Original Article

Effects of upper body resistance training on pulmonary functions in sedentary male smokers

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ABSTRACT

Background: Cigarette smoking is well correlated with lung diseases such as chronic obstructive pulmonary disease. It is common among men than women in India. In addition, sedentary lifestyle is associated with less efficient pulmonary function. Effectiveness of upper body resistance training (UBRT) in improving pulmonary function is unclear. Keeping all these factors in view, this study aims to examine the effect of UBRT on pulmonary function in male sedentary smokers. **Materials and Methods:** This study recruited 36 sedentary male smokers, of which 30 were randomized into two groups after fulfilling eligibility criteria-an exercising experimental group (EG) (N=15) or non-exercising control group (CG) (N=15). The EG group were assigned to exercise for 4 weeks, 3 times weekly on non-consecutive days using UBRT program and breathing exercise. In the CG, only breathing exercise was given for 10 min. Both groups were equivalent in baseline characteristics. **Results:** The improvement in forced expiratory volume in one second (FEV_1) and FEV_1/forced vital capacity (FVC) values were seen significant in EG after 4 weeks of UBRT: from 3.62±0.56 to 3.96±0.51 (P=0.000) and 0.88±0.11 to 0.96±0.13 (P<0.001), respectively. But FVC did not show significant change in the EG (P=0.430). There were no significant changes in FEV_1, FVC, and FEV_1/FVC values in CG after 4 weeks of intervention. On inter-group comparison, significant difference was found between CG and EG for FEV_1 and FEV_1/FVC values. **Conclusion:** Four weeks of UBRT program brought about significant changes in the pulmonary function in male sedentary smokers.

KEY WORDS: Pulmonary function, resistance training, smokers, upper body exercise

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INTRODUCTION

Cigarette smoking has been clearly documented as a primary cause of impaired pulmonary function.[1,2] It is known to cause cardiovascular and cerebrovascular disorders, chronic obstructive pulmonary diseases (COPD), and cancers.[3] It is believed that smoking, either active or passive, has negative influence on lung function, especially forced expiratory volume in one second (FEV_1), forced vital capacity (FVC), FEV_1/FVC, and diffusing capacity for carbon monoxide (DLCo), with simultaneous increase in forced residual capacity value.[4-6] It has been shown that being sedentary and smoking were related to lower Maximal Treadmill Test (MTT), FEV_1, FVC, and FEV_1/FVC ratio in both men and women.[7] It has been found that muscular exercise increases O_2 consumption, rate of diffusion, and the rate and depth of respiration, which lead to improvement in FVC.[8] Moreover, it has been shown that moderate-to-high levels of regular physical activity are associated with a lower lung function decline and risk of COPD in active smokers.[9] The most recent guidelines on pulmonary rehabilitation (PR) recommends the inclusion of exercise training targeted at the muscles of the upper extremities (UEs) in physical therapy programs specific to subjects with COPD.[10] The rationale supporting the inclusion of UE exercise training (UEET) in pulmonary rehabilitation for subjects with COPD is the competitive dual role of a number of UE muscles that sustain the upper girdle, but also act as accessory respiratory muscles, which work more during physical effort and even at rest in a subject who has COPD with diaphragmatic dysfunction. Thus, during activities involving the UEs, respiration becomes ineffective because the accessory respiratory

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muscles work to sustain the shoulder girdle, which may contribute to producing early fatigue and dyspnea.[11] In addition, there is a shift in respiratory work to the diaphragm. This is associated with thoracoabdominal dyssynchrony, severe dyspnea, and termination of exercise at low workloads, especially in subjects with more severe bronchial obstruction. Upper limb exercise training for subjects with COPD has been shown to increase upper limb work capacity, improve endurance, and reduce O_2 consumption at a given workload.[12] It is attributed that that reduction in FEV_1 in subjects with COPD is characterized by thoracoabdominal dyssynchrony of the muscles of inspiration, severe dyspnea, and overall Unsupported Arm Exercise (UAE) intolerance.[13] Arm training can help improve synchronization and coordination, resulting in a decreased minute ventilation.[14] The biological mechanism in which both physical activity and smoking interact antagonistically is an exaggerated inflammatory response in the lungs. Inflammation relates smoking with lung function decline and pathogenesis of COPD. Regular physical activity suppresses the production of inflammatory markers such as Interleukin-6 (IL-6), Tumor Necrosis Factor-Alpha (TNF-α), and C-Reactive Protein (CRP).[9] In addition to UBRT, breathing exercises are capable of increasing the pulmonary ventilation and improving mobilization of the chest wall, drainage of trachea bronchial secretions, promote relaxation, which contributed to a significant increase in vital capacity (VC), FEV_1, peak expiratory flow (PEF), and maximal voluntary ventilation (MVV).[8] Another study has emphasized that by giving short-term high-intensity strength training, pulmonary function might improve.[15] Present literature demands additional research to clarify the effects of UBRT on pulmonary function. Therefore, this study aims to evaluate the efficacy of UBRT on pulmonary function so that more appropriate choices can be made when designing exercise programs for individuals with decreased pulmonary function and to assist in maintenance of normal pulmonary function, particularly in smokers.

MATERIALS AND METHODS

This experimental study recruited 36 subjects from the general population in Mangalore community who responded to a local advertisement and volunteered. Six patients were excluded from the study because four did not meet inclusion criteria and two refused to participate. Figure 1 presents the recruitment and allocation of subjects in two groups and Table 1 presents baseline characteristics of subjects. Inclusion criteria consisted of male subjects in the age group of 25-55 years who reported having smoked a minimum of 10 cigarettes/day for at least 10 years and still use cigarettes.[16] They must have sedentary lifestyle, as in no leisure-time physical activity or activities done for less than 20 minutes or fewer than three times per week.[17] Exclusion criteria were as follows: Incapable of realizing the protocol of respiratory exercises, difficulty in completing the evaluation of pulmonary function,[16] and any known pulmonary, cardiac pathologies, musculoskeletal disorders, or recent surgery. Detailed information about general health, physical activity, and smoking status were self-reported by the subjects in the pre-exercise questionnaire. We had randomly assigned these 30 subjects into two groups: experimental group (EG) (n=15) who underwent 4 weeks of UBRT program and deep breathing exercise, and the control group (CG) (n=15) who underwent only breathing exercise by a simple random table method. The subjects were further provided with an explanation of the risks, benefits, and procedures of the study, along with the subjects being shown the correct technique for each exercise. After all these aspects were discussed, a written consent was obtained for voluntary participation in our study. Table 1 represents the statistical analysis of the subject characteristics based on age, height, weight, and pulmonary functions in chronic smokers. There was no statistical difference between the two groups at baseline.

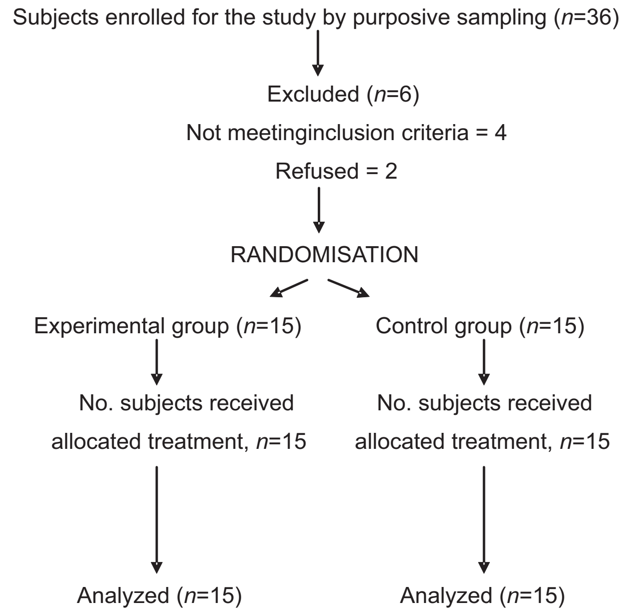

Figure 1: Flow chart of subjects, intervention, and analysis

Table 1: Baseline characteristics of subjects

Characteristics	Experimental (Mean±SD)	Control (Mean±SD)	*P*
No. subjects	15	15	
Age (yrs)	41.50±9.0	37.6±10.4	0.292
Height (cms)	169.0±7.13	167.0±7.02	0.469
Weight (kgs)	69.21±10.70	63.00±8.10	0.088
FEV_1(L)	3.62±0.56	3.54±0.47	0.982
FVC (L)	4.11±0.64	4.16±0.47	0.841
FEV_1/FVC	0.88±0.11	0.84±0.096	0.319

Represents the statistical analysis of the subject characteristics based on age, height, weight, and pulmonary function in chronic smokers.

The 4-week training program included 30 minutes of UBRT that was supplemented with 10 minutes of deep breathing exercises for the EG as well as for CG.

The EG subjects were under the direct supervision of a physiotherapist during the training sessions. At each training session, recordings were made of the exercises performed, the weight used, and the number of sets and repetitions completed for each exercise. Ten minutes of warm-up period was given, which includes general body active exercises and upper extremity muscle stretching. The strength training program included five major muscle groups, which were performed with the following weight-lifting procedures: (1) a seated chest press (mainly for strengthening of the pectoralis major muscle); (2) frontal latissimus dorsi pull-downs (mainly for the latissimus dorsi); (3) seated rows (mainly for biceps, deltoid, and triceps); (4) seated shoulder press (mainly for triceps, deltoid, and pectoralis muscles); and (5) barbell shoulder shrugs (mainly for trepazius). Upper body strength was assessed using one repetition maximum (1RM) method, which was considered the maximum weight that could be lifted through the full range of motion one time.

At beginning of first week, given resistance was 50% of 1RM and it progressively increased to 85% of 1RM during the final week of training. Each exercise was performed as 3 sets of 10 repetitions each. Thereafter, the training workload was increased when more than 10 repetitions per set could be performed. This protocol was repeated for three non-consecutive days of UBRT per week for four weeks. One minute rest period was given between each set and 30 seconds between each exercise. At the end of each session, cool down exercises were given for 10 mins, which also included general body active exercises and upper extremity muscle stretching.

The conventional breathing exercise was given to CG for 10 min and subjects were instructed to maintain their usual activities and not to participate in any form of exercise during the four-week training period. This protocol was also repeated for three non-consecutive days per week for four weeks.

The outcome measures used in this study are pulmonary function measures FVC, FEV_1, and the FEV_1/FVC ratio. Pulmonary functions were measured using computerized spirometer (Spirolyser SPL-10). The spirometry values of all subjects were evaluated before and after the four weeks experimental period. Pulmonary functions were assessed using standard spirometry guidelines given by ATS/ERS.[18] Subjects in both groups were asked to abstain from smoking for at least 4 hours before both the pre-intervention test and post-intervention spirometry measurement procedure.

ETHICS

Ethical clearance was obtained from institutional ethics committee.

STATISTICS

Statistical analysis was performed using SPSS 16.0. For each group, pre- and post-training comparisons were made using paired *t* test and comparisons were made between the control and EG, by using Mann–Whitney *U* test. A value of $P<0.05$ was considered statistically significant.

RESULTS

There was no drop out from our study. All subjects completed four weeks of the UBRT program and the CG underwent only breathing exercise program.

In the EG, there was statistically significant improvement in FEV_1 and FEV_1/ FVC values after four weeks of training from 3.62±0.56 to 3.96±0.51 and 0.88±0.11 to 0.96±0.13 ($P=0.001$), respectively. But there was no statistically significant improvement in FVC value from 4.11±0.64 to 4.13±0.64 ($P>0.05$) as shown in Table 2.

In the CG, there was no statistically significant difference in FEV_1 from 3.54±0.47 to 3.49±0.51, FVC from 4.16±0.47 to 4.15±0.48, and FEV_1/FVC from 0.84±0.096 to 0.84±0.11 values after four weeks of breathing exercise program ($P>0.05$), as shown in Table 3.

On inter-group comparison, significant difference was noted between the control and experimental groups for FEV_1 and FEV_1/FVC values. FEV_1 value in the experimental group was 0.351±0.21 and in the CG it was -0.04±0.13 ($P=0.000$); FEV_1/FVC values in the experimental group was 0.08±0.07 and in the CG it was 5.4±20.9 ($P=0.419$). However, there was no significant change in FVC value, as shown in Table 4.

DISCUSSION

This study sought to evaluate whether UBRT is useful in addition to conventional breathing exercise in male

Table 2: Paired *t* test analysis of mean FEV_1, FVC, and FEV_1/FVC in the experimental group pre- and post-intervention

Variables	Pre-intervention (Mean±SD)	Post-intervention (Mean±SD)	*P*
FEV_1(L)	3.62±0.56	3.96±0.51	0.000 (HS)
FVC (L)	4.11±0.64	4.13±0.64	0.430 (NS)
FEV_1/FVC	0.88±0.11	0.96±0.13	0.001 (HS)

The result shows that there is a significant difference in FEV_1 and FEV_1/FVC values in the experimental group. But there is no significant difference in the FVC value.

Table 3: Paired *t* test analysis of mean FEV_1, FVC, and FEV_1/FVC in the control group pre- and post-intervention

Variables	Pre-intervention (Mean±SD)	Post-intervention (Mean±SD)	*P*
FEV_1 (L)	3.54±0.47	3.49±0.51	0.195 (NS)
FVC (L)	4.16±0.47	4.15±0.48	0.708 (NS)
FEV_1/FVC	0.84±0.096	0.84±0.11	0.462 (NS)

This result shows that in the control group, there is no statistically significant difference in FEV_1, FVC, and FEV_1/FVC values.

Table 4: Mann-whitney *U* test analysis of FEV_1, FVC, and FEV_1/FVC for comparison between groups

Variables	Experimental (Mean ± SD)	Control (Mean ± SD)	*P*
FEV_1(L)	0.351±0.21	-0.04±0.13	0.000 (HS)
FVC (L)	0.0157±0.07	-0.0120±0.12	0.419 (NS)
FEV_1/FVC	0.08±0.07	5.4±20.9	0.001 (HS)

This result shows that there is significant difference between the control and experimental group for FEV_1 and FEV_1/FVC values, but there is no significant change in the FVC value.

smokers with sedentary lifestyle. We found that the combination of UBRT and conventional breathing exercise was safe and well tolerated despite the chronic smoking pattern and was associated with statistically significant improvement in FEV_1. However, our study did not show statistically significant change in the FVC value. Our study has shown similar findings with the previous study, which demonstrated increase in spirometric values in welders after 2 months of arm training, breathing exercise, and incentive spirometry. Authors have attributed the findings to improvement in rate and depth of respiration, consumption of O_2, and rate of diffusion due to muscular exercise. They have also stated that breathing exercise promotes a more efficient breathing pattern, improvement in ventilation, mobilization of the chest wall, drainage of trachea bronchial secretions, as well as promotes relaxation.[8] Another study found improvement in spirometry values in women with breast cancer, which has been attributed to exercise that appeared to maintain erythrocyte concentrations during treatment, but still the mechanisms by which exercise training benefits breast cancer survivors during or after treatment remain elusive.[19] However, in contrast to above studies, a randomized control study has demonstrated decrease in FEV_1 value in severe COPD subjects after resistance training and aerobic training interventions. They have given the probable reason as fatigue due to resistance training session and their medical treatment.[20]

In a previous study, 8 weeks of upper body exercises did not show a statistically significant improvement in the FEV_1/FVC ratio.[21] This finding is in contrast with the present investigation, which shows significant increase in the FEV_1/FVC ratio. This significant increase in the current study was possibly due to the increase in FEV_1 and non-significant change in FVC.

A previous study has demonstrated that FVC value significantly increased after 8 weeks of upper body gravity resistance exercises and proprioceptive neuromuscular facilitation training.[21] A study supporting the above statement found statistically significant improvement in FVC, with unchanged FEV_1 values. They attributed this improvement in the FVC value to improvement in functional capacity.[22] A probable explanation for the increase in FVC in previous studies was that, when exercising the pectoralis major muscle against progressive loads, it can result in a 20% increase in the FVC value of the subjects.[23] Our study shows lesser change in FVC as compared to FEV_1, which needs further evaluation. However, the changes in the FVC are not statistically significant but are clinically relevant. Larger changes in the FVC value in previous studies[21,22] can be due to longer duration of exercise training.

There is statistically significant difference between control and experimental group for FEV_1 and FEV_1/FVC values. Some previous studies[24-27] showed no significant change in these parameters; these may be due to inclusion of different population like severe COPD, older age group (>60 yrs), inadequate sample size, and level of training stimulus. The improvement in pulmonary functions in our study may be due to inclusion of asymptomatic male sedentary chronic smokers aged 25-55 years. Besides, our study differs from other studies in the methodological aspect, as we administered both UBRT and conventional breathing exercise to the EG and only conventional breathing exercise was performed on CG. High-intensity UBRT (50-85% of 1RM) was administered for 4 weeks for non-consecutive days. Thus, due to a combined effect, there may be an improvement in synchronization, coordination, and true metabolic adaptations in the inspiration muscles, which results in decreased minute ventilation and reduction in FRC, which may improve pulmonary function parameters. The present investigation attempted to develop an inexpensive and simple resistance training program as a tool to improve or maintain the pulmonary function of smokers and/or individuals prone to developing pulmonary pathologies. Therefore, the aim of the investigation was to develop a primary preventive strategy to help prevent smokers from developing pulmonary diseases. In doing so, it may provide clinicians, patients and healthy (and possibly pathological) individuals with an additional or improved mode of exercise (over and above the traditional aerobic modes) to improve pulmonary function, health status, and a sense of well-being.

CONCLUSION

Four weeks of high-intensity upper body resistance training with an adjunct in the form of conventional breathing exercise have an important beneficial impact on pulmonary function parameters, especially FEV_1 and FEV_1/FVC values in male sedentary smokers.

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