# Effect of Wearing a Face Mask on the 6-Minute Walk Test in Healthy Volunteers

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## ABSTRACT

**Objective:** This study aimed to examine the influence of wearing different types of face masks on the results of the 6-Minute Walk Test (6MWT) in a cohort of healthy volunteers.

**Materials and Methods:** Volunteers were partitioned into three groups (each comprising 36 individuals) with different mask-wearing conditions: NIOSH-approved N95 mask, and double-mask scenarios featuring two layers of surgical mask, and a combination of a surgical mask covered by a cloth face mask. Each participant performed two rounds of the 6MWT, one while wearing a mask and another without. Various metrics, such as the six-minute walk distance (6MWD), oxygen saturation ($SpO_2$), and dyspnea and fatigue scores, were measured.

**Results:** No significant differences were found in the 6MWD results between the mask-wearing and non-mask-wearing scenarios across all the mask types. Strong positive correlations were also established between the 6MWD results in the mask-wearing and non-mask-wearing conditions. However, a small cohort experienced dyspnea significantly more when wearing double surgical masks compared to not wearing a mask. Additionally, there were no major deviations in $SpO_2$ levels or fatigue scores regardless of the type of mask used.

**Conclusion:** The study indicated that wearing an N95 mask, or double surgical masks, or cloth-over-surgical face masks did not significantly influence the outcomes of the 6MWT in healthy individuals. However, caution is advised in the case of wearing double surgical masks, as this may induce a greater sense of dyspnea. This suggests that face masks can be worn safely during physical fitness and pulmonary function assessments, aligning with their essential role in viral spread prevention in daily life.

**Keywords:** 6-Minute walk test; face mask; oxygen saturation; dyspnea; fatigue (Siriraj Med J 2023; 75: 880-886)

## INTRODUCTION

The 6-Minute Walk Test (6MWT) is a method used to assess functional capacity[1] and illness severity. It is often used for comparative purposes before and after various treatments, such as lung transplantation and lung surgery, pulmonary rehabilitation, chronic obstructive pulmonary disease (COPD), pulmonary hypertension, heart failure, peripheral arterial disease, and fibromyalgia, and to assess elderly patients' functional capacity. In the test, the distance walked in 6 minutes (6-minute walk distance, 6MWD), oxygen saturation in the blood ($SpO_2$), heart rate (HR), respiratory rate (RR), blood pressure (BP), dyspnea score, and fatigue score are measured. The test is easy to perform utilizing simple equipment and technology, and is cost-effective, making it popular in healthcare settings.

Since the beginning of the COVID-19 pandemic caused by the Severe Acute Respiratory Syndrome Coronavirus 2

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(SARS-CoV-2), the World Health Organization (WHO) has recommended wearing face masks as a preventive measure in public places.[2] This measure has been effective in helping prevent the transmission and spread of the virus.[3] However, the use of a face mask may have an impact on the 6-Minute Walk Distance (6MWD), but there is currently no established testing protocol for the 6-Minute Walk Test (6MWT) to be performed during a pandemic situation according to the standards set by the American Thoracic Society[4] or the European Respiratory Society.[5] Existing studies have only explored the effects of wearing face masks on the 6MWD results during the 6MWT in sample groups, considering various types of masks, such as surgical masks or N95 masks, for individuals who have previously been infected with COVID-19[6], while wearing the oronasal surgical mask for patients with end-stage lung diseases[7], and the use of surgical masks with healthy volunteers[8], as well as the effects of wearing multiple layers of masks, such as the double-mask technique[9] involving the use of two surgical masks or a combination of a surgical mask as the first layer and a cloth face mask as the second layer. These studies aimed to provide supplementary information for developing testing guidelines to be used during the COVID-19 pandemic and for other respiratory conditions.

Therefore, this research aimed to add to the field by investigating the impact of wearing a single layer N95 standard face mask, the double-mask technique involving two surgical masks or a combination of a surgical mask and a cloth face mask on the 6MWD during the 6MWT. The study also involved healthy volunteers to provide additional reference test data for walking assessments during a pandemic situation and for other respiratory conditions.

## MATERIALS AND METHODS

Healthy volunteers were included in the study who were aged over 18-years old, with a body mass index (BMI) between 18.5–22.90, non-smokers, and without a history of tuberculosis, coronavirus disease (COVID-19), asthma, chronic obstructive pulmonary disease, cystic fibrosis, and no contraindications to perform the 6MWT). The sample size calculation involved randomizing volunteers into six groups, each with 18 individuals. The calculation was based on data from a literature review, specifically from Swiatek et al.[8] study on the Healthy group. The average 6MWD before wearing a mask was 610.45 meters, and after wearing it, it was 605.36 meters. Since the standard deviation of the difference was unavailable, it was set to 39.62 meters to maximize the sample size, with a maximum expected difference of 30 meters.[10] The highest expected average 6MWD without a mask was 635.36 meters. An independent comparison of means between two population groups was planned using a paired t-test, with a significance level of 5% (standard value = 1.96) and a test power of 80%.

$$\text{n/group} = \frac{\sigma_d^2 (Z_{\alpha/2} + Z_{\beta})^2}{\mu_d^2}$$

$$\text{n} = \frac{(1.96+0.84)^2(39.62)^2}{(605.36-635.36)^2}$$

$$\text{n} = 16$$

The quantitative analysis conducted necessitated careful consideration of the sample size for non-inferiority assessment. Initially, a sample size of 16 was contemplated, but subsequently augmented to mitigate potential data loss. This augmentation constitutes a 10% increment relative to the originally computed sample size, equating to an additional two participants. Consequently, the revised sample size now stands at 18. It is imperative to elucidate that this research encompasses a comparative investigation involving two distinct cohorts: individuals who initially abstained from mask usage and subsequently commenced wearing masks, and those who initially donned masks but subsequently ceased usage. In both groups, a standardized resting period of 30 minutes was observed before mask alteration. Notably, during testing, no masks were worn by participants in accordance with the testing protocols prescribed by the American Thoracic Society/European Respiratory Society.

In the first group, volunteers were equipped with NIOSH-approved N95 masks devoid of valves, specifically the 3M™ 1860S model. Group 2 participants utilized a double-layer medical mask, with each layer comprising 3-sublayers. Group 3, wore a 3-tiered medical surgical mask covered by a cloth face mask. The cloth masks, known as Siri Masks, were tested for dust filtration according to the Thai Industrial Standards Institute (TISI) 2424-2552 / EN143:2000 (European Union Personal Protective Equipment: EU PPE) standards.

This study was approved by the Institutional Review Board of the Faculty of Medicine Siriraj Hospital (COA no. Si 1015/2021).

### Statistical analysis

The study findings were reported using descriptive statistics, including frequency, percentage, standard deviation, maximum, minimum, mean and median values. The study explored various health variables, such

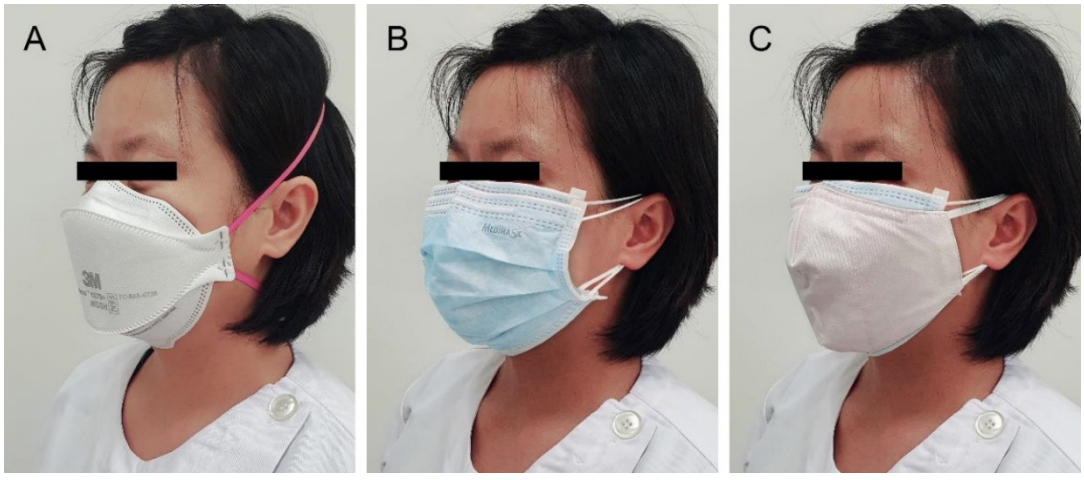


**Fig 1.** Three mask wearing scenarios tested: (A) NIOSH-approved N95 mask without a valve, specifically the 3M™ 1860S, (B) medical surgical mask, double-layered, and (C) three-tiered medical surgical mask covered by a cloth face mask.

as age, gender, weight, BMI, 6MWD, $SpO_2$, HR, dyspnea score, and fatigue score. The statistical software SPSS® Version 18 was employed to analyze the data, utilizing inferential statistics to investigate the relationships between variables or factors, including the independent t-test and Pearson correlation coefficient. Statistical significance was determined using a p-value threshold of less than 0.05.

## RESULTS

Table 1 presents the volunteer characteristics. In total, 108 individuals were included in the study, comprising 13 males and 95 females, with an average age of 37 (±9.08) years old, mean weight of 52.97 (±5.49) kg, average height of 158.70 (±6.08) cm, and mean body mass index (BMI) of 21.0 (±1.29) kg/m$^2$.

From Table 2 and Fig 2, it can be found that the 6MWD in the sample group wearing masks and not wearing masks during the three types of tests did not show statistically significant differences at a significance level of 0.05. Additionally, the 6MWD results when wearing masks and not wearing masks showed a strong positive correlation ($r_{sp}$ = 0.95, p < 0.001) in the same direction. The mean difference in walking distance was 1.431 (±16.64) meters, and the concordance correlation coefficient (CCC) between the meters walked during the 6MWT with and without masks was 0.98. Furthermore, the difference in walking distance was not dependent on the type of mask used (p = 0.252). It was also found that the sample group did not have a difference in the 6MWD greater than 30 meters when wearing masks versus not wearing masks for all types of masks in all the groups.

**TABLE 1.** General characteristics of the study participants.

| | N95 face mask (*n*=36) | Double surgical face masks (*n*=36) | Cloth mask over a surgical face mask (*n*=36) |
|---|---|---|---|
| Age, y | 34.8 (8.71) | 36.4 (8.31) | 37.3 (10.22) |
| Sex, M, n (%) | 3 (8.33) | 4 (11.11) | 6 (16.67) |
| Sex, WM, n (%) | 33 (91.67%) | 32 (88.89%) | 30 (83.33%) |
| Weight, kg | 52.6 (5.87) | 52.5 (4.45) | 53.8 (6.16) |
| Height, cm | 158.4 (6.56) | 158.1 (5.14) | 159.6 (6.53) |
| BMI, kg m$^2$ | 20.9 (1.31) | 21.0 (1.22) | 21.0 (1.33) |

**TABLE 2.** 6MWT differences with or without an N95 face mask, double surgical face mask, or cloth mask over a surgical face mask.

| | N95 face mask (n=36) | | | Double surgical face mask (n=36) | | | Cloth mask over a surgical face mask (n=36) | | |
|---|---|---|---|---|---|---|---|---|---|
| | w | w/o | *p* | w | w/o | *p* | w | w/o | *p* |
| 6MWD, m | 462.7±58.0 | 460.5±57.4 | 0.874 | 454.8±52.22 | 457.4±48.66 | 0.823 | 462.2±59.12 | 463.1±55.98 | 0.945 |
| Basal $SpO_2$, % | 98.4±1.05 | 98.7±1.00 | 0.139 | 98.8±0.90 | 99.1±0.85 | 0.111 | 98.8±1.02 | 99.1±0.89 | 0.222 |
| 1-min $SpO_2$, % | 97.5±1.46 | 97.8±1.70 | 0.417 | 97.9±1.47 | 98.0±1.28 | 0.670 | 97.9±1.31 | 98.5±1.21 | 0.053 |
| 3-min $SpO_2$, % | 97.3±1.62 | 97.8±1.44 | 0.253 | 98.0±1.56 | 97.9±1.47 | 0.757 | 97.7±1.61 | 98.1±1.30 | 0.265 |
| Final $SpO_2$, % | 97.8±1.26 | 98.3±1.30 | 0.145 | 98.3±0.98 | 98.4±1.08 | 0.570 | 98.2±1.04 | 98.4±1.13 | 0.332 |
| After 1-min $SpO_2$, % | 97.5±1.25 | 97.9±1.16 | 0.122 | 98.2±1.08 | 98.5±1.13 | 0.246 | 98.1±1.25 | 98.4±1.13 | 0.280 |
| After 3-min $SpO_2$, % | 97.8±1.05 | 98.1±1.20 | 0.254 | 98.1±1.08 | 98.3±1.01 | 0.370 | 98.1±1.17 | 98.2±1.02 | 0.521 |
| Basal HR, bpm | 79.6±10.13 | 78.0±9.12 | 0.488 | 83.8±9.56 | 83.9±9.50 | 0.980 | 79.1±11.3 | 77.5±10.83 | 0.525 |
| 1-min HR, bpm | 105.9±15.82 | 106.1±16.00 | 0.965 | 111.0±14.98 | 109.1±15.06 | 0.656 | 104.4±18.54 | 104.4±15.73 | 0.989 |
| 3-min HR, bpm | 110.7±16.72 | 109.8±16.97 | 0.807 | 113.5±15.59 | 113.4±16.18 | 0.977 | 106.8±22.42 | 107.1±19.38 | 0.955 |
| Final HR, bpm | 117.4±15.73 | 114.8±13.03 | 0.441 | 119.2±13.85 | 116.4±15.13 | 0.433 | 112.8±16.72 | 110.3±17.29 | 0.539 |
| After 1-min HR, bpm | 95.6±14.61 | 91.6±12.73 | 0.220 | 99.9±13.11 | 94.9±13.20 | 0.104 | 91.3±16.17 | 87.9±17.60 | 0.402 |
| After 3-min HR, bpm | 87.6±12.34 | 86.4±11.74 | 0.661 | 93.4±12.26 | 90.8±12.53 | 0.345 | 84.0±14.78 | 82.3±14.98 | 0.619 |
| Dyspnea basal score | 0.0 (0-2) | 0.0 (0-2) | 0.582 | 0.0 (0-0.5) | 0.0 (0-0.5) | 1.000 | 0.0 (0-2) | 0.0 (0-1) | 0.451 |
| Dyspnea 1-min score | 0.0 (0-3) | 0.0 (0-4) | 0.599 | 0.5 (0-1) | 0.0 (0-1) | 0.080 | 0.0 (0-2) | 0.0 (0-1) | 0.366 |
| Dyspnea 3-min score | 0.5 (0-4) | 0.5 (0-4) | 0.441 | 1.0 (0-2) | 0.5 (0-3) | 0.077 | 0.5 (0-3) | 0.5 (0-2) | 0.145 |
| Dyspnea final score | 2.0 (0-6) | 1.0 (0-6) | 0.166 | 2.0 (0-5) | 1.0 (0-5) | 0.010* | 1.0 (0-4) | 1.0 (0-3) | 0.064 |
| After dyspnea 1-min score | 1.0 (0-6) | 0.5 (0-4) | 0.140 | 1.5 (0-4) | 0.5 (0-5) | 0.016* | 0.5 (0-4) | 0.5 (0-2) | 0.053 |
| After dyspnea 3-min score | 0.5 (0-4) | 0.0 (0-4) | 0.159 | 0.5 (0-3) | 0.0 (0-2) | 0.036* | 0.0 (0-2) | 0.0 (0-2) | 0.320 |
| Fatigue basal score | 0.0 (0-2) | 0.0 (0-2) | 0.519 | 0.0 (0-0.5) | 0.0 (0-2) | 0.067 | 0.0 (0-2) | 0.0 (0-2) | 1.000 |
| Fatigue 1-min score | 0.0 (0-5) | 0.0 (0-2) | 0.298 | 0.0 (0-2) | 0.0 (0-1) | 0.750 | 0.0 (0-2) | 0.0 (0-2) | 0.514 |
| Fatigue 3-min score | 0.5 (0-6) | 0.5 (0-5) | 0.680 | 0.5 (0-3) | 0.5 (0-5) | 0.748 | 0.5 (0-5) | 0.0 (0-4) | 0.605 |
| Fatigue final score | 1.0 (0-7) | 0.5 (0-7) | 0.942 | 0.5 (0-4) | 0.5 (0-5) | 0.626 | 0.5 (0-5) | 0.5 (0-4) | 0.518 |
| After fatigue 1-min score | 0.5 (0-6) | 0.5 (0-7) | 0.542 | 0.5 (0-4) | 0.5 (0-4) | 0.361 | 0.5 (0-4) | 0.0 (0-2) | 0.189 |
| After fatigue 3-min score | 0.0 (0-5) | 0.0 (0-4) | 0.476 | 0.0 (0-3) | 0.0 (0-2) | 0.176 | 0.0 (0-3) | 0.0 (0-2) | 0.356 |

w = With face mask; w/o = Without face mask; 6MWD = 6-minute walking distance; 6MWT = 6-minute walking test; HR = Heart rate; $SpO_2$ = Oxygen saturation measured by pulse fingertip oximeter, Mean±SD or median(Minimum–Maximum); 1-minute and 3-minute scores correspond with measurements at 1 minute and 3 minutes after the 6MWT. Dyspnea and fatigue scores were measured with the Borg scale.

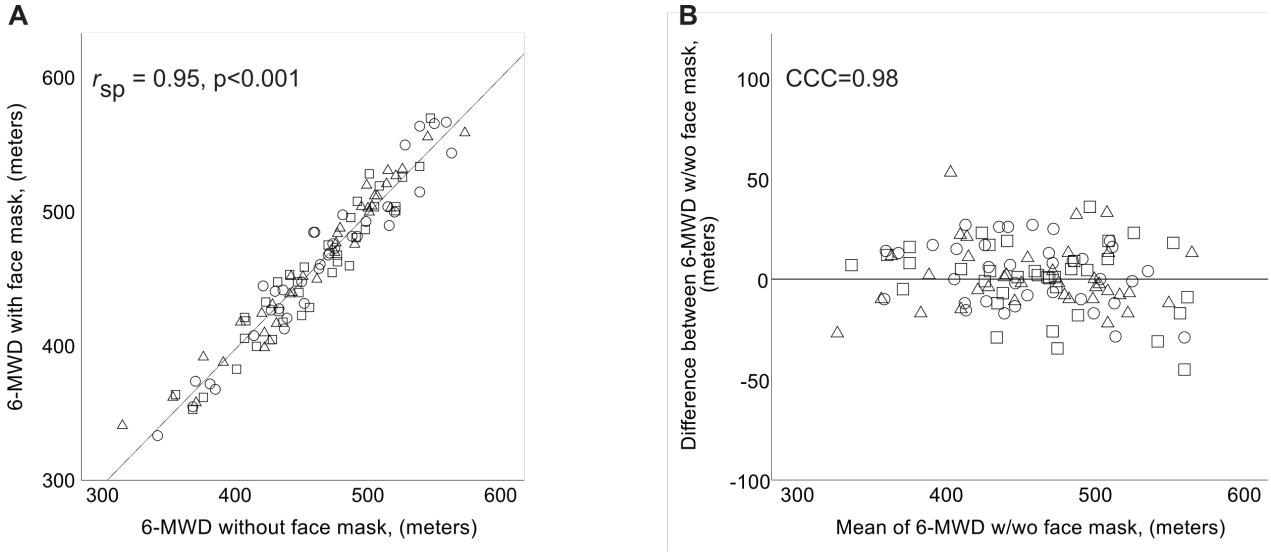


**Fig 2.** (A) Spearman correlation ($r_{sp}$ = 0.95, $p$ < 0.001) and (B) concordance correlation coefficient (CCC) between the meters walked during the 6-minute walking test (6MWT) with and without a face mask (CCC = 0.98).
w/wo = with/without masks. △ = N95 face mask, ○ = Double surgical face masks, □ = Cloth mask over a surgical face mask (n = 36).

No significant decrease in $SpO_2$ of more than 4% was found. However, among the sample group of 34 individuals (62.03%), there was a difference in $SpO_2$ levels when wearing masks versus not wearing masks, with a mean difference of 0.07% (±0.92) after completing the test.

There was no significant difference between wearing masks and not wearing masks in terms of the $SpO_2$, and dyspnea and fatigue scores for the N95 masks and the combination of a cloth face mask over a medical surgical mask. However, among the sample group wearing the double-surgical masks, featuring a 3-layer surgical mask (medical face mask) with two overlapping layers, and not wearing the masks, a significant difference was found in dyspnea after completion of the test (p = 0.010) and at 1 minute (p = 0.016) and 3 minutes (p = 0.036) after completion of the test.

## DISCUSSION

### *Six-minute walk distance*

There was no significant difference in the 6MWD when wearing the N95, double surgical face masks, or cloth mask over a surgical face mask combination during the 6MWT test (p = 0.932, 0.806, and 0.990, respectively). There was also a strong positive correlation in the same direction ($r_{sp}$ = 0.937, p < 0.001) between the 6MWD results and the use of any of the three mask-type scenarios. These findings are consistent with other studies that showed there were no statistically significant differences in the 6MWD when wearing an N95[10-13], surgical face mask[11-15], or cloth mask.[11,13] Furthermore, it was found that wearing or not wearing a mask did not result in a difference of more than 30 meters in the 6MWD, which is clinically significant for diagnosing, predicting, and monitoring individuals with chronic lung diseases.[10,16-17]

### *Oxygen saturation*

There was no significant difference in the $SpO_2$ levels when wearing the N95, double surgical face masks, or cloth mask over a surgical face mask combination during the 6MWT test. These findings align with the study conducted by Fukushi et al.[18], who found that mask-wearing does not impact oxygen saturation levels in red blood cells during any level of exercise load.[19] It is possible that there may be a temporary decrease in blood oxygen saturation after performing activities or exercise, but this effect is short term and clinically insignificant.

### *Dyspnea and fatigue*

The sample group who wore the double surgical face masks experienced significantly higher levels of dyspnea compared to when not wearing a mask during the test and after completing the test, at a statistically significant level of 0.05 (p = 0.010) one minute after the test (p = 0.016), and three minutes after the test (p = 0.036). These findings are consistent with the study conducted by Person et al.[15], who found that wearing a surgical mask resulted in greater dyspnea compared to not wearing one, and with the study conducted by Kusalin et al.[11], who found that surgical masks caused more dyspnea compared to N95 cloth PM2.5 masks. However, Cabanillas-Barea et al.[20] found that N95 masks

resulted in more dyspnea compared to surgical masks. Additionally, Fukushi et al.[18] found that wearing surgical masks or cloth masks did not worsen dyspnea during light to moderate exercise but worsened dyspnea during strenuous exercise. No significant difference in fatigue was observed between wearing or not wearing any of the three types of masks in the present study.

### *Limitations*

This study primarily included middle-aged, healthy individuals with normal BMI and a female predominance. As such, our findings may not be readily extrapolated to diverse populations with varying demographics, obesity levels, and comorbidities, particularly pulmonary and cardiovascular disorders. Moreover, our results are specifically relevant to healthy individuals without underlying cardiac conditions. Additionally, the study's focus was on short-term mask effects, and long-term implications were not explored. Future research should consider these limitations and investigate broader demographic profiles and long-term outcomes.

## CONCLUSION

This study provides valuable insights into the impact of various mask types on 6MWT in healthy individuals. It is important to emphasize that the safety considerations related to different masking strategies discussed herein primarily apply to a cohort of healthy participants without underlying cardiopulmonary diseases.

The findings underscore that, for individuals without pre-existing cardiac or pulmonary conditions, wearing N95 masks, double surgical masks, or a cloth mask over a surgical mask during the 6MWT does not appear to significantly affect the distance walked in six minutes (6MWD), oxygen saturation ($SpO_2$) levels, or fatigue. These results offer reassurance regarding the continued use of face masks as a crucial measure in mitigating the spread of viral infections during daily life and within the context of physical fitness and pulmonary function assessments.

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