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Original Research Article

Effect of pulmonary intervention and vitamin C supplementation on respiratory health status of people exposed to air pollution at Tirupati, Chittoor district, Andhra Pradesh

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ABSTRACT

Background: Air pollution is a significant issue of global concern with implications for public health. The primary objective of this study was to evaluate the impact of air pollution on the respiratory health of individuals who are exposed to air pollution in Tirupati, Chittoor District, Andhra Pradesh.
Methods: The present study utilised a quantitative methodology and employed a randomised control design. A total of 300 individuals using cluster sampling method were selected for this study and divided into four groups. Three of these groups received different interventions, namely pulmonary intervention, vitamin C supplementation, and a combination of pulmonary intervention and vitamin C supplementation, the fourth group served as the control group. These groups were investigated simultaneously and their outcomes were compared.
Results: A notable disparity is observed in the mean scores between the pre-test and post-test measurements in the pulmonary intervention group ($t=2.06$, $p=0.001$), vitamin C supplementation group ($t=3.22$, $p<0.001$), and the combined pulmonary intervention and vitamin C supplementation group ($t=3.99$, $p<0.000$). Conversely, the control group ($t=1.21$, $p=0.23$) did not exhibit a significant difference in the pre-test and post-test mean scores. A statistically significant difference was seen in the mean post-test scores between the experimental and control groups indicated by the derived $f=3.578$ and a corresponding $p=0.014$, which met threshold for statistical significance at the $p<0.05$ level.
Conclusions: From the study findings it is concluded that Pulmonary intervention and vitamin C supplementation has a positive impact on respiratory health status of people exposed to air pollution.

Keywords: Pulmonary intervention, Vitamin C supplementation, Respiratory health related quality of life

INTRODUCTION

Air pollution is a significant global health issue that results in the premature death of millions of individuals annually.[1,2] Epidemiological studies have established the adverse health effects of particulate air pollution, particularly in relation to cardiac and respiratory effects.[3] The emergence of respiratory problems in new-borns and adults due to prenatal or perinatal exposure to air pollution is increasingly seen as a significant public health concern.[4] The susceptibility of prenatal development to environmental exposure renders it particularly sensitive, with lasting implications for later stages of life. There exists a correlation between exposure to airborne pollutants during the prenatal or perinatal period and a range of adverse birth outcomes, including as preterm birth, low birth weight, and congenital malformations affecting the lungs. These anomalies have been found to be associated with respiratory disorders and impaired respiratory function in children and young adults.[5] The examination of deterministic data also provides evidence to substantiate the notion that air pollutants exert an influence throughout early-life stages on several cellular and molecular targets. These targets have been found to be associated with the development of pathological conditions and the disruption of immunological responses, ultimately leading to respiratory dysfunction and the onset of lung illnesses in later stages of life.[6] The prevalence of road traffic air pollution in India is increasing at a concerning rate. Tirupati, as a densely populated city and a prominent pilgrimage hub, has been documented to be affected by car emissions in several blog posts.[7]

Coughing and deep breathing exercises assist to improve pulmonary function by eliminating secretions from the respiratory tract. The mobility and expectoration of secretions in the respiratory system is facilitated by voluntary coughing along with deep breathing.[8] These exercises allow for a greater interchange of gases, increase the quantity of oxygen accessible to cells, and minimise the risk of chest infections. Coughing is an involuntary, abrupt evacuation of air in the lungs with such a distinct and immediately identifiable noise. It fulfils essential roles of protecting the respiratory system against noxious chemicals and preserving patent airway by eliminating superfluous discharges from the airways, despite being the most prevalent manifestation of respiratory illnesses.[9,10]

The use of vitamin C is essential for the sustenance of human life. The documented physiological effects of vitamin C can be attributed to its capacity to operate as an electron donor.[11] Vitamin C exhibits potent antioxidant properties in humans due to its ability to donate electrons, facilitated by its water-soluble nature.[12] The antioxidant capabilities of Vitamin C have been demonstrated in multiple in vitro investigations. The relevance of oxidant-induced tissue damage in the development of human illnesses such as atherosclerosis and cancer has been suggested.[13] There is evidence suggesting a correlation between the consumption of vitamin C and the occurrence of bronchial asthma in the general population, indicating that a diet lacking in vitamin C may provide a risk factor for the development of asthma. Epidemiological studies have established associations between exposure to oxidants, respiratory diseases, and bronchial asthma in offspring of smokers.[14,15]

Considering the increase in mortality and morbidity from air pollution the present study aimed to assess the effect of pulmonary intervention (Deep breathing and coughing exercise) and vitamin C supplementation on respiratory health status of people exposed to the air pollution.

METHODS

Study design

The study employed a randomised controlled trial (RCT) methodology. The current investigation is a prospective, randomised, controlled, pragmatic trial featuring parallel arms. The utilisation of a randomised controlled experiment effectively mitigates the potential influence of selection bias and confounding bias.

Trial category

The study was a pragmatic randomized controlled trial. Pragmatic trials evaluate the effectiveness of interventions under routine-life conditions. The present study was conducted on natural and real-life conditions without optimization of confounding variables.

Number of groups

The present study has four groups (three interventions and one control). The subjects in first group received pulmonary intervention, second group received vitamin C, and third group subjects received combination of pulmonary intervention and vitamin C and fourth group received no intervention.

Intervention model

A parallel type intervention model was used as the study utilized four groups of individuals who are studied concurrently. In this model it is possible to the assess s well as analyse the interventions along-side each other (Table 1).

Table 1: The presentation of research design schematically.

Groups	Pre-test	Intervention	Post-test
Experimental 1	O1	X1	O2
Experimental 2	O1	X2	O2
Experimental 3	O1	X3	O2
Control	O1	C	O2

Areas for groups were selected using a simple random sampling technique Note: O represents observations, O1 represents observation allocation in pre test, O2 represents observation allocation in post test, X represents intervention, X1 represents pulmonary intervention, X2 represents Vit-C supplementation, X3 represents combination of Pulmonary intervention and Vit-C supplementation, C represent control group, each row designates a different group and vertical arrangement represents activities that occurs simultaneously.

Research setting

The study was conducted in Tirupati city, Andhra Pradesh. The accessible sample for this study consisted of adults between 19 to 55 years of age, either residing or working in the selected urban localities of Tirupati, Chittoor District, Andhra Pradesh, India.

Sample and sample size

People exposed to air pollution either residing or working in high pollution zones for a period of not less than the two continuous years, aged between nineteen to sixty years were included in the study. Sample size is estimated using the literature reviews (0.05 alpha, eighty percentages power, allocation ratio of one and population standard deviation of two). Thus, the identified sample size is of sixty-three and with an addition of ten percentages of drop rate the calculated value is of sixty-six. Considering the possibility sample size is extended and rounded off to the seventy five in each group as well as a total of three hundred was the sample size chosen for the study.

Sampling method

Cluster randomization was used in the present study to achieve unbiased comparison group and a balanced randomization. In the process of randomization, the population at Tirupati urban localities was divided into various groups geographically. The clusters for the study were picked using the simple random sampling approach from these groups. The selected geographical clusters were firstly Air bypass road, second town club area, third Leelamahal road and lastly Tirupati bus stand area. Control and experimental groups were randomly allotted to each cluster.

Ethical consideration

Ethical clearance from the ethics committee of Sri Padmavati Mahila Visvavidyalayam the people involved in the study are provided with the details of study and purpose concerning the investigation. The patients had been told that the techniques taught in this study are safe for practice. The informed written consent was obtained from the subjects.

Data collection tool

The demographic profile, clinical profile, and clinical outcome variables were developed by the researcher. Demographic profile comprises the data pertaining to age, gender, occupation, years of experience, residence, education etc., while the clinical outcome variables consist of history of respiratory disease, history of hospitalization, medication usage, etc. St. George respiratory questionnaire (SGRQ) is used to measure the quality of life related to respiratory health after obtaining permission from Dr. Paul, St. George's university, London. Also, digital spirometry was used to assess forced expiratory volume (FEV1) and FVC forced vital capacity. The duration of study lasted for a period of 9 months starting from Oct 2019 to July 2020.

Data analysis:

Data was analysed using SPSS 27 and EZR software. Data was described using the frequency, percentages, mean and standard deviation. Further paired t test, ANOVA, and post hoc Tukey HSD were used to test the hypothesis.

RESULTS

Predicted health related quality of life of participants across the study groups

The mean and standard deviation of total respiratory health related quality of life (R-HRQoL) of people exposed to road traffic air pollution was ranging from 95.19 (SD±20.86) to 98.95 (SD±20.04). The pulmonary intervention group had a mean R-HRQoL score of 98.95 (SD±20.04), vitamin C supplementation group had a mean R-HRQoL score of 95.75, with an SD±20.64, combination of pulmonary intervention and vitamin C supplementation had a score of 97.32±21.41 and control group mean score was 95.19 with a standard deviation of SD±20.86. The pre-test results exhibited no much difference across the study groups in pre-test. It explains the normal distribution of sample characteristics. One-sample Kolmogorov-Smirnov test was performed statistically to test the normal distribution (Table 3).

Predicted clinical outcomes among participants under study

Mean pre-test scores of height was ranging from 154.24±12.491 (control group) to 158.73±10.183 (vit-C group), weight ranged from a minimum of 61.15 (SD±13.701) (PI group) to maximum of 69.95 (SD±68.418) (vit-C), mean BMI scores among study subjects ranged from 25.20 (SD±7.433) (P.I group) to 27.39 (SD±6.318), with regarding to FEV1 mean scores ranged from 3.04 (SD±0.829) (PI group) to 3.28 (SD±0.689) (vit C group), with regard to FVC mean scores ranged from 3.67 (SD±0.704) (PI group) to 3.85 (SD±0.512) (Control group) and with regard to FEV_1/FVC mean scores ranged from 0.826 (SD±0.159) (in control group) to 0.851 (SD±0.686) (vit-C group) (Table 3).

Effect of interventions on total R-HRQoL scores

There is a significant difference between the mean scores of the pre-test and post-test within the pulmonary intervention (t=2.06, p=0.001), vit C supplementation (t=3.22, p<0.001), and combination of pulmonary intervention and vitamin C supplementation (t=3.99, p<0.000) groups. Conversely, the control group (t=1.21, p=0.23) did not exhibit a significant difference in the pre-test and post-test mean scores. Additionally, there was no observed significant difference in the average pre-test scores of the overall respiratory health-related quality of life scores between the experimental and control groups (F=0.494 and p=0.686). A statistically significant difference was seen in the mean post-test scores between the experimental and control groups with a derived f=3.578, and p=0.014, which met the criterion for statistical significance at p<0.05 level. Further to investigate the significant ANOVA results (f=3.57, p=0.23) and to compare interventional and control group post-test scores, Post Hoc Tukey's HSD was performed (Table 4 and 5).

Post Hoc Turkey's HSD revealed a significant difference between the pulmonary intervention group and the group receiving both pulmonary intervention and vitamin C supplementation. The mean difference obtained was -6.86, with a p=0.05, which was significant at p=0.05 level. No other group comparisons had produced a significant difference.

Comparative effect of interventions on clinical outcome-FEV1

The data in the table showed a significant difference between pre-test and post-test mean scores within the interventional groups at p<0.01 level and within control group which was significant at p<0.05 level. The significant difference expressed in control group was the result of decreased FEV1 score in contrast to increased scores observed in all interventional groups. The one-way ANOVA carried out to test the difference of means across the interventional and control groups in pre-test expressed no significant difference (f=1.103; p=0.348). Post-test comparison of differences in means across interventional and control group also revealed no significant difference as the f value obtained was 2.514 and p=0.058, as it is more than alpha (=0.05) (Table 6).

Comparative effect of interventions on clinical outcome-FVC

The table shown above clearly demonstrates a significant difference between the pre-test and post-test scores seen in both the interventional and control groups. The obtained p-values for the interventional groups were as follows: PI group (p=0.001), vitamin C group (p=0.05), combination of PI and vitamin C group (p=0.001), and control group (p=0.005). These p values indicate statistical significance at p<0.05 level. The analysis of variance (ANOVA) was conducted to examine the difference in means between the interventional group and the control group. The resulting f value was 1.5, yielding a p=0.21.

This p value did not reach statistical significance at the predetermined alpha level of p<0.05. The comparison of mean post-test scores between the interventional and control groups yielded a F statistic value of 2.173 and a p=0.09. However, this result was not statistically significant at the p<0.05 level.

Therefore, it may be inferred that there was no statistically significant distinction observed between the control and experimental groups with respect to FVC both in the pre-test as well as the post-test assessments (Table 7).

Table 2: Predicted respiratory health related quality of life across interventional and control group.

HRQL	PI (n=75) mean±SD	Vit C (n=75) mean±SD	PI and vit C (n=75) mean±SD	Control group (n=75) mean±SD
Symptom	12.68±2.86	11.43±3.29	12.02±3.10	11.75±3.41
Activity	49.61±11.48	48.20±11.71	48.58±11.99	46.80±11.35
Impact	36.65±7.27	36.10±7.11	36.70±7.71	36.63±7.69
Total	98.95±20.04	95.75±20.64	97.32±21.41	95.19±20.86

Table 3: Clinical outcome measurements across interventional and control group.

Variables	PI (n=75) mean±SD	Vit C (n=75) mean±SD	PI and vit C (n=75) mean±SD	Control group (n=75) mean±SD
Ht	157.76±13.719	158.73±10.183	155.45±10.068	154.24±12.491
Wt	61.15±13.701	69.95±68.418	66.91±12.052	64.53±10.272
BMI (Kg/m^2)	25.20±7.433	26.17±5.269	27.39±6.318	27.22±7.409
FEV1	3.04±0.829	3.28±0.689	3.07±0.704	3.11±0.815
FVC	3.67±0.704	3.81±0.456	3.76±0.612	3.85±0.512
FEV1/FVC	0.83±0.120	0.851±0.686	0.843±0.104	0.826±0.159

Table 4: Comparison of total R-HRQoL scores among experimental and control group.

Variables	PI (n=75) mean±SD	Vit C (n=75) mean±SD	PI and vit C (n=75) mean±SD	Control GP (n=75) mean±SD	F	Sig (P)
Pre-test	98.95±20.04	95.75±20.64	97.32±21.41	95.19±20.86	0.494	0.686
Post-test	92.61±18.33	86.06±12.36	85.74±11.91	91.50±20.72	3.578	0.014*
T	2.06	3.22	3.99	1.21	-	-
Sig (P)	0.001**	0.001**	0.000**	0.23	-	-

**-significant at p<0.01 level, *significant at p<0.05 level.

Table 5: Tukey's simultaneous test for difference of means for total R-HRQoL score component.

(I) Treatment	(J) Treatment	Mean difference (I-J)	95% confidence interval		Sig. p adj
			Lower bound	Upper bound	
PI	Vit C	-6.5479452	-13.528815	0.432292463	0.0748939
	Pia and vit C	-6.8697717*	-13.803946	0.06440284	0.0532116
	Cont.gp	-1.1099448	-7.999558	5.77966786	0.9756667
Vit C	PI and vit C	-0.3218265	-7.256001	6.61234804	0.9993824
	Cont. gp	5.4380004	-1.451612	12.32761306	0.1759916
PI and vit C	Cont. gp	5.7598268	-1.082468	12.60212148	0.1326329

Multiple comparisons (95% family-wise confidence level). Dependent variable: Total HRQoL (post-test): Tukey HSD*. The observed mean difference exhibits statistical significance at the 0.01 level.

Table 6: Comparative effect of interventions on clinical variable FEV1 in comparison to control group.

Variables	PI (n=75) mean±SD	Vit C (n=75) mean±SD	PI and vit C (n=75) mean±SD	Control group (n=75) mean±SD	F	Sig (P)
Pre-test	3.067±0.70	3.245±0.51	3.134±0.57	3.168±0.63	1.103	0.348
Post-test	3.248±0.64	3.365±0.53	3.297±0.50	3.114±0.61	2.514	0.058*
T	6.08	5.619	6.177	2.511	-	-
Sig (P)	0.001**	0.001**	0.001**	0.014*	-	-

**-significant at p<0.01 level, *significant at p<0.05 level.

Table 7: Comparative effect of interventions on clinical variable FVC in comparison to control group.

Variables	PI (n=75) mean±SD	Vit C (n=75) mean±SD	PI and vit C (n=75) mean±SD	Control group (n=75) mean±SD	F value	P value
Pre-test	3.69±0.65	3.81±0.51	3.72±0.55	3.86±0.48	1.5	0.21
Post-test	3.81±0.64	3.96±0.49	3.87±0.51	3.75±0.46	2.173	0.09
T	5.712	1.903	7.659	5.916	-	-
Sig (p<0.05)	0.001**	0.05*	0.001**	0.005**	-	-

**significant at p0.01; *significant at p0.05.

DISCUSSION

Pulmonary intervention has proved to have a significant impact on the R-HRQoL, this was indicated by the p=0.01. The study findings shown a significant improvement in the R-HRQoL among people exposed to air pollution and performed Deep breathing and coughing exercise.

A similar study aimed to assess effect of pulmonary rehabilitation among COPD patients concluded that the tailored pulmonary rehabilitation programs should be considered for COPD patients of all stages, who have respiratory symptoms and/or who have intolerance to physical effort despite optimal pharmacological treatment. In the study PR has certainly been demonstrated to provide beneficial effects on dyspnea, improvement in muscle strength and endurance, improvement of psychological status, reduction of hospital admissions, and improvement of HRQoL in COPD patients, with a gradual increase in daily physical activity and autonomy.[16]

With respect to Vitamin supplementation the results revealed a highly significant difference between mean pre-test and post test scores. The p=0.001 which was statistically significant. Hence it is evident from the study findings that the vitamin C supplementation has a significant positive effect on overall R-HRQoL of people exposed to air pollution. Combination of Pulmonary intervention and Vitamin supplementation in the study proved to be more effective and significantly improved the quality of life of students.

This research finding are strongly supported by the study carried out to assess the effects of the N-acetylcysteine (NAC) (600 mg), vitamin C (500 mg), a combination of vitamin C + NAC, and placebo, once daily on the antioxidant status of COPD patients (n=79) were studied. The results indicated that antioxidant supplementation improved nutritional status and vitamin C was effective in improving antioxidant status. 17

The present study findings also presented a significant difference in the mean pre-test and post test score with respect to FEV1, and the p=0.001 which was statistically significant. Vitamin C supplementation also significantly improved the FEV1 values among the people exposed to air pollution. The combination of pulmonary intervention and vitamin C supplementation are proven to have significant positive effect on improving the FEV1.

In a study aimed at assessing "FEV1 as an index of rehabilitation success over time" (FIRST), the effects of pulmonary rehabilitaion on lung function in patients with COPD, revealed that the pulmonary rehabilitation was able to substantially stop the FEV1 decline and improved the lung function.[18]

CONCLUSION

Pulmonary intervention and vitamin C supplementation improves the R-HRQoL of people exposed to air pollution. They also have a positive impact on FEV1.with regard to FVC long term interventional studies need to be conducted to assess the effectiveness. From the study findings it is concluded that Pulmonary intervention and vitamin C supplementation has a positive impact on respiratory health status of people exposed to air pollution.

Recommendations

Research on nutritional interventions such as vit E and D supplementation on respiratory health status may aid in limiting the health impacts of air pollution.

It is imperative to conduct comprehensive research on a significant scale in order to evaluate the multifaceted effects of air pollution on health, society, and the economy.

Longitudinal studies conducted with the objective of evaluating the impact of air pollution from transportation on cardiovascular function, cognitive abilities, psychological well-being, respiratory performance, and visual perception, particularly in India, could contribute valuable research findings that could potentially influence government policies regarding the regulation of air pollution emissions and the promotion of health measures.

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