EFFECTS OF WEARING FACIAL MASKS ON PULMONARY FUNCTION, OXYGEN SATURATION, HEART RATE AND BLOOD PRESSURE DURING THE SIX-MINUTE WALK TEST IN HEALTHY SUBJECTS

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ABSTRACT

The widespread use of surgical masks has prompted concern over their physiological effects during exercise, particularly with scarce data from South Asia; this randomized crossover study therefore evaluated 80 healthy young adults in Nepal performing six-minute walk tests with and without a surgical mask, finding that mask use significantly reduced walking distance (537.9 ± 24.9 m vs. 564.8 ± 22.3 m; $p < 0.001$) and post-exercise oxygen saturation (95.8 ± 1.6% vs. 98.1 ± 0.8%; $p < 0.001$), significantly decreased post-exercise pulmonary function (FVC and FEV_1; both $p < 0.01$), and led to significantly higher post-exercise heart rate and systolic blood pressure (both $p < 0.01$), indicating a small but measurable physiological burden during light exercise which, while tolerable for healthy young adults, highlights a need for caution and further study in vulnerable populations with cardiorespiratory conditions.

KEYWORDS

Surgical mask, six-minute walk test, pulmonary function, oxygen saturation, exercise capacity

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INTRODUCTION

The use of facial masks became widespread during the COVID-19 pandemic and remains common in areas with high ambient air pollution. Surgical masks, cloth masks, and respirators are widely used to reduce exposure to respiratory pathogens and airborne particles, contributing to individual and public health protection.[1-3] Despite these advantages, concerns persist regarding potential physiological burdens of mask use during physical activity. Masks may increase breathing resistance, alter ventilation, and modestly affect gas exchange,[4-6] which, although often clinically insignificant in healthy adults, can influence exercise tolerance and cardiopulmonary responses.

The six-minute walk test (6MWT), a standardized submaximal exercise test recommended by the American Thoracic Society (ATS).[7] is widely used to evaluate functional capacity and detect subtle physiological changes. Prior studies on mask use during exercise show mixed findings: some report negligible effects.[8-10] while others note reductions in ventilation, expiratory volumes, and oxygen saturation, particularly with respirators.[11-13]

In Nepal, the issue is highly relevant. Masks are used not only for infection control but also to mitigate exposure to severe urban air pollution. Concurrently, the country faces an increasing burden of cardiovascular disease and chronic respiratory illness associated with environmental and lifestyle factors.[14,15] For such populations, even minor physiological changes from mask use may have clinical implications, yet regional evidence is limited.

Understanding the physiological effects of mask use in healthy individuals is important to establish a baseline for interpreting functional test results and guiding clinical practice. Existing evidence suggests that while mask use may produce measurable physiological changes, these effects are generally small and well tolerated in healthy populations.[16–18]

Accordingly, this study aimed to assess the impact of surgical mask use on pulmonary function, oxygen saturation, cardiovascular parameters, and exercise performance during the 6MWT in healthy young adults, providing locally relevant data for clinical and public health contexts.

MATERIALS AND METHODS

Study design and participants: This randomized crossover study was conducted at Nepalgunj Medical College among 80 healthy volunteers (40 males, 40 females) aged 20–30 years, following approval by the Institutional Review Committee of Nepalgunj Medical College Teaching Hospital (Ref.: 18/081-082) and conducted in accordance with the Declaration of Helsinki. The study was conducted between August and December 2024. Each participant performed two six-minute walk test (6MWT) sessions: one without a mask and one while wearing a standard surgical mask, with the order randomized to counterbalance potential carryover effects. Sessions were scheduled at least 24 hours apart. Exclusion criteria included a history of cardiopulmonary disease, recent respiratory infection, or any musculoskeletal condition that could compromise walking performance.

Sample size: The required sample size was calculated using the formula described by Al-Metha *et al.*[19] for a finite population. Based on a source population of 100 first-year MBBS students, an assumed clinically meaningful difference in the 6-minute walk distance of 30 m, 80% power, and an alpha of 0.05, the minimum sample was estimated at 80 participants, which was adopted as the final study size.

Measurements: The following parameters were assessed:

- *Demographics*: age, sex, and body mass index (BMI) were recorded.
- *Pulmonary function*: Forced vital capacity (FVC) and forced expiratory volume in 1 second (FEV_1) were measured using standard spirometry, following ATS and ERS recommendations.[20,21]
- *Oxygenation and cardiovascular parameters*: Oxygen saturation (SpO_2) and heart rate (HR) were measured using a portable pulse oximeter, while blood pressure (BP) was measured with a manual sphygmomanometer.
- *Exercise capacity*: Functional capacity was assessed by the total distance walked in the 6MWT, following ATS guidelines.[7]

Statistical analysis: Continuous variables were summarized as mean ± standard deviation (SD). Paired t-tests were applied for normally distributed data, while the Wilcoxon signed-rank test was used for non-normally distributed data. Statistical significance was set at $p < 0.05$. Analyses were performed using SPSS.

RESULTS

Participant characteristics: All 80 participants completed both masked and unmasked 6MWT sessions. The mean age was 24.6 ± 2.8 years,

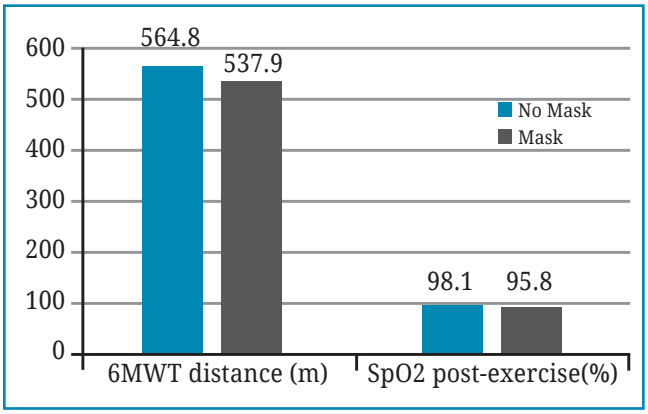

Fig. 1: Bar chart showing 6MWT distance and post-exercise SpO_2 with and without mask.

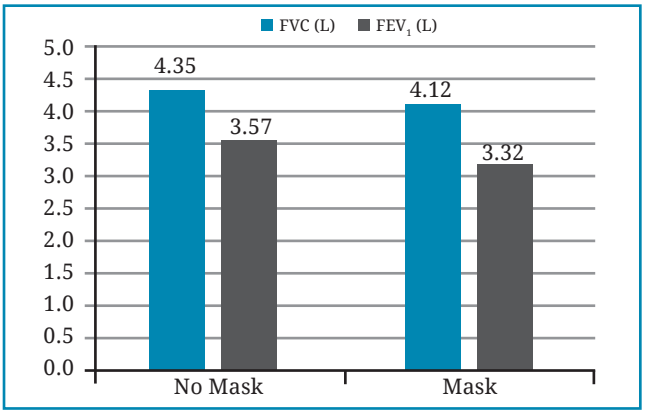

Fig. 2: Bar chart illustrating pulmonary function (FVC and FEV_1) with and without mask.

Table 1: Key outcomes with and without mask use

Parameter	No mask (Mean ± SD)	Mask (Mean ± SD)	p-value
6MWT distance (m)	564.8 ± 22.3	537.9 ± 24.9	<0.001
SpO_2 post-exercise (%)	98.1 ± 0.8	95.8 ± 1.6	<0.001
FVC (L)	4.35 ± 0.42	4.12 ± 0.45	<0.01
FEV_1 (L)	3.57 ± 0.34	3.32 ± 0.36	<0.01
Post-exercise HR (bpm)	104 ± 11	110 ± 12	<0.01
Post-exercise SBP (mmHg)	126 ± 11	132 ± 12	<0.01

and the mean BMI was 23.2 ± 2.1 kg/m², with equal representation of males and females.

Exercise performance and oxygenation: Wearing a surgical mask significantly reduced 6MWT distance compared to the unmasked condition (537.9 ± 24.9 m vs 564.8 ± 22.3 m, p <0.001). Post-exercise oxygen saturation (SpO_2) also declined from 98.1 ± 0.8% (no mask) to 95.8 ± 1.6% (mask, p <0.001), indicating a modest reduction in functional exercise capacity and oxygenation.

Pulmonary function: Pulmonary function measurements showed slight reductions with mask use. Forced vital capacity (FVC) decreased from 4.35 ± 0.42 L without a mask to 4.12 ± 0.45 L with a mask (p <0.01). Forced expiratory volume in 1 second (FEV_1) decreased from 3.57 ± 0.34 L to 3.32 ± 0.36 L with mask use (p < 0.01), suggesting minor ventilatory limitation during masked exercise.

Cardiovascular parameters: Resting heart rate (HR) and blood pressure (BP) were similar between conditions. Post-exercise HR increased modestly with mask use (110 ± 12 bpm vs 104 ± 11 bpm, p <0.01), and post-exercise systolic BP was slightly higher (132 ± 12 mmHg vs 126 ± 11 mmHg, p <0.01). These findings indicate mild cardiovascular responses to the additional respiratory load of mask use.

Summary of key outcomes: Table 1 summarizes all physiological and performance outcomes for masked versus unmasked 6MWT sessions.

DISCUSSION

This study confirms that wearing surgical masks during the six-minute walk test (6MWT) leads to small but measurable physiological changes in healthy young adults. In our cohort of 80 participants, mask use was associated with a statistically significant reduction in walking distance (from 564.8 ± 22.3 m to 537.9 ± 24.9 m; p <0.001) and a decline in post-exercise SpO_2 (from 98.1 ± 0.8% to 95.8 ± 1.6%; p <0.001). Pulmonary function showed modest decreases (FVC from 4.35 ± 0.42 L to 4.12 ± 0.45 L, p <0.01; FEV_1 from 3.57 ± 0.34 L to 3.32 ± 0.36 L, p <0.01), and cardiovascular parameters (heart rate, systolic blood pressure) rose slightly post-exercise (HR: 104 ± 11 → 110 ± 12 bpm; SBP: 126 ± 11 → 132 ± 12 mmHg; both p <0.01). These results demonstrate that while the physiological burden of wearing a surgical mask is detectable, it remains modest in young healthy adults.

Our findings align with prior research showing that surgical and N95 masks increase breathing resistance and perceived exertion.[1,4,6] Systematic reviews also indicate that although physiological changes are measurable, they

are usually small and not clinically meaningful in healthy individuals.[9,22] Some studies even suggest that mask use does not impair moderate-intensity exercise performance, supporting our observation that young adults tolerate mask use well.[10]

High-filtration respirators, such as N95 masks, impose a greater cardiopulmonary load than surgical masks, often resulting in more pronounced elevations in heart rate and exertion during sustained or vigorous activity.[3,23] This is consistent with prior observations of minor yet consistent reductions in pulmonary function and exercise capacity under masked conditions, reinforcing the notion that the magnitude of effect is proportional to the mask's resistance and the intensity of exercise.[3,23]

From a clinical perspective, these findings hold important implications for the interpretation of functional tests in settings where mask-wearing is mandated. Clinicians should be aware that modest reductions in 6MWT distance, oxygen saturation, or spirometric volumes in masked patients may partly reflect the external resistive load rather than intrinsic cardiopulmonary deterioration. This distinction is particularly critical in regions like Nepal, where masks are routinely worn for protection against both airborne infections and severe ambient pollution.[15] Misinterpretation of such mask-induced variations could lead to unnecessary clinical concern or intervention.

Although healthy young adults tolerated mask use without difficulty, vulnerable groups such as older people or those with COPD or cardiovascular disease may experience greater functional limitations.[24,25] These groups often operate with reduced cardiopulmonary reserve, and even modest increases in breathing effort or mild gas exchange alterations could meaningfully impact exercise capacity and symptoms. Recent meta-analyses emphasize the need for further evaluation in these populations, particularly during higher-intensity or prolonged activity.[26,27] In South Asian and Nepali contexts, this is especially relevant given the high burden of cardiopulmonary diseases and widespread exposure to pollution, as documented in studies from Kathmandu Valley.[15] A recent Nepali study also reported increases in blood pressure and pulse rate during physical exertion with KN95 mask use, echoing our cardiovascular findings.[28]

Recent experimental work strengthens this interpretation. It has been reported that surgical masks during moderate exercise lead to slight reductions in oxygen saturation and increased exertion.[26] Other studies found that both surgical and N95 masks caused small reductions in pulmonary function during treadmill exercise, consistent with our spirometry findings.[27] Additionally, research demonstrated that high-filtration masks increased end-tidal CO_2 but remained within safe physiological limits.[29] Further reviews emphasized that cardiopulmonary effects are more pronounced during high-intensity or prolonged activity.[30,31] Other studies reinforced that young healthy adults tolerate mask use well, although caution is needed in vulnerable populations.[32] Finally, a systematic review confirmed the overall safety implications of mask use.[33]

Our findings align with previous work from our group (Maharjan *et al*[34]), which reported reduced oxygen saturation, elevated heart rate, and increased perceived exertion during the Chester Step Test with surgical mask use. Together, these findings indicate a mild but consistent cardiorespiratory burden across submaximal exercise, with heart rate changes at lower intensities and oxygen desaturation at higher workloads. Although well tolerated in healthy individuals, these effects should be considered when interpreting exercise tests and advising vulnerable populations.

Strengths of this study include the randomized crossover design, which minimized inter-individual variability, and strict adherence to standardized ATS 6MWT protocols. Limitations include the single-center cohort, modest sample size, and evaluation of only surgical masks. These factors limit generalizability, especially to older or diseased populations.

Taken together, this study adds to the growing evidence that mask use during submaximal exercise imposes measurable but mild physiological changes in healthy young adults. While safe in this population, further studies are needed in vulnerable groups, particularly in Nepal, to ensure clinical and public health recommendations are tailored to populations with lower physiological reserve. Future research should also compare different mask types, assess responses across a range of exercise intensities, and evaluate strategies to mitigate discomfort while maintaining protective efficacy.

In conclusion, wearing a surgical mask during the 6MWT in healthy young adults causes small but statistically significant reductions in walking distance, oxygen saturation, and

pulmonary function, with mild increases in heart rate and blood pressure. Despite these changes, effects remain within clinically tolerable limits, supporting the safety of mask use during light to moderate activity in this population. Clinicians should account for mask-related effects when interpreting functional tests. Caution is warranted in vulnerable groups, and further studies are needed across different populations, mask types, and exercise intensities.

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