

Impact of exercise training on peak expiratory flow rate in relation to body mass index – An Indian perspective

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Abstract

Background: Overweight has a considerable impact on spirometry variables which are thought to be improvised by isotonic exercise and diet regime – though the combined effects have not been investigated and precisely proved as yet. We hypothesized that programmed exercise training improves the Peak expiratory flow rate in overweight, more so if there is associated weight loss.

Objective: The objective was to investigate and evaluate the effect of dynamic exercise and dietary weight-loss program of 12 weeks on the Body mass index and Peak expiratory flow rate in overweight adolescents.

Settings and Design: Adichunchanagiri Institute of Medical Sciences, Karnataka. A cross-sectional pilot study.

Materials and Methods: Dynamic lung parameter, Peak expiratory flow rate, was measured in 20 overweight boys and in equal number of age and gender matched normal weight controls using computerized spirometer (BPL APREMIS 3.1).

Statistical analysis used: Collected data were statistically treated using the SPSS software.

Results – Body mass index and pre training baseline Peak expiratory flow rate revealed very significant difference ($P < 0.001$) between the two groups. Following 12 weeks of regular aerobic exercise combined with calorie restricted diet protocol, the experimental group showed a longer pulmonary endurance. Overall 19.6% improvement in Peak expiratory flow rate was observed in the high-BMI participants. The pre- and post-training changes in the Body mass index amongst the overweight, was statistically significant ($P = 0.0350$) with 25% i.e., five boys achieving healthy weight limit.

Conclusion: Body mass index, restricted diet and exercise are concomitantly affecting Peak expiratory flow rate result. The results indicate that exercise training with a restricted diet not only improved respiratory fitness but more so the Body mass index in the overweight adolescents.

Keywords: Body Mass Index, Overweight, Exercise, Diet, Peak Expiratory Flow Rate, Spirometry.

Introduction

Worldwide, adolescent overweight (OW) has reached epidemic proportions despite major efforts to promote weight reduction. The national average of OW adolescents in India is currently 19.9% i.e., 1 in every 3 of them. The negative influence of fat distribution on lung function has been shown by both indirect and direct assessment. (1) However, the effect of weight loss, on breathing mechanics is unclear. To investigate, the aim of this pilot study in an Indian setting, is to employ new methods to examine an old question i.e., firstly, to describe the Peak expiratory flow rate (PEFR) response in normal weight (NW) and OW adolescents and secondly, the same lung parameter after a 12-week supervised exercise-training program combined with restricted diet in the OW group.

Extensive research have shown that regular exercise constitute a way to increase inspiratory muscle function (Laoutaris et al., 2011) and elastic recoil of the lungs, but there still exist paucity of scientific documentation relating to the abstract association of PEFR with Body mass index (BMI) and exercise. Thus, the results of this research can provide baseline information and help to conceptualise solutions to battle 'BMI blues'.

Abbreviations: OW = overweight; NW = normal weight; BMI = body mass index; PEFR = Peak expiratory flow rate.

Materials and Methods

Research Design

Participant Population: A total of 40 healthy, gender-matched MBBS students of the age group 17 to 20 years, leading a sedentary lifestyle were recruited from Adichunchanagiri Institute of Medical Sciences (AIMS), Karnataka, to participate in this study. "Healthy" was defined as being free of any major pulmonary, cardiovascular, metabolic disease states, such as hypertension and/or any endocrine dysfunction. Individuals with habit of alcohol and tobacco consumption and those with chest and spinal deformities or on any medication were excluded. A detailed physical examination was conducted to exclude cardiac or pulmonary diseases. The criterion for OW or the exercising group was an age-adjusted BMI based on WHO guideline on the South Asian values between 23 – 27.99 kg/m². This group had 20 participants (n=20) with BMI between 24.85±1.17. The non-exercising, NW control group (n=20) were matched according to BMI cut-off limits between 17.5 – 22.99 kg/m². In this group, the BMI was between 20.23±1.30. None of the students were on a reducing diet or exercise program. All of them were provided written informed assent and consent. The study procedures were reviewed and approved by the institutional review and ethical board. The experimental group participated in a 12 weeks diet and aerobic

exercise plan (five 30 minute sessions of jogging in a week), while control group had no plan of diet restriction and exercise during that period of time.

Anthropometric methods: The weight of each participant, while wearing minimal clothing, was measured using electronic scales (Hanson, CHINA) to the nearest 0.1 kg. The standing height was measured using a wall-mounted stadiometer to the nearest 0.1 cm, while the participants' occiput, back, and bare heel were touching the stadiometer. The BMI was calculated using Quetelet formula/index –

$BMI = \text{Weight in kilograms} / \text{Height in m}^2$

After 12 weeks, repeat measurements were performed with calculation of BMI to note the changes in both the groups.

Exercise-Training Protocol: The training protocol was carried out in a supervised and structured environment (Laboratory of Research Physiology). The procedure was conducted both morning and evening and no participant had prior experience of using the treadmill. The exercise plan was explained and the next participant was encouraged to watch the running on the treadmill. The students were asked to wear light T-shirt and shorts, and to restrict their food intake for at least 1.5 hours before the session. All sessions were under supervision and the duration, heart rate and distance walked were recorded on the treadmill monitor. Participants in the exercise group trained on stationary treadmills five times per week, for 30 minutes per session, at 60-80% of maximum heart rate (MHR), for 12 weeks (60 total exercise sessions). This aerobic exercise plan included 20 minute session of jogging with 5 minutes of warm-up and 5 minutes of cool-down exercises.

All participants adhered to the requirements, so no visits were rescheduled. Attendance was at least 90% of all scheduled training sessions. Participants in the control group were instructed to maintain current levels of physical activity and did not participate in any structured diet and/or exercise program.

12 Week Diet Program: Besides receiving an exercise prescription, as detailed above the OW group also received dietary counselling and an individualized diet program. The participants were enrolled into a energy/calorie restriction program of 1500 - 1700 kcal per day to create a calorie deficit, that continued for 12 weeks. Students were instructed on portion sizes, food exchanges and to record dietary intake using a daily dietary exchange checklist. Compliance to the diet was measured by random, weekly, 24-hours dietary recalls and were encouraged to lose 250-500gms weight per week. The exercising group also attended a weekly 30 minutes class during which they received additional instruction on the study procedure updates, weight loss principles, nutrition guidelines and the importance of compliance to the dietary regimen.

Assessment of Peak Expiratory Flow Rate (PEFR):

Peak expiratory flow rate was measured by using advanced computerized spirometer (BPL APREMIS 3.1) according to standard procedure. The forced expiratory manoeuvre was demonstrated to all the participants. Each student was made comfortable during the testing which was carried out in the evening hours, as expiratory flow rates are highest in late afternoon. All were asked to refrain from tea, coffee, chocolates and caffeinated soft-drinks on the day of recording. The volunteer is first asked to take 3-4 normal breathes through the mouthpiece of the spirometer, to make him familiarize with the instrument. Then instruction was given to take a slow and deep inspiration and exhale as rapidly, forcefully and completely as possible in one single blow into the prevent pneumotachometer – all in standing position with the nose clip on. Sufficient care was taken to ensure that a tight seal was maintained between the lips and the mouth piece. The best of three trials was considered for data analysis. After the basal recording, repeat measurements were performed after 12 weeks of both groups.

Statistical Analysis

Descriptive and inferential statistical analysis has been carried out in the study. Comparison of variables between groups before and after 12 weeks were analyzed, which produced P values for the effects of group status (exercise vs. control) and time (baseline vs. post). Stepwise regression analysis was used to determine the relation between anthropometric measurement and PEFR. Results on continuous measurements are presented on Mean \pm SD (Min-Max). Significance is assessed at 5 % level of significance. The following assumptions on data is made –

Assumptions:

1. Dependent variables should be normally distributed,
2. Samples drawn from the population should be random,
3. Cases of the samples should be independent.

Student t test (two tailed, independent) has been used to find the significance of study parameters on continuous scale between two groups (Inter group analysis) on metric parameters.

Significant figures

+ Suggestive significance (P value: $0.05 < P < 0.10$)

* Moderately significant (P value: $0.01 < P \leq 0.05$)

** Strongly significant (P value: $P \leq 0.01$)

Statistical software: The Statistical software namely SAS 9.2, SPSS 15.0, Stata 10.1, MedCalc 9.0.1, Systat 12.0 and R environment ver.2.11.1 were used for the analysis of the data and Microsoft word and Excel have been used to generate graphs and tables.

Results

Anthropometric characteristics of the subjects are summarized in Table 1 and Fig. 1 for each group. All data are shown as mean (SD).

Table 1: Comparison of physical parameters among OW and NW (pre-training)

Variables	Overweight (OW) group	Control (NW) group	P value
Age in years	18.25±0.72	18.05±0.60	0.346
Height (cm)	169.95±6.39	168.45±7.76	0.509
Weight (kg)	71.70±5.48	57.45±6.72	<0.001**
BMI (kg/m ²)	24.85±1.17	20.23±1.30	<0.001**

NW- Normal Weight

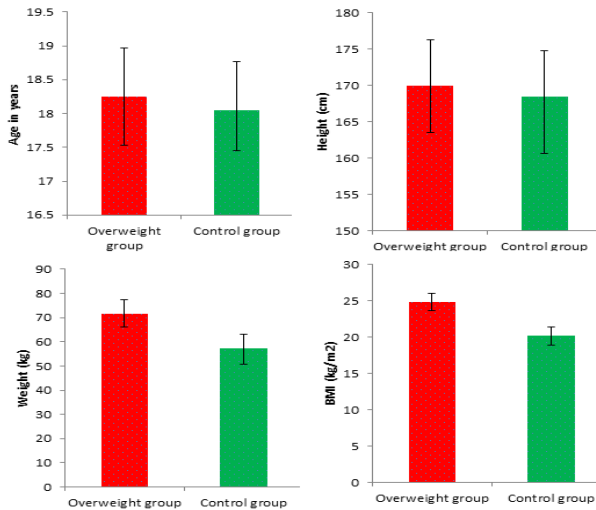


Fig. 1: Comparison of physical parameters among OW and NW (pre-training)

OW – Overweight, NW – Normal weight

The mean weight and BMI of OW individuals are significantly more than the NW and it is one of the basis of case selection in the present study. In the OW group BMI showed significant negative correlation with PEFR. The pre-training mean PEFR for the OW and NW are shown in Table 2 and Fig. 2 (a), (b). After adjustment for age, height, BMI, the differences in PEFR and its % Predicted, remained highly statistically significant at P<0.001.

Table 2: Comparison PEFR variable among OW and NW (pre-training)

Pre-training: Observed	Overweight (OW) group	Control (NW) group	P value
PEFR (l/min)	401.45±42.71	461.15±30.99	<0.001**
Predicted PEFR	542.30±12.5	537.85±17.87	0.367
% Predicted PEFR	74.06±8.02	85.82±6.33	<0.001**

NW- Normal Weight

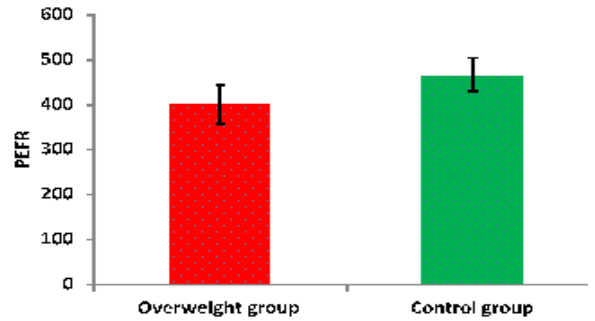


Fig. 2 (a): Comparison PEFR variable among OW and NW (pre-training)

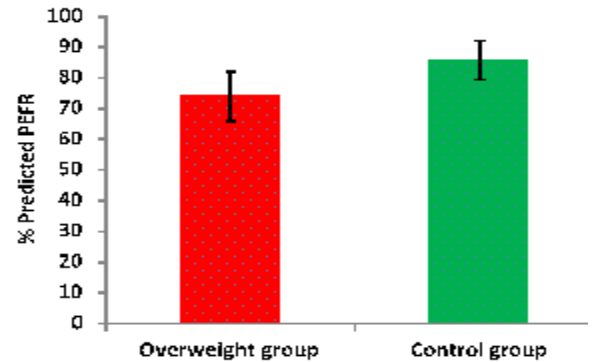


Fig. 2(b): Comparison % Predicted PEFR variable among OW and NW (pre-training)

OW – Overweight, NW – Normal weight

Pre-training, comparative study of baseline PEFR in the OW and NW is statistically significant, unlike the post-training (Table 3).

Table 3: Comparison PEFR variable among OW and NW (post-training)

Post-training: Observed	Overweight (OW) group	Control (NW) group	P value
PEFR (l/min)	479.90±49.54	465.35±31.85	0.276
Predicted PEFR	542.90±12.62	537.85±17.87	0.308
% Predicted PEFR	88.38±8.75	86.95±6.38	0.465

NW- Normal Weight

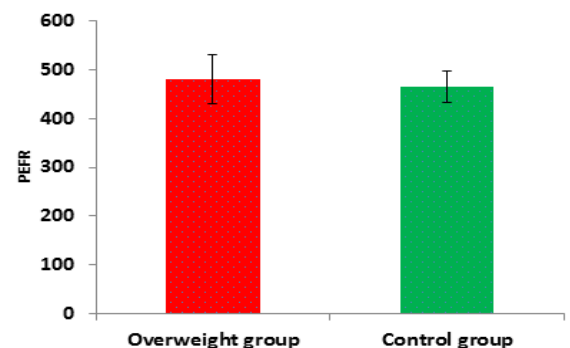


Fig. 3 (a): Comparison PEFR variable among OW and NW (post-training)

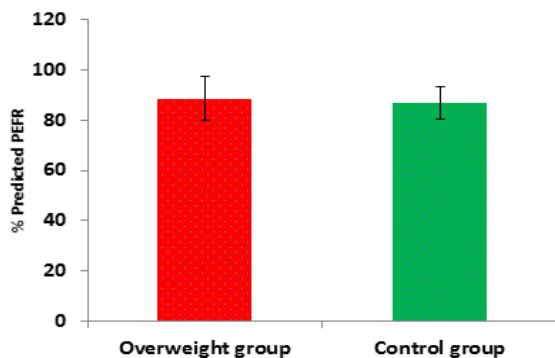


Fig. 3 (b): Comparison % Predicted PEFR variable among OW and NW (post-training)

OW – Overweight, NW – Normal weight

Intragroup study, pre-training and post-training, the correlation matrix between BMI and PEFR, in the OW showed significant statistical result (Table 4), proving that the compliance to the strategic regime by the adolescents went a long way in the zeal to improve their pulmonary status.

Table 4: Comparison BMI and PEFR variable among OW

Variables	Overweight group (Pre-training)	Overweight group (Post-training)	P value
BMI(kg/m ²)	24.85	24.015	0.0350*
PEFR(l/min)	401.45±42.71	479.90±49.54	<0.0001**
Predicted PEFR	542.30±12.52	542.90±12.62	0.8807
% Predicted PEFR	74.06±8.02	88.38±8.75	<0.0001**

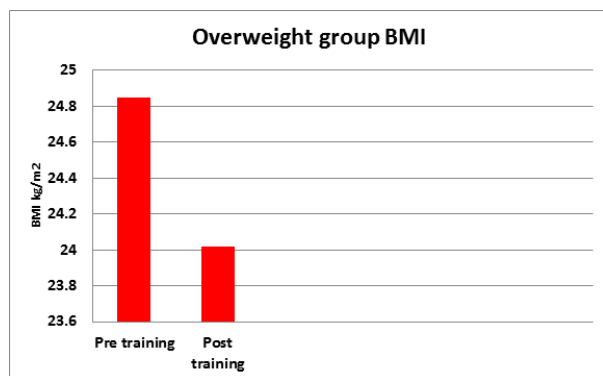


Fig. 4 (a): Comparison of BMI variable amongst OW (pre-training and post-training)

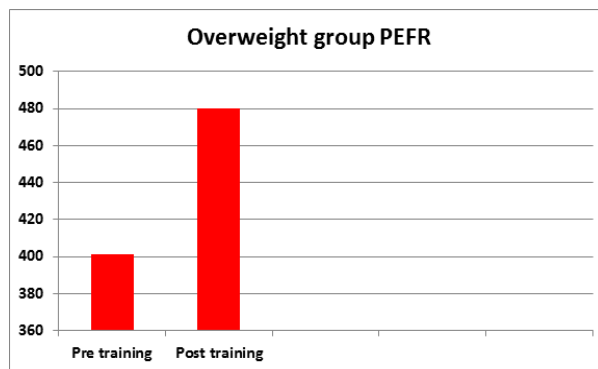


Fig. 4 (b): Comparison of PEFR variable amongst OW (pre-training and post-training)

Overall 19.6 % improvement in PEFR was observed in the experimental group. Moderately significant but very encouraging and positive result is seen in the OW with respect to the body mass (post-training 25% of the OW attained normal BMI).

Table 5: Comparison BMI and PEFR variable among NW

Variables	NW Control	NW Control (after 12 weeks)	P value
BMI (kg/m ²)	20.23	20.60	0.3610
PEFR (l/min)	461.15±30.99	465.35±31.85	0.6749
Predicted PEFR	537.85±17.87	537.85±17.87	1.0000
% Predicted PEFR	85.82±6.33	86.95±6.38	0.5772

NW- Normal Weight

As expected, statistically nothing significant was noted in the NW (Table 5). Generally, our results were consistent with other studies that normal lung function values are varied according to BMI, with a significant add end that exercise associated with a restricted balanced diet will go a long way in not only improving the lung compliance but also decrease the body weight thus reinforcing the pulmonary performance.

Discussion

In this study the effect of aerobic exercise in combination with calorie restricted diet on the BMI and PEFR, is compared and analysed. Following 12 weeks of training both parameters showed significant improvement in the OW. This positive relationship between aerobic exercise and PEFR is supported by Cheng et al., in which physical activity improved pulmonary function in healthy sedentary people. Kaufman et al., studied the effect of aerobic training on ventilatory efficiency in overweight children, and found that the training helped to reverse the decrements in cardiopulmonary function. Obesity and exercise can independently affect different parts of the respiratory

system. All the same, the exact percentage of this influence, individually, remains obscure to the researchers.⁽²⁾

The expiratory parameter, PEFR, is dependent upon several variables including airway resistance and maximal voluntary muscular effort. Causes for the differences observed in the overweight are not clearly known but altered mechanical muscular activity due to adiposity, altered airway calibre and increase respiratory resistance along with remodelling of respiratory passage due to circulating inflammatory mediators, as fat mimics chronic inflammatory condition, may be responsible for the restrictive pattern of flow rate.⁽³⁾ It is interesting to note that the results of PEFR obtained from pre-obese and obese subjects as well as the Pearson correlation of PEFR with different obesity markers demonstrated an impairment of the pulmonary function with increasing body weight but not to such an extent that it will be evident clinically.⁽⁴⁾

In the past two decades, there has been an increased awareness of the negative consequences of stress, high caloric intake, malnutrition which includes excess nutrition, and lack of physical activity in youth. Placing the facts, India has the third highest number of obese and overweight population after United States and China. It is physiologically plausible to presume that if overweight adolescents are limited in ventilatory function and efficiency (whether because of the actual excess weight on their chest and trunk or simply because of a 'deconditioned' state), exercise training might help improve that function.⁽²⁾ In fact, Health care providers often call exercise the 'miracle' or 'wonder' drug – alluding to the wide variety of proven benefits that it provides.

Exercise training is an important modality of weight management in overweight, which must be undertaken as early as possible (Jolliffe and Janssen, 2006). A study was carried by Chitra et al., in 2011 to explore the effect of aerobics on pulmonary function in general population. The observations were, improvement in lung volumes and flow rates due to better mechanical factors and lower airway resistance influenced during the training period. One of the clear-cut benefits of exercise regime is psychological, people who exercise regularly 'feel better'. Such effects may also be attributed to release of endorphins during exercise.⁽⁵⁾ Endorphins are reported to relieve mental stress and induce a sense of well-being and alleviates post exercise pain. This probably plays a vital role in exercise adherence.

Since accumulation of fat reduces the muscle strength, there is decrease effort in stretching of respiratory muscles.⁽⁶⁾ Physical activity has been shown to increase muscular strength, reduce body fat and increase lean body mass, thus helping to keep BMI within physiological limits.⁽⁷⁾ Increased respiratory muscles strength contributed to the improved breathing mechanics and increased aerobic capacity after training.⁽⁸⁾

Exploration of the relationship between fitness and fatness has proved that training improves the 'physical working capacity' (PWC) of an individual. These improvements can be explained by the improvement in muscle metabolism (Hamilton et al; 1995). The performance of muscular work requires the physiological responses of the cardiovascular and ventilatory systems to be coupled with the increase in metabolic rate; efficient coupling minimizes the stress to the component mechanisms supporting the energy transformations.⁽⁵⁾ The complex interplay can be probably explained by understanding the cumulative effects of better strengthening of respiratory muscles as a result of physical training, as skeletal muscle control many crucial elements of aerobic conditioning including lung ventilation, delayed onset of fatigue and the autonomic changes that occur, which is modulated by the Central reflexes.

Effects of Weight Loss on PEFR: The effects of structured exercise and dietary programs on pulmonary function in asymptomatic OW subjects is unclear. To the best of our knowledge we are the first to assess the impact of calorie restriction and exercise training on PEFR in relation to BMI, at least in this part of the world.

Because of aerobic training, Respiratory Quotient (RQ) decreases causing oxidation of more fats. Therefore, increased fatty acids are mobilized from tissues stores into the blood, sparing glycogen.⁽⁹⁾ As physical performance is a direct function of glycogen stores, the endurance increases. This outcome facilitates muscle oxidative capacity by – increase in the number of mitochondria and oxidative enzymes in the muscle fibres.⁽⁵⁾

Interesting, in this observational study, the change in PEFR were consistent across the entire cohort of OW students, and this did not correlate with the amount of weight lost. Following this regime, five students reached the target of normal body weight and the rest with minor fluctuation still fall in the OW category. This suggests that some of the limitations of overweight on ventilatory efficiency might not be solely attributable to the additional body weight, but could be a manifestation of the 'untrained state' that is typically associated with overweight.⁽¹⁰⁾ This suggests that all participants in our weight reduction program improved their quality of life, regardless of relative weight changes, presumably because the program includes an exercise with diet component and a counselling/support component (which could improve emotional well-being). Moreover, since BMI of the OW group was not so overt and the participants were young, motivation and enthusiasm may have overcome the deficits, even it had existed. This 'primus genus' project, was conducted to assess pulmonary efficiency and the scope of implementing exercise programs for improvement in positive coping skills. Thus, the results can serve as a baseline reference values and be utilize for intervention, policy making/amendment of medical colleges.

Conclusion

Our study suggests that professional institutes should develop and promote awareness regarding the adverse effects of overweight and obesity to help in improving the level of physical activity, life style modification, which, with a little effort, not only catalyst quality of life in general, but indirectly, patient care, particularly in students of healthcare services.

By conducive strategy and conceptualise the implementation of substantial diet restriction and healthy eating habits associated with, regular exercise have led to conclude that it is a 'success story' for the representative sample to get the equation – "Fitness is - 70% diet and 30% exercise" right and get results.

Same suggestion is also applicable to the normal weight students to maintain or even to improve their respiratory performance and avoid overweight.

Limitations and implication for future research: This was a pilot study including only male students. This shortcoming in the study design may affect the generalization of the results to other sections of society. The relatively small sample could potentially limit the statistical power, and, therefore, additional studies with larger sample sizes are needed to evaluate our observations. The findings warrants further investigation such as, other lung function parameters, in different age groups, in different ethnicity and longitudinal studies in this field which may explore more precise correlations between different adiposity markers and lung function, as BMI has its own limitation. We did not include overweight who were not going through the weight-reduction program as controls, which is another potential limitation of our study.

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