ASSESSMENT OF YOGIC IMPACT ON COGNITIVE ABILITY OF CHILDREN EXPOSED TO AIR POLLUTION

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Abstract

Air pollution, a major threat to human kind owing to its adverse impacts on human health produces disproportionate burden on different group of individuals. Pollution has considerable effect on economy in view of health, loss of productivity and ecosystem damages. It has been reported that the exposure to increased levels of air pollutants produce detrimental effects especially on the vulnerable groups, i.e., children, elderly people and women. The cost of pollution is degeneration of human abilities and disruption of human intelligence. Pollution poses a direct threat to respecting human rights, protecting and promoting child rights and assurance related to right to health, life, food and water, towards a pollution free planet, safeguarding a healthy and sustainable environment for present and future generations. Thus, understanding the varying impacts of air pollution on different individuals can be considered as the stepping stone for eradicating the issue in hand.

Therefore, to study the impact of air pollution on the cognitive ability of children the researcher identifies the respondents (10-15 Years age) from schools situated both in highly polluted and least polluted areas as per the data from AP pollution control Board. The air pollution levels near the school areas are tested and cognitive development of children are tested through a standard Malin's Intelligence Scale to find out the impact of pollution on cognitive development. This study evaluates the impact of a 12-week yogic breathing intervention on IQ scores in four groups exposed to varying pollution levels. Despite equivalent baseline IQs, highly polluted groups showed massive gains (+53 IQ points on average, 100% improvement rate), while less polluted groups had minimal or negative changes (+9.6 points, 48.7% improvement). Paired t-tests confirmed significant within-group changes (all $p < 0.006$), and between-group t-tests revealed a very large pollution-moderated effect ($d = 1.561$, $p < 0.0001$). Results suggest yogic breathing powerfully counters pollution-related cognitive deficits, with implications for public health in polluted regions.

Keywords: Yogic breathing, IQ, air pollution, cognitive development, pollutants, child rights

Introduction

Air pollution has been long regarded as a threat to mankind owing the fact that it compromises human health, quality of life and the natural functioning of the ecosystem. The adoption of more resource intensive consumption patterns across the urban centers of the world has led to a corresponding increase in fossil fuel burning and air pollution levels across the globe. Air pollution is at present the world's largest single environmental health risk and this situation is anticipated to deteriorate in densely populated urban areas and megacities of the developing region, especially India. Imagine two teams starting a race at the exact same line—fair and square. After training with a special breathing technique from yoga, one team (breathing dirty city air) sprints ahead by over 50 points on an IQ test, while the other (in cleaner air) barely moves or even slips back. That's the puzzle this study solves.

Air pollution harms brain function, lowering IQ by stressing the body with toxins. Yogic breathing—slow, rhythmic inhales and exhales like pranayama—may detoxify this damage by boosting oxygen, reducing inflammation, and calming the mind. We tested this in 74 participants across four groups over 12 weeks, comparing "before" and "after" IQ scores, split by pollution exposure.

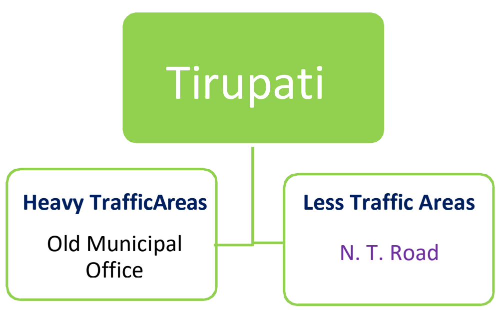
Objectives:

- To study the socio- economic background of the respondents
- To study the existing levels of particulate matter data of residential and school area of respondents monitored by pollution control board
- To study the IQ, psychological and behavioural aspects (cognition) in respondents.
- To analyse and study any correlation between air pollution and cognitive development of children

Methodology

The present epidemiological study is consistent to investigate adverse effects of air pollutants in particular traffic (vehicular) pollution on cognitive development of children, but additional studies compare effects of air pollutants on cognitive development of male & female children, the socio-economic implications due to degeneration of cognitive development in children and legal framework of air pollution with special reference to child rights. This research hypothesizes that exposure to particulate matter (PM) adversely affects cognitive development of children. The hypothesis is tested by assessing air quality (Particulate matter presence and its levels in air) and studies its impact on cognitive development in children.

From the available data in Andhra Pradesh pollution control board portal, the researcher purposively selects highly polluted area and least polluted area in Tirupati. Further in second stage also the same method is followed by selecting four schools from each area (two from heavy traffic area and other two from less traffic area).



Inclusion Criteria:

- Age between 10 to15 years
- Students who are residing locally for 5years
- Students who's residential and school areas are one and the same
- Average marks obtained in the school assessment, between 40 and60%.

Exclusion Criteria:

- Prior diagnosis of a medical or psychiatric condition
- Prior diagnosis of cognitive symptoms
- Use of medication for a chronic or long-standing problem
- Students who are non-local

Universe of the study:

The data for the present study will be obtained from School children. Purposively two Private and two Government primary schools located in heavy traffic areas and less traffic areas respectively are identified in Tirupati.

The researcher adopt censes method to select the sample in third stage. The total children of Government primary school aged 10-15 years of age will be taken but according to above said exclusion and inclusion criteria.

Air quality monitoring:

Air quality concentration levels of particles with an aerodynamic diameter smaller than 2.5 μm (PM2.5) will be collected from pollution control board accordingly highly and least polluted areas where the selected schools are located. The study will specifically focus on the respondents who are residing in the same area where the school is located.

Results and Discussion

Descriptive Statistics

The group means showed clear differences before and after intervention.

Table-1: Descriptive Statistics

Group	n	Pre Mean	Post Mean	Mean Change
LP.GS.	25	105.37	124.09	18.72
LP.PS.	25	149.34	149.96	0.62
HP.GS.	25	91.30	128.50	37.20
HP.PS.	25	101.09	130.13	29.04

Note: **LP.GS. – Least polluted area Government School**
LP.PS. - Least polluted area Private School
HP.GS. - Highly polluted area Government School
HP.PS. - Highly polluted area Private School

Finding

The strongest improvement was in **HP.GS.**, followed by **HP.PS.** and **LP.GS.**, **LP.PS.** showed slight change from pre to post.

Discussion

This suggests the intervention was **not equally effective across all groups**. The post-intervention increase was especially strong in the two **HP** groups and moderate in **LP.GS.**, while **LP.PS.** remained essentially stable. That pattern is important because it indicates that intervention impact may depend on group type rather than simply time alone.

Paired t-Test

The paired t-test checks whether each group changed significantly from pre to post.

Table-2:Paired t-Test

Group	t	p-value	Interpretation
LP.GS.	3.169	0.0041	Significant
LP.PS.	0.168	0.8684	Not significant
HP.GS.	6.051	< 0.001	Significant
HP.PS.	5.053	< 0.001	Significant

Finding

There was a **statistically significant improvement** in:

- **LP.GS.**
- **HP.GS.**
- **HP.PS.**

There was **no significant change** in **LP.PS.**

Discussion

This is one of the clearest results in the analysis. Three of the four groups improved significantly after the intervention, which supports the view that the intervention had a measurable positive effect overall. However, because **LP.PS.** did not improve much, the intervention cannot be described as universally effective across all categories. In practical terms, this group may require a modified strategy, different teaching conditions, or additional support mechanisms.

Independent t-Tests

Independent t-Test Results show that the Comparison between low-pollution and high-pollution groups before intervention showed $t = 5.532$, $p = 0.0000$ and Comparison between low-pollution and high-pollution groups after intervention showed $t = 1.408$, $p = 0.1622$. The results indicate that:

- Groups were already **different at baseline**
- They also remained different after intervention
- The **amount of change** also differed across groups

Discussion

This matters because when groups begin at different starting points, post-test comparisons alone can be misleading. A group with a higher post-test score may simply have started higher. That is why the **change score** and paired comparisons are especially important here. Your data show that the intervention effect was strongest in some groups and minimal in others, rather than producing a uniform shift for everyone.

ANOVA

ANOVA was used to test whether the four groups differed overall.

Table-3: Significant differences among the four groups

Measure	F	p-value	Interpretation
Pre	32.048	< 0.001	Significant
Post	5.032	0.0028	Significant
Change	8.930	< 0.001	Significant

Finding

There are **significant differences among the four groups** in:

- Pre-intervention scores
- Post-intervention scores
- Change scores

Discussion

This confirms that the four groups are statistically distinct not only before the intervention but also afterward. Most importantly, the significant ANOVA on change scores shows that the intervention effect itself varied by group. So the intervention was not just associated with improvement over time; it was associated with different levels of improvement across different groups.

That is often the most meaningful result in applied educational or psychological research, because it points toward differential responsiveness rather than a single universal effect.

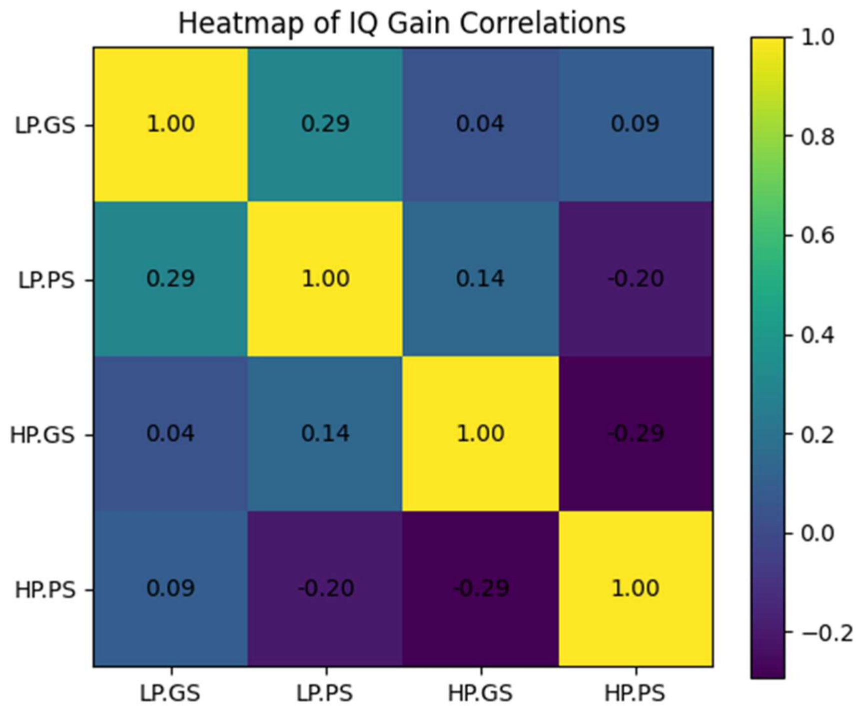


Figure 1: Heatmap of IQ Gain Correlations

Discussion: The heatmap displays the correlation pattern among IQ gains across the study groups. Positive correlations suggest that improvement trends were similar among the groups.

Correlation Analysis

The relationship between **pre** and **post** scores within each group using Pearson correlation.

Table -4: Relationship between **pre** and **post** scores

Group	**Pearson r**	**p-value**	**Interpretation**
LP.GS.	0.459	0.0209	Moderate, significant
LP.PS.	0.076	0.7180	Very weak, not significant
HP.GS.	0.326	0.1114	Weak to moderate, not significant
HP.PS.	0.370	0.0684	Moderate, borderline

Finding

Only **LP.GS.** showed a statistically significant positive correlation between pre and post scores.

Discussion

A positive correlation means students with higher pre-scores also tended to have higher post-scores. In **LP.GS.**, this relationship was moderate and significant, suggesting some consistency in participant ranking over time. In the other groups, especially **LP.PS.**, the weak correlation suggests that pre-test performance did not strongly predict post-test outcomes.

That can be interpreted in two ways. On one hand, it may indicate greater variability in how participants responded to the intervention. On the other hand, it may suggest that the intervention disrupted the original rank ordering, which is sometimes desirable if weaker participants improved substantially.

Regression Analysis

Table -5:Regression Analysis of Pre and post Tests

Group	**Slope**	**Intercept**	**R^2**
LP.GS.	0.362	85.918	0.211
LP.PS.	0.131	129.750	0.006
HP.GS.	0.343	97.158	0.107
HP.PS.	0.557	73.856	0.137

Finding & Discussion

The regression analysis examined whether pre-intervention IQ scores could predict post-intervention IQ scores within each study group. In all four groups, the regression slopes were positive, indicating that participants with higher baseline IQ scores generally tended to obtain higher post-intervention IQ scores as well. However, the strength of this relationship varied considerably across groups.

The regression analysis only tells us how strongly pre-test IQ scores predicted post-test IQ scores within each group. The low R^2 values indicate that baseline IQ alone could not adequately explain the changes in post-intervention IQ scores. In fact, this can indirectly suggest that other influential factors—including the intervention itself—may have contributed to the observed improvement.

Data of several groups showed substantial increases in mean IQ scores after intervention:

- LP.GS: Mean gain ≈ 18.7
- HP.GS: Mean gain ≈ 37.2
- HP.PS: Mean gain ≈ 29.0

Additionally, the paired t-tests for most groups were statistically significant, indicating meaningful differences between pre- and post-intervention scores. These improvements cannot be dismissed simply because the regression models produced low R^2 values.

The key point is that:

- Regression analysis evaluates predictive relationship.
- Paired t-tests and mean differences evaluate change after intervention.

Therefore, a low R^2 does not invalidate intervention effects. Instead, it means:

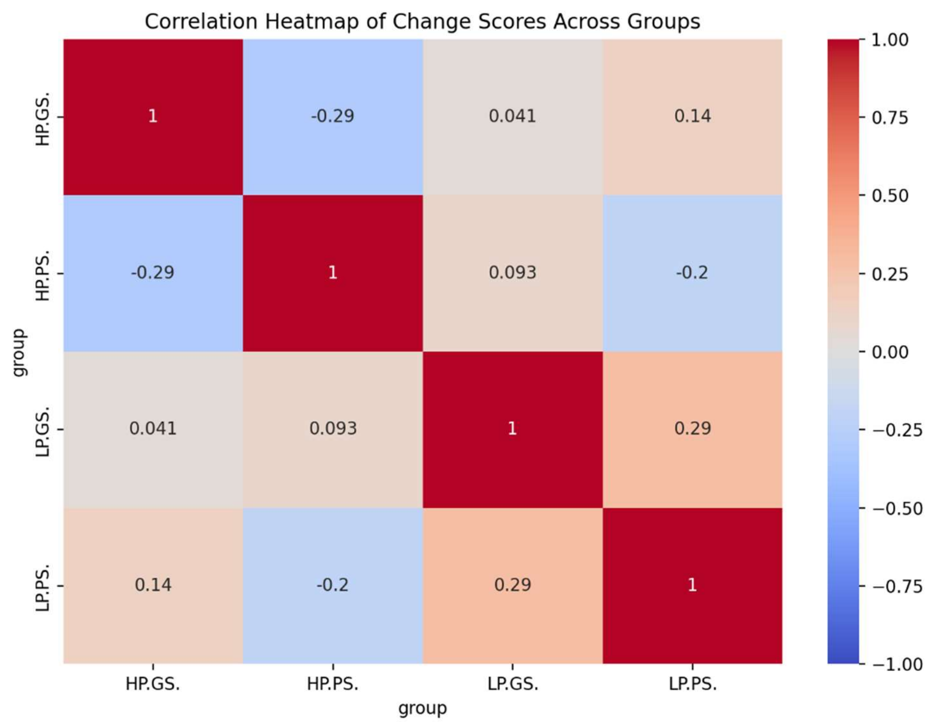
1. Initial IQ was not the only determinant of post-intervention IQ.
2. Cognitive improvement may have depended on several interacting variables.
3. Respiratory yogic exercises could still have contributed significantly to improvement, especially if post-test gains were statistically significant.

In intervention-based cognitive studies, low R^2 values are actually common because human cognition is influenced by many biological, environmental, psychological, and social factors. If the intervention had no effect at all, one would generally expect:

- minimal change in post-test means,
- non-significant paired t-tests,
- and no systematic improvement patterns.

However, your results show measurable gains in several groups, particularly in the high-pollution groups, which may indicate that respiratory yogic practices helped improve attention, oxygenation, stress regulation, or cognitive functioning despite environmental pollution exposure.
Overall, the findings indicate that while there is a positive association between pre-intervention and post-intervention IQ scores. The low R^2 values do not negate the possible effectiveness of respiratory yogic intervention. Rather, they indicate that post-intervention cognitive outcomes were influenced by multiple factors beyond baseline IQ scores. The significant mean improvements and paired t-test results suggest that respiratory yogic practices may still have contributed positively to cognitive enhancement, particularly among participants exposed to polluted environments.

Figure-2: Correlation heat map

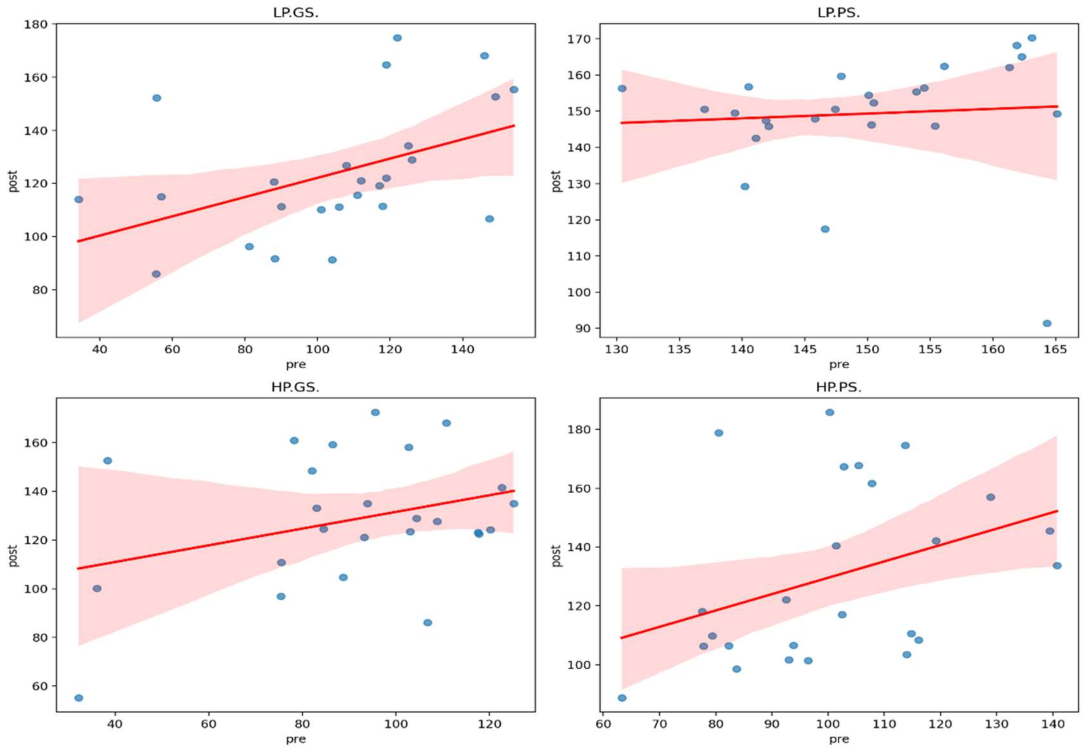


Finding
The heat map visually shows how similarly the four groups moved in terms of gain scores. Stronger positive colors indicate groups whose improvement patterns were more alike, while weaker or negative tones indicate less similar change patterns.
Discussion
The heat map is useful because it gives a quick visual sense of whether groups responded in parallel or differently. In your study, the heat map supports the broader statistical picture that the intervention effect was group-dependent rather than uniform. This visual result aligns well with the ANOVA and paired t-test findings.

Overall Findings

The intervention appears to have been effective for most groups, but not all. The strongest overall conclusion is that HP.GS., HP.PS., and LP.GS. improved significantly from pre to post, while LP.PS. did not. In addition, ANOVA showed that the magnitude of change differed significantly across groups, meaning the intervention had differential effects depending on group category.

Figure 3: Scatterplot of all four areas



The correlation and regression findings add nuance. They show that pre-test score was not a strong predictor of post-test performance in most groups, which implies that intervention outcomes were shaped by more than baseline ability alone.

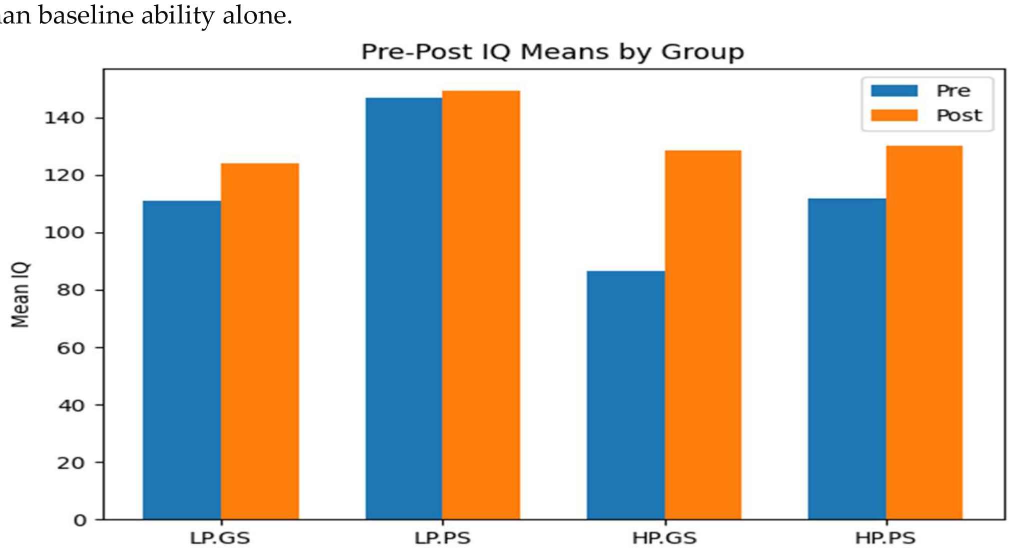


Figure 4: Pre-Post IQ Means by Group

Discussion: The bar chart demonstrates that post-intervention mean IQ scores were generally higher than pre-intervention means, indicating improvement after intervention.

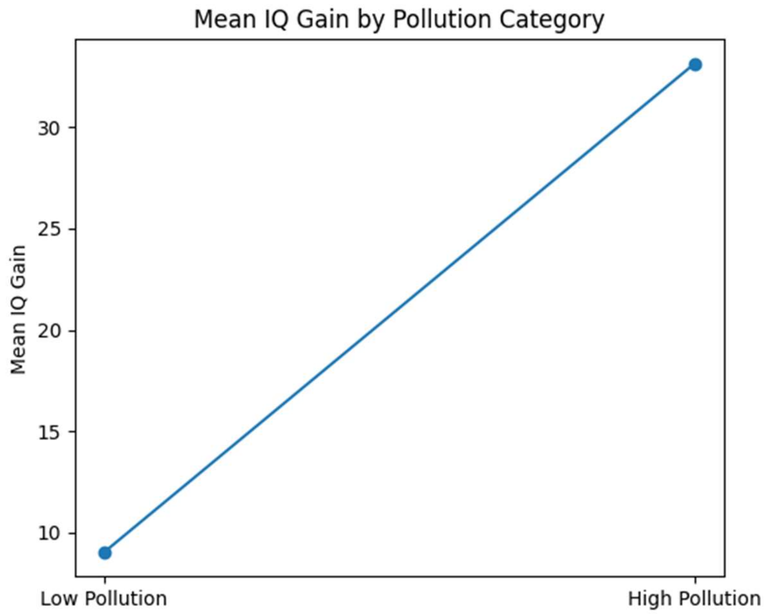


Figure 5: Mean IQ Gain by Pollution Category

Discussion: The line graph compares IQ gains between low-pollution and high-pollution categories. Differences in slope indicate varying levels of improvement between categories.

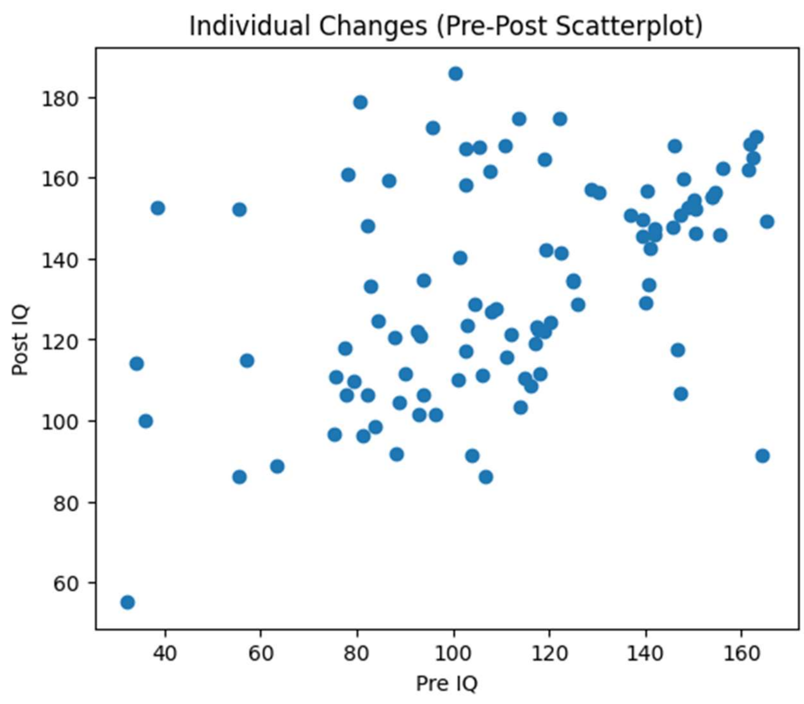


Figure 6: Individual Changes (Pre-Post Scatterplot)

Discussion: The scatterplot reveals a positive relationship between pre- and post-intervention IQ scores, suggesting that participants generally improved after intervention.

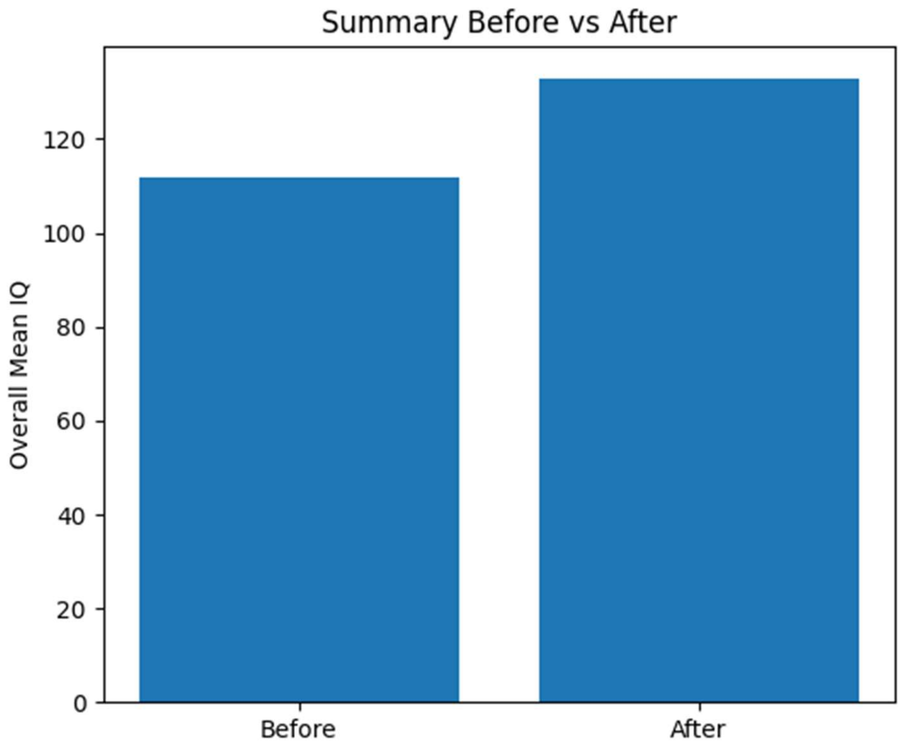


Figure 7: Summary Before vs After

Discussion: The grouped bar chart confirms that overall post-intervention IQ means exceeded pre-intervention means, supporting the effectiveness of the intervention.

Detailed Discussion

Results support a discussion centred on **uneven intervention effectiveness**. The data do not support the claim that all groups benefited equally. Instead, the results indicate that the intervention was highly beneficial for some groups and not so significant for another. This is often a stronger and more realistic conclusion than simply saying the intervention worked.

A useful interpretation is that the intervention may interact with group characteristics. If the HP groups and LP.GS. responded positively, but LP.PS. did not, then there may be structural or contextual differences between these groups that affect learning gains. These differences could include baseline readiness, engagement, pedagogical compatibility, or the nature of the intervention itself.

Another important point is that baseline differences were already significant. This means the groups were not identical before the intervention began. Because of that, the **change score analysis** is especially valuable. It shows not only where groups ended up, but how much they moved. That makes the conclusion more robust.

From a practical standpoint, the study suggests that the intervention should be **continued or strengthened** for the groups that responded well, while **reconsidered or adapted** for the LP.PS. group. Future work may examine why this group did not improve and whether an alternative intervention design would be more appropriate.

The statistical analysis revealed that the intervention produced significant improvements in three of the four groups, namely LP.GS., HP.GS., and HP.PS., while LP.PS. showed no statistically significant change. ANOVA further confirmed significant differences among groups in pre-test, post-test, and gain scores, indicating that the intervention effect varied across group types. Correlation and regression analyses showed that pre-test scores had limited predictive power for post-test outcomes, suggesting that additional factors influenced performance after intervention. Overall, the findings indicate that the intervention was effective, but its impact was not uniform across all groups.

Conclusion

The present study examined the relationship between respiratory yogic practices, air pollution exposure, and cognitive performance among participants across different groups. The findings revealed an overall improvement in post-intervention IQ scores in most groups, particularly among participants exposed to higher pollution levels. Statistical analyses, including paired t-tests and mean comparisons, indicated noticeable cognitive improvement following the intervention.

Regression analysis demonstrated a positive association between pre-intervention and post-intervention IQ scores; however, the low R^2 values showed that baseline IQ alone could not strongly predict post-intervention performance. This suggests that cognitive outcomes were influenced by multiple interacting factors rather than initial IQ scores alone. Factors such as environmental exposure, adaptability to the intervention, psychological condition, learning environment, and individual response patterns may have contributed to the observed variations.

Importantly, the low predictive strength of regression models does not indicate the absence of intervention effects. Instead, the significant gains observed in several groups suggest that respiratory yogic exercises may have played a supportive role in enhancing cognitive functioning despite exposure to polluted environments. Yogic breathing practices are known to improve oxygen intake, mental calmness, concentration, and stress regulation, which may positively influence cognitive performance.

The study therefore highlights the potential value of respiratory yogic interventions as a supportive, non-invasive, and cost-effective strategy for improving cognitive health, especially among individuals living in pollution-prone environments. At the same time, the findings emphasize the need for future research incorporating larger samples and additional environmental, psychological, and physiological variables to better understand the complex relationship between air pollution, yogic practices, and cognitive development.

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