Inspiratory Muscle Strength, Functional Capacity, and Quality of Life in Urban Traffic Police: A Cross-Sectional Study

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Abstract: BACKGROUND: Air pollution, especially from vehicular emissions, affects traffic police due to prolonged roadside duty. Continuous inhalation of particulate matter and toxic gases can impair lung function and lead to respiratory diseases. Assessing Inspiratory Muscle Strength (IMS), Functional Capacity (FC) and Quality of Life (QoL) in high-risk group helps understand health impact of chronic exposure and preventive.
OBJECTIVES: To assess Inspiratory Muscle Strength (IMS), Functional Capacity (FC) and Quality of Life (QoL) in Urban Traffic Police in Ahmedabad, Gujarat.
METHADOLOGY: Cross-sectional observational study was conducted over 1–2 months in Ahmedabad. Study included healthy, non-smoking traffic police with over one year and informed consent. History of smoking, respiratory/cardiac conditions, or recent surgery were excluded. Demographic data were collected. IMS was measured using Capsule-Sensing Pressure Gauge device. QoL was assessed using SF-12 questionnaire. FC was measured using DASI.
RESULTS: Among 40 participants, mean CSPG was 105.25 ± 26.70, DASI 39.74 ± 6.06, PCS 12.65 ± 1.51, and MCS 18.63 ± 2.66. Weak, non-significant Spearman's correlation was found between CSPG and PCS ($p = 0.052$). No significant correlation was DASI ($p = 0.859$) or MCS ($p = 0.861$).
CONCLUSION: Traffic police showed moderate IMS, fair functional capacity, and low QoL. No significant correlation was found between IMS and functional capacity/QoL, indicating other factors contribute to reduced well-being.

Keywords: Inspiratory Muscle Strength, Quality of Life, Functional Capacity, Traffic Police

I. INTRODUCTION

Urban air pollution remains a pervasive public-health challenge in India, and especially in rapidly growing cities such as Ahmedabad, Gujarat. Vehicular emissions generate a range of airborne contaminants including nitrogen oxides (NO_2), sulphur oxides (SO_2), carbon monoxide (CO), and particulate matter ($PM_{2.5}$/PM_{10}) which together contribute to the airborne toxic burden surrounding heavily trafficked roadways.(1)

Several studies of traffic-police personnel demonstrate a measurable decrement in pulmonary function compared with control groups. For instance, the Saurashtra region study of traffic police found significantly reduced forced vital capacity (FVC) and maximum voluntary ventilation (MVV) in exposed personnel.(1) Similarly, the study in Chennai among 250 traffic police revealed reduced PFT parameters relative to matched controls.(2)

Within the occupational cohort of roadside traffic police, inspiratory muscle strength (IMS) is a functional domain that remains under-investigated despite its physiologic importance. The inspiratory muscles (principally the diaphragm and accessory muscles) are key to ventilatory pump mechanics, and in other clinical populations reduced IMS has been associated with poorer functional capacity and diminished health-related quality of life (HRQoL).

For example, a systematic review and meta-analysis by Manifield et al. found that although inspiratory muscle training (IMT) improved maximal inspiratory pressure (MIP), results for functional capacity were not statistically significant in older adults.(3)

Other studies Cordeiro et al. 2023 suggest that IMT may benefit both functional capacity and QoL in adults across different clinical conditions.(4) Likewise, in Kashmir Valley, traffic police personnel had significantly lower FEV_1 and forced vital capacity

(FVC) compared to matched controls. These findings highlight that even in healthy, non-smoking individuals, chronic exposure to traffic-derived pollutants may compromise pulmonary mechanics.[5]

While much of the occupational research has focused on conventional spirometric indices, less attention has been paid to inspiratory muscle strength (IMS) and its downstream influence on functional capacity (FC) and quality of life (QoL). Inspiratory muscles, including the diaphragm and accessory muscles, are central to ventilatory pump mechanics.

When these muscles are weakened or loaded by increased airway resistance or lung pathology, ventilatory efficiency declines, and the individual's ability to perform physical tasks may reduce. In clinical populations (e.g., heart-failure, chronic kidney disease, COPD), lower maximal inspiratory pressure (MIP) or reduced IMS has been associated with diminished FC and reduced health-related QoL.[6]

Traffic police personnel are chronically exposed to vehicular emissions, fine particulate matter, and other airborne pollutants during prolonged duty hours on congested roads. Such continuous exposure may lead to progressive deterioration in respiratory health, even among non-smoking and otherwise healthy individuals.

However, limited studies have explored the relationship between inspiratory muscle strength, functional capacity, and quality of life in this occupational group, particularly in the Indian context. Although previous studies have demonstrated reductions in conventional spirometry indices such as FVC and FEV_1, limited research has examined the inspiratory muscle strength (IMS), which plays a critical role in maintaining ventilatory efficiency and functional capacity.

Assessing IMS, along with functional capacity (FC) and quality of life (QoL), provides a more comprehensive understanding of the subclinical respiratory effects of chronic air pollution exposure. Furthermore, identifying these associations may assist in developing targeted preventive and rehabilitative interventions, such as inspiratory muscle training (IMT), to preserve respiratory function and enhance occupational well-being in traffic police personnel.

The present study aims to assess inspiratory muscle strength, functional capacity, and quality of life in traffic police personnel exposed to vehicular air pollution and to examine the relationships among these variables.

It also compares these parameters with age-matched, non-exposed controls to evaluate the occupational impact of chronic pollutant exposure. It is hypothesized that inspiratory muscle strength will show a significant positive correlation with both functional capacity and quality of life among exposed traffic police personnel, while the null hypothesis states that no significant correlation exists between inspiratory muscle strength, functional capacity, and quality of life in this population.

II. METHODOLOGY

Study Design and Duration

A cross-sectional observational study was conducted over a period of 1-months in Ahmedabad.

Study Population and sample size

The study included 40 healthy participants, non-smoking traffic police personnel with a minimum of one year of active service. Participation was voluntary, and written informed consent was obtained from all participants before data collection.

Sampling technique:

Convenient sampling

Criteria for selection

Inclusion Criteria:

- Participants willing to participate
- Healthy nonsmoker traffic police in the age group of 45–60 years
- Minimum one year of active-duty service
- Non-smokers

Exclusion Criteria:

- History of smoking or tobacco use
- Known respiratory or cardiac conditions
- Recent thoracic or abdominal surgery
- Any acute illness during the time of testing

Materials

- Pen / Pencil
- Paper
- chair
- Proforma
- Consent form

- IMS was measured using Capsule-Sensing Pressure Gauge device
- QoL was assessed using SF-12 questionnaire
- FC was measured using DASI.

Disclaimer:
- There was No conflict of interest
- There was No financial involvement
- This was an observational study hence; ethical approval was not required as per Helsinki declaration.

Outcome Measures:
1. Inspiratory Muscle Strength (IMS)

Inspiratory muscle strength was assessed by measuring Maximal Inspiratory Pressure (MIP) using a Capsule-Sensing Pressure Gauge device.[7]
Procedure:[7]
- The participant was seated comfortably in an upright position with feet flat on the floor.
- A disposable mouthpiece was attached to the device, and the participant was instructed to maintain a tight lip seal to avoid air leakage.
- The participant was asked to exhale completely to residual volume (RV) and then perform a forceful, maximal inhalation against the occluded mouthpiece.
- Three trials were recorded with 30–60 seconds rest between each effort to prevent fatigue.
- The highest value obtained (in cmH_2O) was recorded as the final MIP score.

2. Quality of Life (QoL)

Quality of life was assessed using the Short Form-12 (SF-12) Health Survey, a validated and reliable tool widely used to measure health-related quality of life in adult populations, including occupational groups.
Procedure:
- The SF-12 questionnaire was administered in a quiet, well-lit environment to minimize distractions.
- Participants were instructed to answer all items based on their health status during the past four weeks.
- It was self-administered, and assistance was provided only for clarifying instructions, not for influencing responses.
- The survey required approximately 5–7 minutes to complete.
- The questionnaire evaluates eight health domains:

1. Physical functioning
2. Role limitations due to physical problems
3. Bodily pain
4. General health
5. Vitality
6. Social functioning
7. Role limitations due to emotional problems
8. Mental health

- Responses were scored using the standard SF-12 scoring algorithm to obtain two summary measures:
  - Physical Component Summary (PCS)
  - Mental Component Summary (MCS)
- Higher PCS and MCS scores indicate better perceived physical and mental health, respectively.

3. Functional Capacity (FC)

Functional capacity was measured using the Duke Activity Status Index (DASI), a validated, 12-item questionnaire that estimates a person's ability to perform activities of daily living and light recreational tasks.
Procedure:
- Participants completed the questionnaire in a calm, ventilated setting.
- They were instructed to respond to each item with "Yes/No" based on their current ability to perform tasks such as walking outdoors, climbing stairs, personal care activities, household chores, and moderate physical activities.
- Each "Yes" response had a predetermined point value based on metabolic equivalents (METs).
- The points for all "Yes" responses were summed to obtain the total DASI score.
- Higher scores indicated better functional capacity.

Data Collection Procedure:
Demographic information including age, gender, height, weight, BMI, and years of service was recorded. All outcome measures (IMS, SF-12, and DASI) were administered in a single session in a quiet, well-ventilated room to minimize environmental bias and ensure participant comfort.

Data Analysis:
Statistical analysis was performed using Microsoft Excel and SPSS version 20. Descriptive statistics, including mean and standard deviation, were calculated for demographic variables and outcome measures (IMS, SF-12, and DASI). The normality of the data was assessed using the Shapiro–Wilk test. As the data were not normally distributed, non-parametric statistics were used. The Spearman's Rank Correlation Coefficient (rho) was applied to determine the relationship between Inspiratory Muscle Strength (IMS), Quality of Life (SF-12 PCS and MCS), and Functional Capacity (DASI). A p-value < 0.05 was considered statistically significant.

III. RESULTS

A total of 40 participants were included in the present study. The mean age of the participants was 41.80 ± 8.65 years. The mean height and weight were 160.30 ± 3.88 cm and 65.85 ± 5.39 kg, respectively, while the mean BMI was 25.65 ± 2.37 kg/m², indicating that the majority of participants were in the overweight category. Inspiratory muscle strength (IMS) measured using the Capsule-Sensing Pressure Gauge (CSPG), functional capacity (DASI), and quality-of-life scores (MCS and PCS) were analyzed.

Table 1: Demographic Characteristics of the Participants

Variable	Mean ± SD
Age (years)	41.80 ± 8.65
Height (cm)	160.30 ± 3.88
Weight (kg)	65.85 ± 5.39
BMI (kg/m²)	25.65 ± 2.37

Table 2: Mean and Standard Deviation of IMS, Functional Capacity, and QoL Scores

Parameter	Mean ± SD
IMT (CSPG)	105.25 ± 26.70
DASI	39.74 ± 6.06
MCS (SF-12)	18.63 ± 2.65
PCS (SF-12)	12.65 ± 1.51

The mean Inspiratory Muscle Strength (IMS) was 105.25 ± 26.70, indicating moderate variability in inspiratory effort among participants. The mean Duke Activity Status Index (DASI) was 39.74 ± 6.06, reflecting moderate functional capacity. Quality-of-life scores showed a mean Mental Component Score (MCS) of 18.63 ± 2.65 and Physical Component Score (PCS) of 12.65 ± 1.51, indicating low physical and mental health perception in this population.

Table 3: Correlation Between IMS (CSPG), Functional Capacity (DASI), and Quality of Life (MCS & PCS)

Correlation with CSPG	r-value	p-value	INTERPRETATION
Duke Activity Status Index (DASI)	–0.029	0.859	No correlation between IMS (CSPG) and functional capacity (DASI); relationship is negligible and not statistically significant.
Physical Component Score (PCS, SF-12)	0.310	0.052	Weak positive correlation between IMS and physical QoL; not statistically significant but shows a trend (higher IMS may be better physical QoL).
Mental Component Score (MCS, SF-12)	0.029	0.861	No correlation between IMS and mental QoL; relationship is negligible and not statistically significant.

Table 3 demonstrates the correlation between CSPG (IMS) and various outcome measures. The results show that CSPG has no meaningful relationship with functional capacity as measured by the Duke Activity Status Index ($r = -0.029$, $p = 0.859$), indicating a negligible and statistically insignificant association. Similarly, the correlation between CSPG and mental quality of life (MCS, SF-12) is negligible ($r = 0.029$, $p = 0.861$), suggesting no link between IMS and mental well-being. In contrast, CSPG shows a weak positive correlation with physical quality of life (PCS, SF-12) ($r = 0.310$), although this trend does not reach statistical significance ($p = 0.052$).

This suggests that individuals with higher IMS scores may have slightly better physical health status, but the evidence is insufficient to confirm a definitive relationship. Overall, CSPG does not demonstrate significant correlations with functional capacity or quality-of-life measures in this sample.

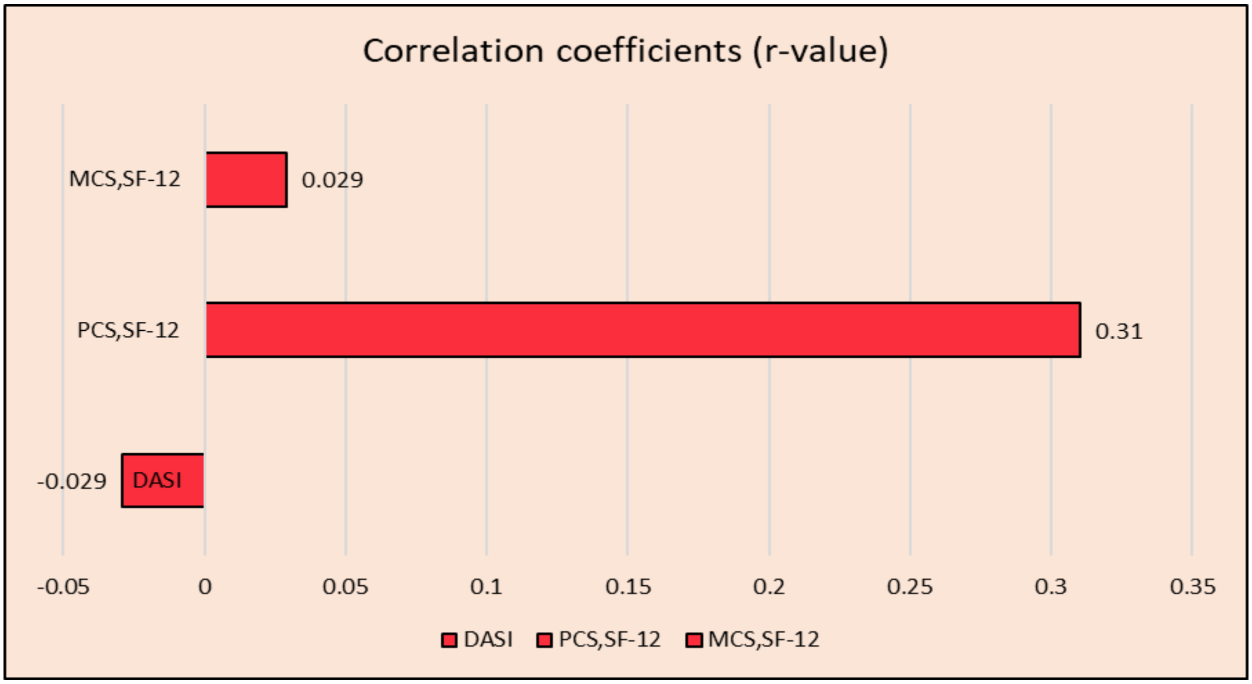

Figure:1 Regression Coefficients for correlation between CSPG, DASI and QoL

IV. DISCUSSION

In this cross-sectional study of 40 adult participants (mean age 41.80 ± 8.65 years; mean BMI 25.65 ± 2.37 kg/m²), we examined the associations between inspiratory muscle strength (IMS) measured via the Capsule-Sensing Pressure Gauge (CSPG), functional capacity (DASI), and health-related quality of life (HRQoL: PCS and MCS of SF-12).

Our results demonstrated that IMS did not show a statistically significant correlation with functional capacity ($r = -0.029$, $p = 0.859$) or with mental quality of life ($r = 0.029$, $p = 0.861$). A weak positive association was observed between IMS and physical quality of life ($r = 0.310$, $p = 0.052$), which approached but did not cross the conventional threshold for statistical significance.

The absence of a meaningful correlation between IMS and functional capacity in our sample aligns with findings from previous research in healthy older adults, where maximal inspiratory pressure (MIP) was not a limiting factor for HRQoL or functional capacity in the absence of respiratory pathology. For example, Inspiratory Muscle Strength and Cardiorespiratory Fitness Association with Health-Related Quality of Life in Healthy Older Adults (Roldán et al., 2021) found that while cardiorespiratory fitness (6-MWT) was moderately associated with HRQoL, MIP was not significantly related in healthy seniors.[8]

Similarly, the effects of inspiratory muscle training in older adults (Mills et al., 2015) reported improvements in inspiratory muscle strength through training but did not observe significant changes in quality of life in healthy older adults.[9] These comparisons suggest that in non-diseased populations, inspiratory muscle strength may not strongly drive functional capacity or self-perceived quality of life.

The trend toward a weak positive correlation between IMS and physical QoL in our study ($r = 0.310$, $p = 0.05$) suggests a subtle relationship in which participants with greater inspiratory muscle strength tended to perceive slightly better physical health. Although the correlation did not reach statistical significance, the effect size ($r = 0.310$) indicates a modest association. This may be attributed to the characteristics of our sample relatively healthy adults without significant respiratory impairment resulting in a restricted range of IMS values and physical limitations, which can reduce the likelihood of detecting stronger correlations. Evidence from clinical populations (such as COPD or spinal cord injury) has demonstrated more pronounced associations between inspiratory muscle performance and quality-of-life outcomes.

For example, a systematic review by Woods *et al.* (2023) reported that although inspiratory muscle strength significantly improved following inspiratory muscle training, the resulting changes in both physical and mental quality of life were inconsistent. This difference suggests that the impact of IMS on QoL may be more apparent in populations with substantial respiratory compromise compared to relatively healthy adults.[10]

The divergence between clinical and healthy samples may reflect the fact that in healthy individuals, inspiratory muscle strength is not the limiting factor for functional capacity or QoL other factors such as peripheral muscle condition, cardiovascular fitness, comorbidities, or psychosocial factors may play a more dominant role.

Our findings therefore support the notion that in the absence of significant respiratory dysfunction, IMS may not strongly predict functional capacity or quality of life. However, the trend identified suggests potential value in exploring this relationship in larger or more heterogeneous samples. It may be that once inspiratory muscle strength falls below a certain threshold (as in disease states), its impact on functional and QoL outcomes becomes more pronounced. In our relatively healthy sample, the lack of significant associations may reflect a “ceiling effect” whereby most participants had sufficient IMS so that it did not limit function, or a range restriction that diminished correlation strength.

Several methodological considerations should be noted. First, the cross-sectional design precludes inference of causality; we cannot determine whether improved IMS leads to better physical QoL, or whether participants with better physical health also maintain stronger inspiratory muscles. Second, our sample size (n = 40) may limit statistical power to detect weaker associations; the p-value of 0.052 for the IMS–PCS association suggests that with a larger sample, this relationship may have achieved significance. Third, our cohort consisted of adults with relatively mild variation in IMS, functional capacity and BMI; thus, findings may not generalize to populations with greater impairment or chronic disease. Finally, we used self-reported (SF-12) quality of life and a functional capacity index (DASI) rather than objective performance tests (e.g., 6-minute walk test), which may limit sensitivity.

For future research, longitudinal or intervention designs (e.g., inspiratory muscle training) may help clarify whether improvements in IMS translate into better functional or QoL outcomes in non-diseased populations, and whether a threshold of IMS exists where it becomes clinically relevant. Additionally, research should consider multisystem influences on QoL (respiratory, cardiovascular, musculoskeletal) and examine moderating variables such as age, sex, BMI, and comorbidities. If the trend toward IMS–physical QoL can be replicated in larger samples, IMS measurement may help refine assessment of physical health even in otherwise healthy adults.

V. CONCLUSION

In conclusion, our study found no statistically significant association between inspiratory muscle strength and functional capacity or mental QoL, and only a weak non-significant trend toward association with physical QoL. These findings suggest that in a relatively healthy adult population, inspiratory muscle strength is not a major determinant of functional capacity or self-perceived quality of life but further research is warranted to explore subtle associations and the contexts in which IMS may become influential.

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