IJPMR 15, April 2004; 17-22

A Study of Efficiency of Breathing exercises to improve Pulmonary function in Tetraplegic and High Paraplegic subjects

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Abstract

Spinal cord injury lesions above D_5 disable respiratory muscles, resulting in restriction of total lung capacity and vital capacity, increasing markedly at high thoracic and cervical lesion.[2]

Thirty tetraplegic and high paraplegic subjects who fulfilled the inclusion criteria were studied prospectively. Their pulmonary function was measured using Pony spirometer and breathing exercises were advised, which were done thrice a day for 6 weeks and reviewed.

Restrictive type of pulmonary function in the quadriplegics and high paraplegics were found in initial assessment. Following rehabilitation therapy with breathing exercise, we found significant improvement in FVC. FEV_1, PEF, PIF and $FEF_{25-75\%}$, improvement was significant, signifying more effective clearance of the respiratory secretions. Vital capacity and ERV improved in high paraplegic. Respiratory rate showed trend towards reduction. Significant improvement in cough PEF and maximum voluntary ventilation signifies the effectiveness of assisted cough technique, which helps in decreasing the mucus plugging and accumulation of secretions.

We concluded that the rehabilitation therapy with breathing exercise, is a simple and an effective therapy resulted in significant improvement of the pulmonary function.

Key words: Tetraplegia, Paraplegia, pulmonary function, Forced vital capacity, Vital capacity, Maximum voluntary ventilation.

Introduction

People with spinal cord injury are at increased risk of chronic respiratory symptoms, added disability and early death from respiratory complication.[1] Lesions above D_5 disable respiratory muscles, resulting in restriction of total lung capacity and vital capacity, increasing markedly at high thoracic and cervical lesion levels. Restriction may lead to atelectasis and chronic infection, which in turn may lead to chronic airway obstruction,

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with reduced expiratory flow rates and added disability due to breathlessness. Bronchial hyperreactivity also may result from higher-level SCI,[2,3] further increasing the risk of obstructive dysfunction. Nevertheless, most people with SCI retain reasonable normal expiratory lung volumes.[4,5] Thus, restrictive dysfunction is predominant respiratory manifestation of SCI.

Various types of breathing exercises, including abdominal weight (AW) and inspiratory resistance (IR) breathing have been used to train tetraplegic patients to improve their respiratory muscle functions.[7, 8] Efficiency of respiration is reduced because of paradoxical movement of the chest wall inspiration and reduced lung and chest wall compliance.[9,10] Thus, as a result of respiratory muscle dysfunction and intrapulmonary abnormalities, breathing patterns become altered; breaths are more shallow and rapid with a shorter expiratory time, predisposing individuals to ventilatory muscle fatigue.[4, 11]

The primary interest of the study was to observe how pulmonary rehabilitation programs lead to change in pulmonary function in Indian patients without using any sophisticated instruments, as there were not enough studies in the literature. The main objective of the study was to see the effect of breathing exercise on pulmonary function in tetraplegic and high paraplegic patients.

Materials and Method

In this prospective study all patients with tetraplegia or high paraplegia (D_6 or higher neurological level) of any sex, age above 12 years, who attended Dept of PMR, at AIIMS, New Delhi between Dec 2000 to Aug 2002, who satisfied the inclusion criteria, were included in the study. Inclusion Criteria**:** Tetraplegia, high paraplegia (D6 and above), without altered consciousness, after 6 weeks of injury and informed consent. Pony Spirometer, which satisfied the American Thoracic Society (ATS) regulations, was used to evaluate static and dynamic lung functionality.

Accordingly 36 subjects were available to be included in the study. However, thirty cases successfully completed the study. At the beginning of the study all subjects pulmonary function test were measured in sitting position using Pony spirometer identically. Subjects were instructed on the performance of the Forced vital capacity test , Slow vital test and Maximum voluntary ventilation test as demonstrated by the tester. The test was performed a maximum of three times with 1-2 minutes rest between each test.. The tester gave standardized verbal encouragement to each subject. The Pony spirometer reports predicted, actual and percent-predicted values for each subject.

The breathing exercises 1.Diaphragmatic breathing, 2.Use of Weights for strengthening the diaphragm, 3. Manual assisted cough, 4. Inspiratory resistance training was demonstrated to the patient and the attendees of the patient. Patients did these breathings exercise regularly thrice daily for a period of maximum 30 min as tolerated for 6 week in home or ward. At the end of 6 weeks pulmonary function was measure and values obtained were compared with the baseline values.

Statistical method

Descriptive statistics were found out for each quantitative variable. For comparing clinical variables Paired t test/Wilcoxon Sign Rank test was applied. The result was considered significant at 5% level of significance, that is, $p<0.05$. SPSS -10 statistical Software was used for statistical analysis.

Observations and Results

When analyzing the 30 subjects who completed the study, the male and female ratio

as was 7.5:1. In Tetraplegic (37 %) there were 10 males and 1 female.and in high paraplegics (63%) there were 16 males and 3 females. The age distribution of the subjects was varying from 18 to 48 years. The mean age was 29.53±7.84 years. Neurologically there were C5 and C6 i.e. 13.3% each, and D5 & D6 is 20% and 16.6% respectively in the study. 70 % of subjects belonged to ASIA group B. Mean duration at which the study was done from the date of spinal cord injury was 12.10±6.91 months. 19 patients (63 %) had spasticity grade of 2 on Ashworth modified scale and were medicated for that. About 11 patients had secondary complications of pressure sore and two had heterotropic ossification. Six subjects who were smokers had discontinued after the injury.

i.e. the % of predicted vital capacity <60% and >34% and reduction in maximum voluntary ventilation.(Table 1) Out come to the exercise was quantified in terms of change is the clinical measured variables from that of the baseline measured value of the subjects.. A statistical significance ($p< 0.05$) improvement was found in forced vital capacity -FVC, FEV_1, PEF, PIF, FEF_{25-75}, Slow vital capacity- VC, ERV, Maximum Voluntary ventilation and Cough PEF. at 6 weeks,(Table 1) There was a trend in reduction of post therapy Rf, which signifies that our subjects could take slow and deep respiration. Among the tetraplegics it was observed that highly statistically significant ($p<0.005$) improvement was present in FVC,

Table 1:Over the time comparison in the clinical variables in all subjects(n =30)

variable	Baseline	6 weeks	p value
mean±SD	mean±SD		
FVC	1.94±0.54	2.22±0.56	0.000*
FEV1	1.83±0.54	2.17±0.56	0.000*
PEF	3.64±1.82	4.01±1.41	0.049*
PIF	2.73±1.23	2.80±1.45	0.779
FEV1/FCV	94.3±9.00	96.15±3.88	0.306
FEF25-75	2.59±0.78	2.95±0.77	0.001*
FEV1/VC	94.5±14.78	100.01±14.69	0.097
Cough PEF	4.86±1.04	6.03±1.40	0.000*
VC	1.93±0.82	2.13±0.51	0.136
ERV	0.33±0.16	0.44±0.21	0.045*
Rf	24.20±11.42	21.71±8.44	0.100
MVV	61.36±19.65	79.72±23.04	0.000*

*** p<0.05 significant**

All the subjects were having moderate to severe restrictive type of pulmonary function

Cough PEF, and MVV (Table 2). High paraplegic showed statistically significant ($p<0.05$) improvement in FVC, FEV_1 PEF, FEF_{25-75}, Cough PEF, VC, ERV and MVV

Table 2:Over the time comparison of variable in Tetraplegic patients (n=11).

Variable	Base line	6-weeks	p value
mean±SD	mean±SD		
FVC	2.02± 0.50	2.26±0.54	0.003*
FEV1	1.87± 0.52	2.21±0 .51	0.022*
PEF	4.01±2.28	3.95±1.78	0.872
PIF	3.13±1.06	3.20±1.69	0.880
FEV1/FCV	92.90±13.84	94.70±4.74	0.713
FEF25-75	2.56± 0.51	2.80± 0.68	0.228
FEV1/VC	91.60±17.19	99.32±17.54	0.291
Cough PEF	4.97± 0.96	6.36±1.52	0.000*
VC	2.15±1.17	2.17± 0.54	0.949
ERV	0.34± 0.17	0.39± 0.18	0.549
Rf	24.49±8.02	19.32±7.31	0.066
MVV	67.03±16.64	83.49±25.16	0.003*

*** p<0.05 significant**

Table 3:Over the time comparison of clinical variables in High paraplegic (n=19).

variable	baseline	6 weeks	p value
	mean±SD	mean±SD	
FVC	1.89±0.56	2.19±0.58	0.000*
FEV1	1.81±0.56	2.14±0.59	0.001*
PEF	3.42±1.51	4.04±1.19	0.003*
PIF	2.49±1.28	2.56±1.28	0.815
FEV1/FCV	95.05±4.62	96.98±3.11	0.069
FEF25-75	2.61±0.91	3.02±0.81	0.001*
FEV1/VC	96.16±13.40	100.41±13.28	0.210
Cough PEF	4.78±1.10	5.84±1.32	0.000*
VC	1.79±0.52	2.10±0.51	0.000*
ERV	0.32±0.16	0.46±0.22	0.047*
Rf	24.04±13.21	23.09±8.91	0.694
MVV	58.08±20.92	77.53±22.13	0.000*

*** p<0.05 significant**

(Table 3). Six subjects were excluded from our study as they did not came for follow up.

Discussion

The main objective of our study was to see any quantified improvement in the pulmonary function in our study group following the rehabilitation exercise protocol. It is well known that patients of tetraplegia and high paraplegia are having restrictive type of respiratory dysfunction, which is observed in many studies.[2-6,11.] In our study group, we found the pulmonary function was pronounced restrictive type, without any sign of obstructive dysfunction. FEV_1/FVC % was more that 75% in our subjects, which rules out any kind of obstructive airway disease. Reines & Harris [12] studied pulmonary function and incidence of respiratory infection of individuals with SCI ranging from C_1-L_5 and it was concluded that FVC was an important predictor of respiratory difficulties. A reduced PEFR, FEF_{25-75}, may occur due to large airway obstruction, as well as lack of sufficient effect to inhale maximally and exhale forcibly.[13] Reduced FEF_{25-75} may occur due to small airway obstruction as well as lack of effort to sustain maximal exhalation. Vital capacity and ERV were severely reduced in almost all subjects. Which confirms those of other study [8]. A reduction of vital capacity occurs in restrictive lung diseases because the subject's inhaled volume is reduced and there is a reduction in TLC.[14] Normally ERV depends on the action of abdominal muscles in co-ordination with expirationally active intercostal muscles.[14]

It is well known that tidal volume is within normal limits and increase in the respiratory rate is present, this is in confirmation with other findings.[11] In our study, MVV was reduced to more than 50% predicted. MVV reflects both the dimensions of the pulmonary system and the ability to use respiratory muscle to generate flow.[15]

. All our subjects underwent a rehabilitation exercise protocol, which was to improve the strength and endurance of the diaphragm, intercostal muscles and assisted coughing. Respiratory muscle training has been studied in several different populations, including patients with chronic obstructive pulmonary disease, muscular dystrophy, and SCI. The most successful findings, however, have been attained using a resistive device in the SCI populations, consisting of both acute and chronic tetraplegia, in which several investigators have demonstrated significant and progressive increase in respiratory muscle strength and endurance while improving lung volumes.

We observed that after exercises a statistically significant improvement ($p<0.05$) was present in the FVC, FEV_1, PEF, $FEF_{25-75\%}$, Cough PEF, ERV, and MVV (table 1). It is consistent with the finding of previous researchers,[8] but they did not measure all these variables in their study. Derrikson [8] study involved 6 patients with cervical cord injury indicated that FVC, MVV, PEF, and MIP significantly increased after 7 weeks of exercises. High paraplegic subjects showed significant post therapy improvement in FVC, FEV_1, PEF, FEF_{25-75}, Cough PEF, VC, ERV and MVV (table 3). Crane LD[16], in a study on paraplegic after endurance exercise, found a significant improvement of FEV_1 and MVV, which supports the findings of our study.

Completeness of the injury had no greater out come on the study similar observation was done by Almenoff et al,[4] Cough PEF was significantly improved in our study (table-1, 2 and 3), which was a proof that the method of coughing used was very effective in both quadriplegic and high paraplegic. Technique of "assisted cough" was used in traditional methods of rehabilitation for patients with inadequate cough[17]. Studies have shown

that a significant improvement of cough can be achieved by this method, with a range of improvement of 0% to 57%. We observed a trend in reduction of respiratory rate, which signifies that they were able to breath a slow and deeper.

Conclusions

We conclude that pulmonary rehabilitation exercise protocol prescribed to the SCI patients with reduced pulmonary functions is very much effective to provide a positive outcome. Pulmonary exercises were simple and effective therapy without any need for purchase of any sophisticated instrument. It should be emphasized, nevertheless, that such a training program must be regular and continuous and, thus incorporated into a lifestyle change. Only when such respiratory muscle training is chronically sustained will it induce changes that may help protect against both the development of respiratory muscle fatigue and recurrent respiratory infections.

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