

Comparative Analysis of VO₂ Max with Different Types of Masks in Healthy Young Adults: An Observational Study

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Abstract

Background: The widespread use of face masks during respiratory disease outbreaks has raised concerns regarding their potential impact on aerobic capacity and oxygen uptake during exercise. While masks are essential for infection control, their influence on functional cardiorespiratory performance remains insufficiently understood.

Objective: To compare estimated maximal oxygen consumption (VO₂ max) during submaximal exercise under three mask conditions in healthy young adults.

Methods: A cross-sectional observational study was conducted among 75 healthy individuals aged 20–40 years. Participants performed the Six-Minute Walk Test (6MWT) while wearing three different mask configurations: Cotton + Surgical mask, Double Surgical mask, and N95 mask. Tests were conducted in randomized order. Estimated VO₂ max was calculated after each trial. Statistical analysis was performed using non-parametric tests.

Results: Our study recruited 75 healthy volunteers. The participants had a body mass index ranging from 14 to 30.9, with an average of 24.35±3.16. As per Non Parametric Test, Kruskal Wallis Test Estimated VO₂ max was not significant in all three mask As KW test value was 0.15 and P value 0.93. As per Post-hoc statistics for RPE there is significant difference between Double surgical and cotton + surgical P<0.001 and Between N95 and Cotton + Surgical P=0.006, For SBP there is significant difference between Double surgical and N95 P=0.01, between Double surgical and cotton + surgical P<0.001 and Between N95 and Cotton + Surgical P <0.001, For DBP there is significant difference between Double Surgical and N95 P=0.001 and Between N95 and Cotton + Surgical P <0.001

Conclusion: Cotton + Surgical mask led increment in Heart Rate, Respiratory Rate, Blood Pressure and RPE compare to Other mask condition. Double Surgical mask is better for Protection and also that doesn't affects much to normal Physiological Systems of body.

Keywords: Double Masking, N95 mask, Cotton + Surgical mask, Double Surgical mask, 6MWT, Submaximal Exercise Test, CRF, VO₂ max

INTRODUCTION:

“Physical activity,” “exercise,” and “physical fitness” are related but distinct concepts. Physical activity

is defined as any bodily movement produced by skeletal muscles that results in energy expenditure, measured in kilocalories. Exercise is a planned, structured, and repetitive subset of physical activity aimed at improving or maintaining physical fitness. Physical fitness encompasses health- and skill-related attributes, including cardiorespiratory fitness (CRF), body composition, muscular strength and endurance, flexibility, agility, balance, coordination, speed, and reaction time.^{1,2}

CRF, also known as aerobic fitness or maximal aerobic power, is a key component of health-related fitness. Higher CRF levels are associated with numerous health benefits, whereas low CRF correlates with increased all-cause mortality. VO_2 max is the best indicator of CRF and aerobic endurance, serving as a measure of exercise performance and a marker for population-based fitness and cardiovascular risk.³

Submaximal exercise tests such as the Six-Minute Walk Test (6MWT) are widely used to estimate VO_2 max in clinical and research settings.^{6,7,8} These tests are practical, safe, and easily administered, especially when maximal testing is not feasible.

During the COVID-19 pandemic, wearing face masks became a necessary preventive measure. Masks, including surgical masks (SM), N95 respirators, and cloth masks, are effective in reducing viral transmission.^{7,8,9} However, there are concerns about their effects on physiological responses and exercise performance. Mask use can increase CO_2 rebreathing, leading to discomfort, fatigue, dyspnea, and alterations in HR, RR, and BP during exercise.^{9,11}

NEED OF THE STUDY

While previous studies indicated minor physiological effects of mask-wearing, direct assessments during exercise remain limited. Simon Driver et al. reported that cloth masks reduced exercise time and VO_2 max due to perceived discomfort.¹³ Other reviews suggested minimal impact in healthy individuals but were based mostly on circumstantial evidence.¹⁴

Double masking (cloth + surgical mask or double surgical mask) and N95 masks are known to reduce COVID-19 exposure by nearly 95%, according to the US CDC.¹⁵ The physiological effects of different mask types during submaximal exercise, such as the 6MWT, require further evaluation.^{16,18}

AIM:

To compare VO_2 max and related physiological responses with different types of masks (Cotton + Surgical Mask, Double Surgical Mask, and N95 Mask) in healthy young adults.

OBJECTIVES:

1. To analyze VO_2 max with Cotton + Surgical Mask.
2. To analyze VO_2 max with Double Surgical Mask.
3. To analyze VO_2 max with N95 Mask.
4. To analyze Rate of Perceived Exertion (RPE) with Cotton + Surgical Mask.
5. To analyze RPE with Double Surgical Mask.
6. To analyze RPE with N95 Mask.
7. To compare VO_2 max across the three mask types.
8. To compare RPE across the three mask types.

METHODOLOGY:

Study Design

Observational study conducted after approval from the Institutional Ethical Committee.

Sample Selection

Population: Healthy young adults (age 20–40 years).

Sampling Method: Convenient sampling from residential areas, medical settings, and colleges in Ahmedabad.

Sample Size: 75 subjects (pilot study estimation; significance level 5%).

Study Duration: 5 months.

Inclusion Criteria:

- Willing to participate
- Age 20–40 years
- Both genders

Exclusion Criteria:

- Dyspnoea \geq Grade 2 (NYHA)
- Systemic, cardiopulmonary, orthopaedic, neurogenic disorders
- Surgery within past 6 months

Outcome Measures

- Estimated VO₂ max (ml/kg/min)
- Heart rate (HR)
- Respiratory rate (RR)
- Blood pressure (BP)
- Oxygen saturation (SpO₂)
- Rate of perceived exertion (RPE)
- Distance covered in 6MWT

Materials

- Cotton + Surgical Mask, Double Surgical Mask, N95 Mask
- Pulse oximeter, sphygmomanometer, stethoscope
- Stopwatch, chair, cones, 30-meter corridor
- NYHA scale, Borg scale, consent forms, stationery

Procedure

Subjects provided written consent and demographic details. Baseline HR, RR, SpO₂, BP, and RPE were recorded. Subjects performed the 6MWT while wearing each mask type in a randomized sequence (lottery method). Post-test physiological parameters were recorded, and estimated VO₂ max was calculated.

STATISTICAL ANALYSIS

Data were analyzed using SPSS v20.0 and Microsoft Excel 2010. Descriptive statistics (mean ± SD) were used for demographics and physiological measures. Normality was tested with the Kolmogorov–Smirnov test, indicating non-normal distribution; hence, non-parametric tests were used. Kruskal-Wallis tests assessed differences among mask conditions for VO₂ max, BP, and RPE ($\alpha = 0.05$). Post-hoc analyses determined pairwise differences.

RESULTS:

Total 75 subjects were selected and both male and female were included for the study. Their Age, Gender, Weight and BMI was taken for demographic data of subjects and that was analyzed by descriptive statistics. Data were in mean ± standard deviation manner.

Variable	Mean ± SD
Age (years)	28.16 ± 5.70
Weight (kg)	58.39 ± 10.57
BMI (kg/m ²)	24.35 ± 3.16

Table 01: Shows Mean values for Age, Weight and BMI of all 75 subjects.

Gender Distribution: 39 females (52%), 36 males (48%).

Mask Type	VO ₂ max (ml/kg/min)	6MWD (m)
Cotton + Surgical	42.67 ± 5.01	458.93 ± 45.05
Double Surgical	42.90 ± 5.07	469.91 ± 57.54

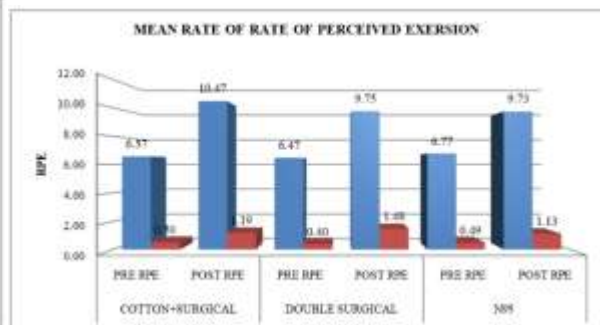
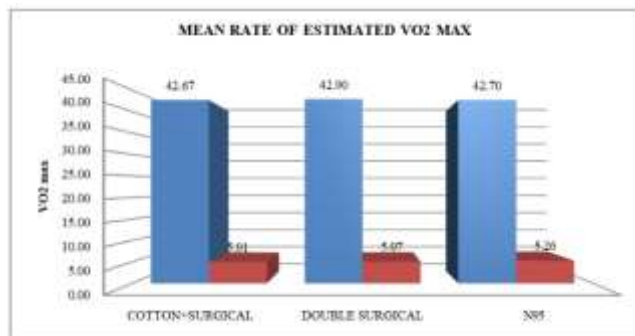
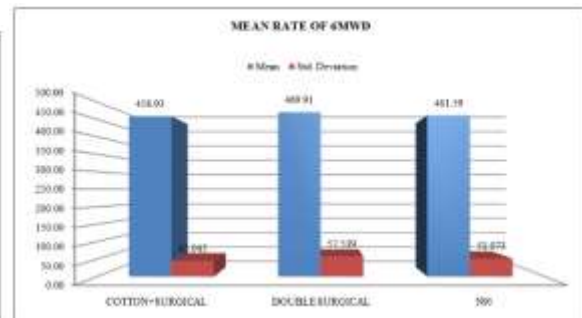
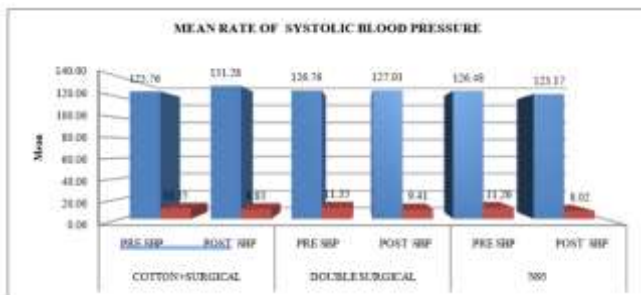
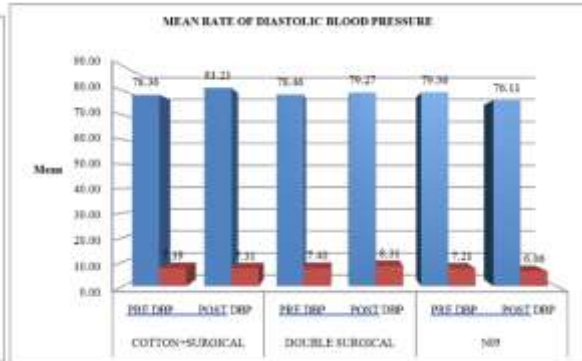
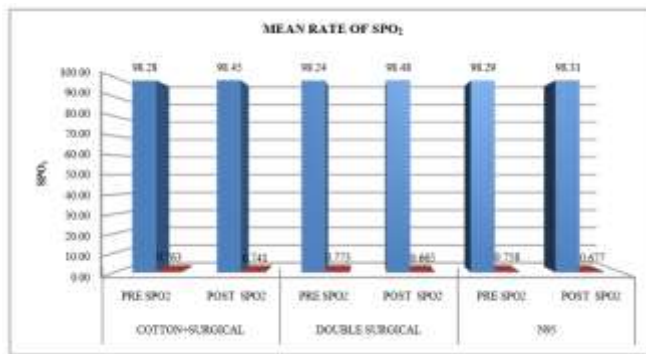
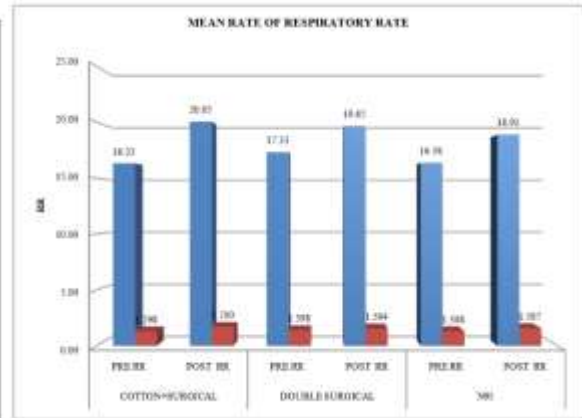
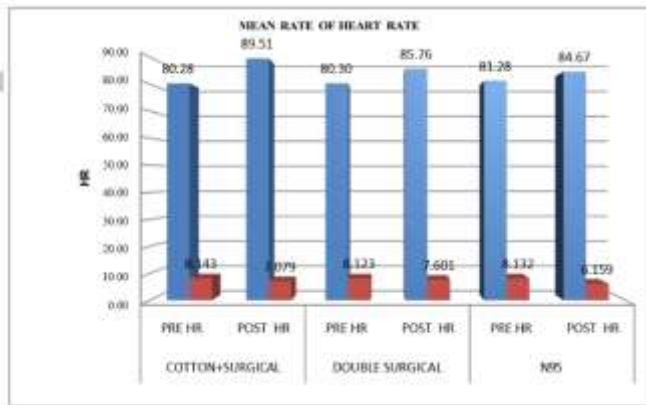
Mask Type	VO ₂ max (ml/kg/min)	6MWD (m)
N95	42.70 ± 5.26	461.59 ± 51.07

Table 02: Mean estimated VO₂ max and 6MWD

Kruskal-Wallis test showed no significant difference in VO₂ max among masks (KW = 0.15, p = 0.93). RPE was significantly higher with Cotton + Surgical Mask compared to Double Surgical Mask (p<0.001) and N95 Mask (p=0.006).

Parameter	Mask Type	Pre-test Mean ± SD	Post-test Mean ± SD
Heart Rate (bpm)	Cotton + Surgical	80.28 ± 8.14	89.51 ± 7.08
	Double Surgical	80.30 ± 8.12	85.76 ± 7.60
	N95	81.28 ± 8.13	84.67 ± 6.16
Respiratory Rate (rpm)	Cotton + Surgical	16.33 ± 1.30	20.05 ± 1.70
	Double Surgical	17.33 ± 1.40	19.65 ± 1.56
	N95	16.38 ± 1.31	18.91 ± 1.59
SpO₂ (%)	Cotton + Surgical	98.28 ± 0.76	98.45 ± 0.74
	Double Surgical	98.24 ± 0.77	98.48 ± 0.66
	N95	98.29 ± 0.76	98.31 ± 0.68
Systolic BP (mmHg)	Cotton + Surgical	125.76 ± 10.35	131.28 ± 9.83
	Double Surgical	126.76 ± 11.35	127.01 ± 9.41
	N95	126.48 ± 11.26	123.17 ± 8.02
Diastolic BP (mmHg)	Cotton + Surgical	78.36 ± 7.36	81.21 ± 7.31
	Double Surgical	78.46 ± 7.40	79.27 ± 8.31
	N95	79.36 ± 7.21	76.11 ± 6.06
RPE	Cotton + Surgical	6.57 ± 0.50	10.47 ± 1.19
	Double Surgical	6.47 ± 0.40	9.75 ± 1.48
	N95	6.77 ± 0.49	9.73 ± 1.13

Table 03: Physiological Parameters under Three Mask Conditions (n=75)



DISCUSSION:

There is limited research on the effects of wearing different masks on functional capacity during submaximal exercise. Therefore, the purpose of this study was to analyze the effects of wearing cotton and surgical mask, double surgical mask and N95 protective mask on VO₂ max in healthy, young individuals during 6 Minute Walk Test, a submaximal exercise test.

There were significant differences in HR, RPE and BP between mask conditions. However, this components was significantly higher while wearing an Cotton and surgical mask compared to Double

Surgical mask and N95 mask.

The results from study found no statistical significant difference in 6MWD between three conditions. Distance averaged 458.93, 469.91 and 461.58 meters for the Cotton and Surgical Mask, Double Surgical Mask and the N95 mask conditions. The average total distance from study fell within the normative reference values (400 to 700 meters) for healthy young adults.⁴¹

The result shows no statistical significance as per KW Test in Estimated VO₂ max values as averaged 42.78289, 43.00719 and 42.82404 for the Cotton and Surgical Mask, Double Surgical Mask and the N95 mask conditions.

During self-paced exercise, the work rate achieved is primarily regulated by feedback from the sensory motor systems based on the presence of a pre-exercise template for that activity and by feedback from the periphery.⁴⁶

It is presently thought that the Rating of Perceived Exertion (RPE) is a summation of afferent signals during exercise, and that it, along with central and peripheral fatigue.⁴⁷ The results showed that with masked exercise at usual training intensities, there was no significant compromise in covered distance and VO₂ max, but a higher RPE in order to maintain training performance.^{47,48}

As per mean values and standard deviation values of VO₂ max and distance there is less difference as mentioned above but its minimal change can't be proved with statistical analysis.⁴⁷

This study is to investigate vital components while submaximal exercises with double face mask coverings. Benjamin reported that with self-paced running, with Surgical mask, N95 and No mask conditions. The subjects in that study showed a relatively constant pace across the different masked conditions, suggesting that mask usage did not alter pacing strategies at the runners self-selected exercise intensity. However, this study also had same criteria as per subjects paced walking in 6MWT.⁴⁸

The result suggested that the subjects attempted an increased walking intensity with the Cotton and Surgical mask compare to N95 mask, there would have been larger physiological changes as HR, RR and BP, and would have led to a decrease in walking velocity.

The significant difference while wearing Cotton and surgical mask, and N95 masks was likely due to trapping of CO₂ inside the masks as per Smith et al. (2013).⁴⁸ The woven material and seal of the mask around the nose and mouth limits airflow, which would trap air inside the mask. They found a significant increase in end-tidal carbon dioxide (EtCO₂) while wearing an N95 mask as compared to both Surgical mask and No mask condition. In other study, Epstein et al. (2020) tested young males 18 years and older who were regular aerobic exercisers, however, a maximal cycle ergometer protocol was used in their study instead of a submaximal walk test.⁴ Their study suggests that an increase in the sensation of dyspnea while wearing Surgical mask or N95 masks occurs with a variety of aerobic activities and intensities. As per this studies we can say Increased expired CO₂ while wearing this two mask conditions increases CO₂ rebreathing, which can heighten vital components.⁵⁰

Li et al. (2005) found that HR was significantly higher in N95 masks compared to SMs. Subjects exercised at increasingly greater intensities followed by a 10-minute rest session.⁵¹ Fikenzer et al. (2020) found that wearing a SM or N95 mask had a significant impact on not only subject discomfort, but also cardiopulmonary function. Maximal ventilation was 23% lower and VO₂max was 13% lower while wearing an N95 mask.⁵²

Overall, the results from several studies suggest that apparently healthy, young, and active individuals can safely perform submaximal exercise while wearing a face masks; However, there can be increase in vital signs. Because there was a significant increase in HR, RR, RPE and BP while wearing a Cotton + Surgical

mask, a Double Surgical mask and an N95 mask, patients with pulmonary problems should perform exercise with caution.

CLINICAL SIGNIFICANCE:

- Supports exercise continuation during infectious outbreaks
- Confirms safety of mask use during moderate activity
- Provides evidence for public health recommendations

LIMITATIONS:

- Healthy young population only
- Submaximal testing
- Short duration exposure

CONCLUSION:

The study concludes that:

- VO_2 max and 6MWD are not significantly affected by mask type during submaximal exercise in healthy young adults.
- Physiological parameters (HR, RR, BP, RPE) are most affected with Cotton + Surgical Mask and least affected with Double Surgical Mask.
- Double Surgical Mask provides a balance of protection and minimal physiological disturbance, making it suitable for safe submaximal exercise.

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