317	3.7±0.2	36.7±0.2	1.000
PCS	26.9±8.1	26.9±7.5	0.715	28.7±4.4	29.1±4.1	0.063
MCS	35.1±1.7	35.0±3.0	1.000	36.3±1.5	36.6±1.8	0.066

SF-36: Short form-36; Group 1: Cervical spinal cord injury; Group 2: Thoracic spinal cord injury; Pre-tr: Pre-treatment; Post-tr: Post- treatment; PF: Physical function; PD: Physical difficulty; GH: General health; SF: Social function; ED: Emotional difficulty; PH: Physical health; PCS: Physical component summary; MCS: Mental component summary; SD: Standard deviation; p<0.05 significant; *p<0.05.

studies. Coexistence of chest trauma in patients with thoracic injuries may lead to higher respiratory complications in the thoracic group. Respiratory complications may lead high morbidity and mortality risk in both acute and chronic phases after SCI.[14-16] Noninvasive methods to provide assisted ventilation are also effective, but yet underutilized.[17]

Upper thoracic spinal fractures are less common than cervical or thoracolumbar fractures. This is due to the more stable biomechanical structure of this region. More severe traumatic energy is needed for injury in the thoracic region. In these patients, rib fractures and accompanying injuries such as hemothorax and pneumothorax may also contribute to the increase in morbidity and mortality.[18]

Jackson et al. reported that respiratory complication rate was 67% in the acute phases of SCI on the average of 17.7 days and during rehabilitation.[2] Of these, 31% were pneumonia, 36% were atelectasis, and 22% were respiratory failure. Respiratory complications were 84% at the C1-C4 vertebra level, 60% at the C5-C8 vertebra level, and 65% at the T1-T12 level. In the C1-C4 vertebra group, pneumonia was the most common complication in 63% of patients. This complication was followed by respiratory failure (40%) and atelectasis (40%). Pleural effusion was detected at thoracic levels more than other respiratory complications (38%). Atelectasis and hemothorax followed with 37% and 32%, respectively.

Fisburn et al. concluded that the rate of respiratory complications in the patients with C3-T11 level injury was 50% in patients with complete injuries.[19] It has already been shown that respiratory muscle training may help the treatment and increases respiratory muscle strength in patients with SCI.[8,18-22] Respiratory muscle training accompanying to the rehabilitation program have an effect on increasing the induration of diaphragm and other inspiration muscles, the main inhalation muscle, the distribution of air to the non-ventilated alveoli, and preventing microatelectasis.[23] Liaw et al., reported significant differences in vital capacity, total lung capacity, and FEV_1 after resistive exercises in tetraplegic patients.[3]

Pursed lip breathing frequency reduces dyspnea and PaCO2, increases tidal volume and oxygen saturation.[24] The proprioceptive stimulus created by the pressure applied to certain parts of the chest wall is utilized to provide better expansion of these regions with segmental breathing.[25]

Shin et al. suggested that short-term self-respiratory muscle training should be included in all spinal cord injury rehabilitation programs.[26] Wang et al. reported in a meta-analysis that respiratory muscle training would effectively improve pulmonary func-

tion in spinal cord injury.[27] Roth et al. reported that expiratory muscle resistance training exercises might be useful for the patients with SCI who had an injury at T1 level and above in a randomized controlled trial.[15]

Silva et al. found a significant increase in FVC values and endurance of the respiratory muscles after a 6-week exercise program in a controlled study in 12 patients with thoracic injuries.[28]

In our study, there was not any significant difference between the first PFT measurement parameters of both groups ($p>0.05$). PFT results showed a significant improvement in both groups after treatment ($p<0.05$). The increases in FVC, FEV_1, and PEF values were statistically significantly higher in thoracic injury group compared to the cervical injury group ($p<0.05$). There was no statistically significant difference between the groups in terms of increase in FEV_1/FVC (%) and FEF 25-75% after treatment.

In our study, when evaluating the SF-36 quality of life scale of both groups, a statistically significant improvement was found in the social function values of the thoracic group. Mueller et al. concluded that there was a high increase in the physical component of the SF-12 after inspiratory resistance training compared with placebo in tetraplegic patients.[8] An important goal of rehabilitation programs is to provide an improvement in the quality of life. The high rate of respiratory complications, especially in tetraplegic patients, adversely affects the quality of life. Jain et al. reported that low quality of life scores were associated with low FEV_1 and low FVC values in SCI patients with cervical, thoracic, lumbar, and sacral injuries.[29]

Although this is a short-term study, improvement in social function was significant. The improvement was only in the thoracic group with higher respiratory complications compared to the cervical group. This result is parallel with the literature, the decrease in secondary problems is associated with the increase in social functions. Craig et al. stated that less serious secondary medical complications might predict social participation in patients with SCI.[30] Piatt et al. showed that 75% of those with secondary health problems had reduced social participation.[31] This may explain the difference in the social function parameters of the patients in the thoracic group after rehabilitation in this study. Functional status was improved in both groups after treatment, but there wasn't a significant difference in term of functional improvement between the groups.

There were some strengths and some limitations in this study. The strength of this study is including the patients with both cervical and thoracic injuries. The first limitation is the relatively short follow-up period. Also the number of patients was relatively small. The lack of a control group in our study is a limitation. All patients with cervical or thoracic spinal cord injury should benefit from breathing exercises. Therefore, a control group was not formed.

CONCLUSION

As a result, breathing exercises accompaning to conventional rehabilitation program provided better results in terms of not only pulmonary functions but also in functional status and social functions of quality of life especially in the patients with thoracic injuries.

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Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

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