# Effect Of Face Mask On Oxygen Saturation During Exercise In Healthy Individuals

*A Crossover Study*

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**Abstract**

**BACKGROUND : Covid 19 outbreak has a profound impact on almost every aspect of life [1]. Center for Disease Control (CDC) recommends community use of masks to prevent transmission of SARS-CoV-2 [8]. Straying away from a sedentary lifestyle is essential in these times of global pandemic of covid 19 to reduce health risks [7]. There is a concern that wearing a face mask during exercise will reduce oxygen uptake or increase carbon dioxide rebreathing, which can result in low blood oxygen levels, reduced oxygen delivery to muscle and reduced exercise capacity. When people go outdoors wearing a mask, they know that they are at a lower risk of catching the infection. Exercising at public places wearing a mask will keep them satisfied that they are safe.**

**Methodology : Ethical approval was taken. 106 subjects, between the age group 18-25 years were included. They performed exercise on treadmill following Bruce Protocol until exhaustion. The exercise was performed twice by each individual, once without wearing mask and then while wearing cloth mask on two consecutive days. The vitals were monitored throughout the test using pulse oximeter and the pre and post exercise values were noted. The level of exertion was noted through Borg scale of rate of perceived exertion.**

**Result : On comparing the mean of pre and post values of $SPO_2$ while exercising without mask, mean for pre $SPO_2$ is 98±0.6325 %, and for post $SPO_2$ is 97.849±0.7782 % (p=0.081).**

**On comparing the mean of pre and post values of $SPO_2$ while exercising with mask, mean for pre $SPO_2$ is 97.953±0.6953 %, and for post $SPO_2$ is 97.142±1.099 % (p<0.001).**

**On comparing the mean values of $SPO_2$ post exercise between exercising without and with mask, a significant difference was seen (p<0.001).**

**Conclusion : The study concludes that there is a significant reduction in $SPO_2$ while exercising with mask.**

**The range of oxygen saturation drop while exercising with mask was within the normal limits (97.953-97.142). The $SPO_2$ of only 2 subjects went below 95%.**

**Hence, though the results are statistically significant, it may not be clinically significant.**

***Key words*— exercise, $SPO_2$, oxygen saturation, mask.**

## Introduction

Covid 19 outbreak has a profound impact on almost every aspect of life [1]. On March 11, 2020, the World Health Organisation (WHO) has declared the novel coronavirus outbreak a global pandemic [1]. The most common clinical presentation of severe COVID-19 is acute respiratory failure consistent with the acute respiratory distress syndrome [2]. Airway, lung parenchymal, pulmonary vascular, and respiratory neuromuscular disorders all feature in COVID-19 [2].

The primary route of infection is likely via small droplets ejected by carriers while speaking, breathing, coughing, or sneezing [1]. It spreads to person to person through close contact [3].

This virus could be transmitted through the air by small particle droplet nuclei known as aerosols, which are defined as a collection of solid or liquid particles suspended in a gas phase [4]. Such expiratory particles have a diameter of around 1 micrometer, and they are invisible to the naked eye [4]. Aerosols can be transmitted very easily by the air stream due to their small size [4]. In a very recent study about the transmission of COVD-19 droplets, it was proven that aerosols are involved in the spread of disease [4].

Droplets settle quickly and therefore restrict the transmission of the virus to the people near the carrier [4]. However, nuclei droplets can be typically suspended longer than droplets, leading to air-borne transfer in long-distance and to the increased number of infections [4]. The studies revealed that aerosol transmission accounts for about half of all transmission cases [4]. When a person breathes, talks or coughs, droplets and droplet nuclei can fly as far as 8 m (26 feet) [5]. Environmental conditions such as wind and humidity can further worsen the risk factors via enhanced distributions of the droplets in the air [5].

Evidence exists that use of face masks reduce the transmission of Covid 19 [6]. Facemasks serve as personal protective equipment that could filter airborne particles and prevent them from reaching the respiratory system as well as prevent inter-individual infections of coronavirus [7].

Center for Disease Control (CDC) recommends community use of masks to prevent transmission of SARS-CoV-2. Masks are primarily intended to reduce the emission of virus-laden droplets by the wearer ("source control"), which is especially relevant for asymptomatic or presymptomatic infected wearers who feel well and may be unaware of their infectiousness to others (estimated to account for more than 50% of SARS-CoV-2 transmissions) [8]. Masks also help reduce inhalation of these droplets by the wearer ("filtration for wearer protection") [8]. The community benefit of masking for SARS-CoV-2 control is due to the combination of

these two effects (source control and filtration for wearer protection); individual prevention benefit increases with increasing numbers of people using masks consistently and correctly [8].

Regardless of the type, setting, or who wears the face mask, it serves primarily a dual preventive purpose; protecting oneself from getting viral infection and protecting others [9]. Therefore, if everyone wears a face mask in public, it offers a double barrier against COVID-19 transmission [9].

There are three types of masks that WHO recommend for the public: Reusable non-medical masks, Disposable medical masks, other types of well fitting non-medical masks, including homemade multi-layered masks are an acceptable option.

The cloth mask should be made of three layers-

- Inner layer of absorbent material, such as cotton.
- Middle layer of non-woven non-absorbent material, such as polypropylene.
- Outer layer of non-absorbent material, such as polyester or polyester blend [10].

Multi-layer cloth masks block release of exhaled respiratory particles into the environment, along with any microorganisms associated with these particles [8]. Cloth masks not only effectively block most large droplets (i.e., 20-30 microns and larger), but they can also block the exhalation of fine droplets and particles (also often referred to as aerosols) smaller than 10 microns which increase in number with the volume of speech and specific types of phonation [8]. Multi-layer cloth masks can both block 50-70% of these fine droplets and particles and limit the forward spread of those that are not captured [8].

It is recommended that the health professionals, covid positive individuals, people working in close proximity of covid positive individuals and symptomatic individuals should wear N95 or surgical mask. The general population is recommended to wear cloth mask in order to preserve the supply of surgical or N95 masks for medical personnel.

Straying away from a sedentary lifestyle is essential in these times of global pandemic of covid 19 to reduce health risks [7]. Sedentary behaviour (energy expenditure fewer than 1.5 MET in reclining or sitting postures) is identified as risk factor for cardiometabolic disease such as obesity, coronary artery disease, and hypertension [7]. Exercise is effective for prevention of obesity, diabetes and hypertension, all of which are leading risk factors for complications of covid 19 [6]. Low-intensity exercise for sedentary individuals and moderate exercise for active individuals are recommended by Center for Disease Control (CDC) and American College of Sports Medicine (ACSM) to maintain cardiovascular and musculoskeletal fitness in global population [7]. Covid 19 restrictions have increased the sedentary behaviour among people. Thus, out of all the factors responsible for causing cardiometabolic diseases, sedentary lifestyle has become a major factor of concern. Hence, it has become even more important to exercise and keep oneself fit.

The heavy panting from jogging and other sports produces violent exhalations with higher momentum than tidal breathing, closer to cough in some instances [5]. This increases the distance travelled by the droplets trapped within the exhaled cloud and supports additional distancing during vigorous exercise [5]. As sports clubs, gyms, and public spaces may serve an important source of viral transmission, masking may become an integral part of physical activity [1].

This measure might be even more important during aerobic activity, such as running or biking, as some preliminary studies show that small droplets can spread as far as 5 meters while walking at a pace of 4 km/h and 10 meters when running at 14.4 km/h [11]. Wearing a face mask during vigorous exercise might, therefore, be important for the prevention of spread of infectious respiratory droplets [6]. However, the ability to exercise vigorously while wearing a face mask is a concern [6]. One hypothesis is that oxygen uptake will be compromised and that trapping of air in face mask will increase rebreathing of carbon dioxide, leading to hypercapnic hypoxia [6]. Another hypothesis is that facemask will increase resistance to respiration and thus work of breathing [6].

The corona virus pandemic has increased the awareness about oxygen saturation in people since one of the main clinical feature of covid 19 is drop in oxygen saturation level ($SPO_2$).

Many individuals tend to avoid exercising as all public places like gym, park, jogging tracks are closed and also because of fear of getting infected. But, it is important to exercise regularly as it will help to keep strong immune system and prevent complications of covid.

There is a concern that wearing a face mask during exercise will reduce oxygen uptake or increase carbon dioxide rebreathing, which can result in low blood oxygen levels, reduced oxygen delivery to muscle and reduced exercise capacity. But, using face mask for prevention of spread of infection has been made compulsory by World Health Organisation.

It is still not clear if there is actual fall in saturation or it is just the fear of breathlessness.

When people go outdoors wearing a mask, they know that they are at a lower risk of catching the infection. Exercising at public places wearing a mask will keep them satisfied that they are safe.

It is therefore important to determine if exercise is compromised by wearing mask.

**Aim-**

To study the effect of mask on oxygen saturation during exercise in healthy individuals.

**Objectives-**

1. To study the effect of exercise without mask on oxygen saturation by using pulse oximeter.
2. To study the effect of exercise with mask on oxygen saturation by using pulse oximeter.

**Hypothesis**

Null Hypothesis:

There is no change in oxygen saturation with or without mask during exercise.

*Alternative Hypothesis:*

There may be change in oxygen saturation with or without mask during exercise.

**RESEARCH QUESTION-**

Is there any change in oxygen saturation while performing exercise with mask?

**MATERIALS & METHODOLOGY-**

Methodology-
Study Design: Crossover study
Study Set-up: PCMC
Sampling Technique: Convenient Sampling
Sample Size: 106
Study Duration: 6 months
Materials Required-

1. Triple layer Cloth Mask
2. Treadmill
3. Pulse Oximeter
4. Borg Scale of Rate of Perceived Exertion (6-20 scoring)
5. Watch
6. Pen
7. Paper
8. Pad

**INCLUSION CRITERIA & EXCLUSION CRITERIA-**

| Inclusion Criteria | Exclusion Criteria |
|---|---|
| Young healthy individuals | Any cardiorespiratory, musculoskeletal or neurological disorder |
| Age between 18-25 years | Post-covid less than 2 months |
| | Individual with any symptom of Covid |

**OUTCOME MEASURES-**

1. Oxygen saturation on Pulse Oximeter
2. Borg scale of Rate of Perceived Exertion

**PROCEDURE-**

Ethical committee clearance was taken. Consent was taken from the subjects who fulfilled the inclusion criteria and who volunteered to participate in the study. Exercise test on treadmill following modified Bruce protocol until exhaustion was performed. Each subject performed the test without face mask on day 1 and with face mask on day 2 at the same time. Instructions on how to correctly wear the mask (to ensure adequate nose and mouth coverage) were given. The oxygen saturation and pulse rate was monitored continuously during the test, using pulse oximeter. The rate of perceived exertion was monitored before and after the test, using Borg scale of Rate of Perceived Exertion (6-20 scoring). The test started with stage 0 of modified Bruce protocol at 1.7 mph speed, 0% grade. The level was increased after every 3 minutes. Criteria to terminate exercise- If the oxygen saturation falls below 95%, or if the patient asks to stop. The reason for stopping the exercise was noted. The data was statistically analysed.

**STATISTICAL ANALYSIS-**

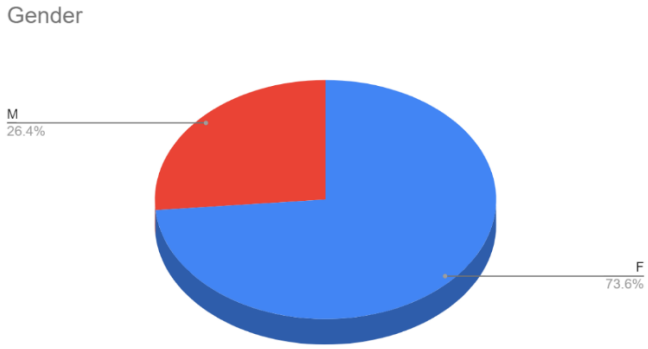
- Data was collected and analyzed by appropriate statistical tests.
- To compare the vitals pre and post exercise in each condition, paired t test was used.
- To compare the vitals post exercise between both the exercise conditions, unpaired t test was used.

TABLE 1: GENDER WISE DISTRIBUTION OF THE STUDY (N=106)

Interpretation: Table 1 shows that out of 106 subjects, 28 are male and 78 are female.

| | Male | Female |
|---|---|---|
| n=106 | 28 | 78 |

FIGURE 1: GENDER WISE DISTRIBUTION OF THE STUDY IN PERCENTAGE



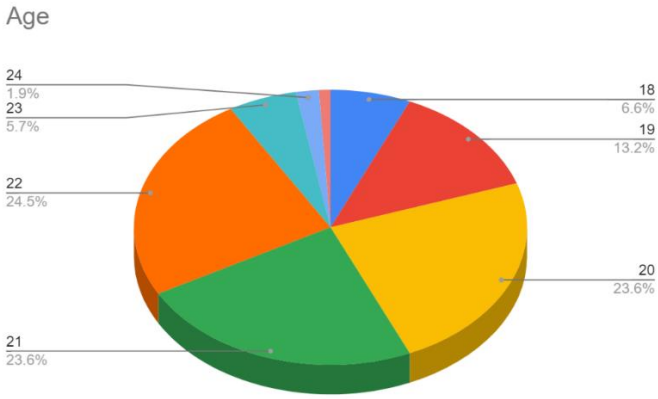

Interpretation: Figure 1 shows that out of 106 subjects, 26.4% are male and 73.6% are female.

TABLE 2: AGE WISE DISTRIBUTION OF STUDY

Interpretation: Table 2 shows that out of 106 subjects, 7 are 18 years old, 14 are 19 years old, 25 are 20 years old, 25 are 21 years old, 26 are 22 years old, 6 are 23 years old, 2 are 24 years old, and 1 are 25 years old.

| | 18 years | 19 years | 20 years | 21 years | 22 years | 23 years | 24 years | 25 years |
|---|---|---|---|---|---|---|---|---|
| n= 106 | 7 | 14 | 25 | 25 | 26 | 6 | 2 | 1 |

FIGURE 2: AGE WISE DISTRIBUTION OF STUDY IN PERCENTAGE




Interpretation: Figure 2 shows that out of 106 subjects, 6.6% are 18 years old, 13.2% are 19 years old, 23.6% are 20 years old, 23.6% are 21 years old, 24.5% are 22 years old, 5.7% are 23 years old, 1.9% are 24 years old, and 0.9% are 25 years old.

TABLE 3: PAIRED T TEST FOR PRE AND POST $SPO_2$ WHILE EXERCISING WITHOUT MASK

Interpretation: Table 3 shows that there is no significant change in $SPO_2$ pre and post exercise while exercising without mask.

| $SPO_2$ without mask | Mean | Standard Deviation | Mean Difference | t Value | p Value |
|---|---|---|---|---|---|
| Pre | 98 | 0.6325 | 0.1509 | 1.763 | 0.081 |
| Post | 97.849 | 0.7782 | | | |

FIGURE 3: GRAPHICAL REPRESENTATION OF MEAN OF PRE AND POST $SPO_2$ WHILE EXERCISING WITHOUT MASK

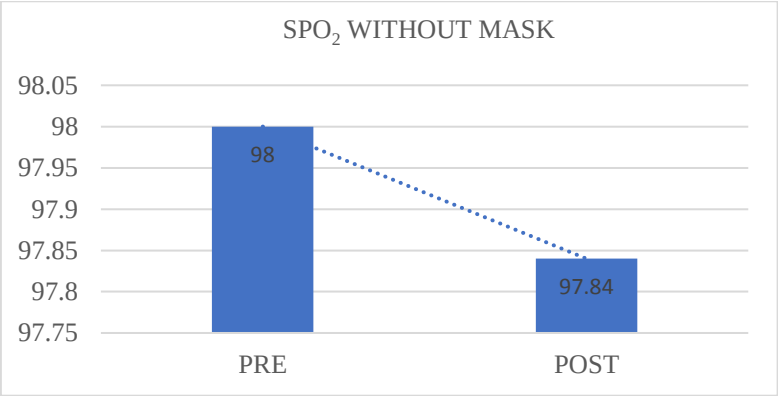



TABLE 4: PAIRED T TEST FOR PRE AND POST $SPO_2$ WHILE EXERCISING WITH MASK

Interpretation: Table 4 shows that there is a significant change in $SPO_2$ pre and post exercise while exercising with mask.

| $SPO_2$ | Mean | Standard Deviation | Mean Difference | t Value | p Value |
|---|---|---|---|---|---|
| Pre | 97.953 | 0.6953 | 0.8113 | 7.078 | <0.001 |
| Post | 97.142 | 1.099 | | | |

FIGURE 4: GRAPHICAL REPRESENTATION OF MEAN OF PRE AND POST $SPO_2$ WHILE EXERCISING WITH MASK

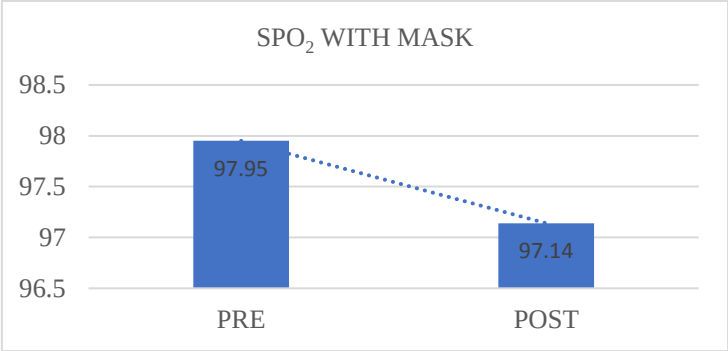


TABLE 5: UNPAIRED T TEST TO COMPARE POST TEST $SPO_2$ WHILE EXERCISING WITHOUT MASK AND POST TEST $SPO_2$ WHILE EXERCISING WITH MASK

Interpretation: Table 5 shows that there is a significant change in $SPO_2$ post exercise while exercising with mask.

| $SPO_2$ (Post Exercise) | Mean | Standard Deviation | Mean Difference | t Value | p Value |
|---|---|---|---|---|---|
| Without Mask | 97.849 | 0.7782 | 0.707 | 5.409 | <0.001 |
| With Mask | 97.142 | 1.099 | | | |

FIGURE 5: GRAPHICAL REPRESENTATION OF MEAN OF $SPO_2$ POST EXERCISE WHILE EXERCISING WITHOUT AND WITH MASK

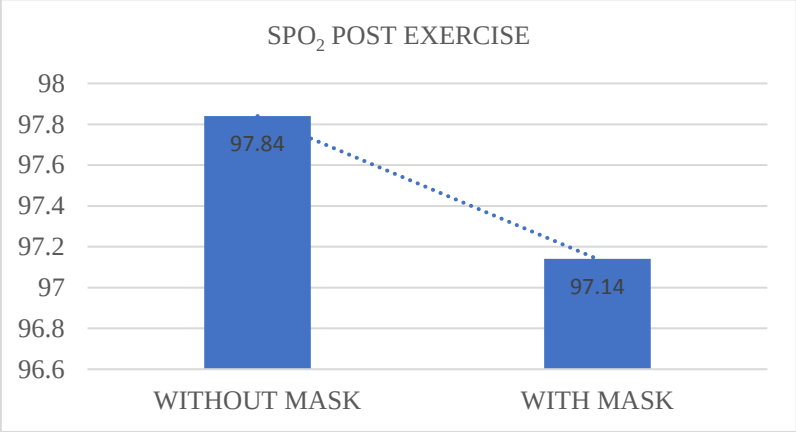



TABLE 6: MEAN SCORE OF PRE AND POST PR WHILE EXERCISING WITHOUT MASK

Interpretation: Table 6 shows that mean score for PR before exercise without mask is 89.132±12.749, and PR after exercise without mask is 147.169±13.689

| Pulse Rate | Mean | Standard Deviation | Mean Difference |
|---|---|---|---|
| Pre | 89.132 | 12.749 | -58.037 |
| Post | 147.169 | 13.689 | |

FIGURE 6: GRAPHICAL REPRESENTATION OF MEAN OF PRE AND POST PR WHILE EXERCISING WITHOUT MASK

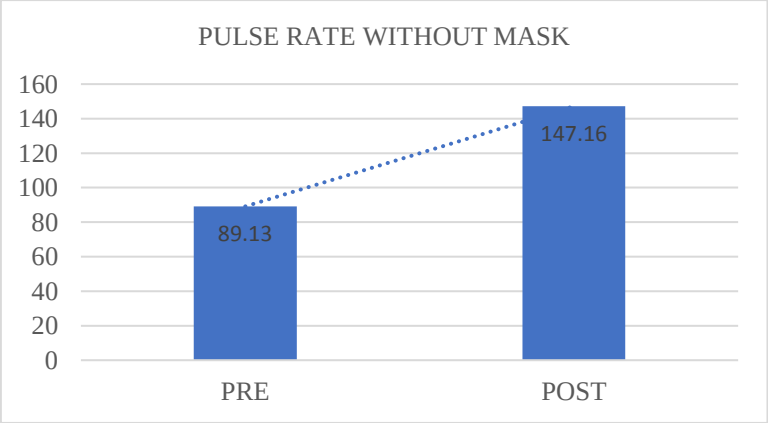



TABLE 7: MEAN SCORE FOR PRE AND POST PR WHILE EXERCISING WITH MASK

Interpretation: Table 7 shows that mean score for PR before exercise with mask is 89.028±15.022, and PR after exercise with mask is 152.556±13.756

| Pulse Rate | Mean | Standard Deviation | Mean Difference |
|---|---|---|---|
| Pre | 89.028 | 15.022 | -63.528 |
| Post | 152.556 | 13.756 | |

FIGURE 7: GRAPHICAL REPRESENTATION OF MEAN OF PRE AND POST PR WHILE EXERCISING WITH MASK

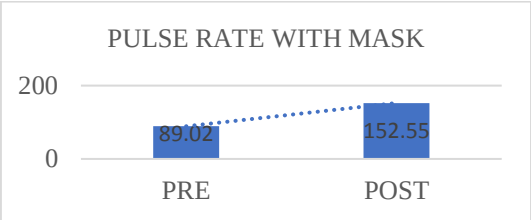


TABLE 8: UNPAIRED T TEST TO COMPARE POST TEST PR WHILE EXERCISING WITHOUT MASK AND POST TEST PR WHILE EXERCISING WITH MASK

Interpretation: Table 8 shows that there is no significant change in PR post exercise while exercising with mask.

| Pulse Rate | Mean | Standard Deviation | Mean Difference | t Value | p Value |
|---|---|---|---|---|---|
| Without Mask | 147.169 | 13.689 | -5.387 | 2.858 | 0.0047 |
| With Mask | 152.556 | 13.756 | | | |

FIGURE 8: GRAPHICAL REPRESENTATION OF MEAN OF PR POST EXERCISE WHILE EXERCISING WITHOUT AND WITH MASK

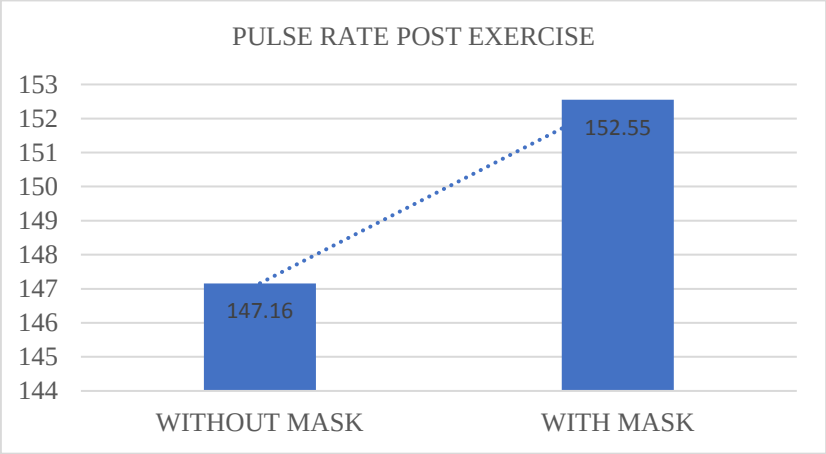



TABLE 9: UNPAIRED T TEST TO COMPARE POST TEST RPE WHILE EXERCISING WITHOUT MASK AND POST TEST RPE WHILE EXERCISING WITH MASK

Interpretation: Table 9 shows that there is a significant change in RPE post exercise while exercising with mask.

| RPE | Mean | Standard Deviation | Mean Difference | t Value | p Value |
|---|---|---|---|---|---|
| Without Mask | 12.443 | 2.107 | -2.094 | 6.903 | <0.001 |
| With Mask | 14.537 | 2.306 | | | |

FIGURE 9: GRAPHICAL REPRESENTATION OF MEAN OF RPE POST EXERCISE WHILE EXERCISING WITHOUT AND WITH MASK

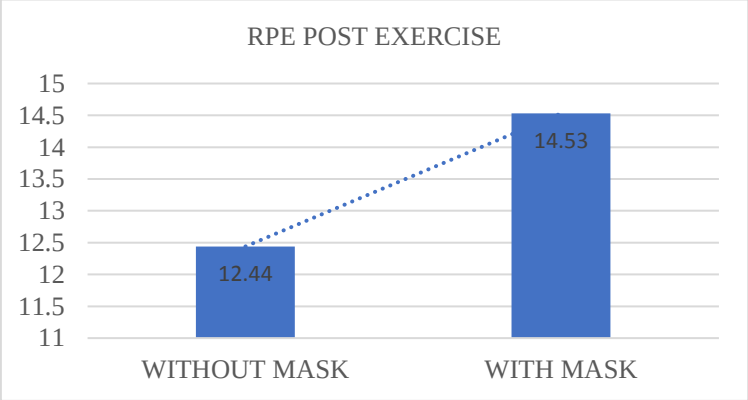



TABLE 10: UNPAIRED T TEST TO COMPARE TIME TO EXHAUSTION WHILE EXERCISING WITHOUT AND WITH MASK

Interpretation: Table 10 shows that there is no significant change in time to exhaustion while exercising with mask.

| Time to exhaustion | Mean | Standard Deviation | Mean Difference | t Value | p Value |
|---|---|---|---|---|---|
| Without Mask | 17.05 | 1.876 | 0.33 | 1.149 | 0.2518 |
| With Mask | 16.72 | 2.287 | | | |

FIGURE 10: GRAPHICAL REPRESENTATION OF MEAN OF TIME TO EXHAUSTION WHILE EXERCISING WITHOUT AND WITH MASK

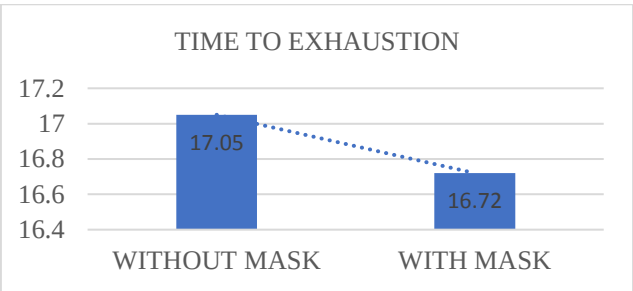
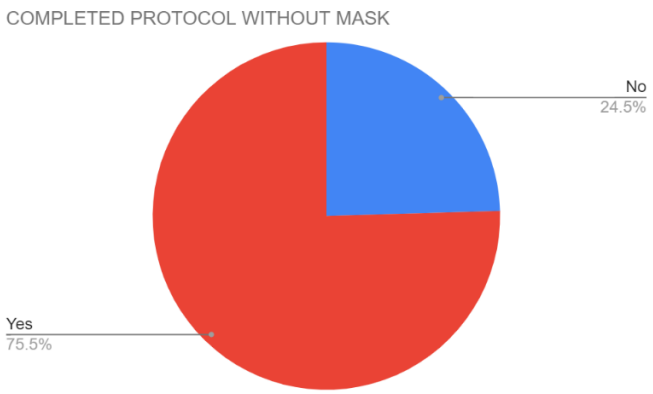


TABLE 11: NO. OF SUBJECTS WHO COMPLETED THE PROTOCOL WHILE EXERCISING WITHOUT MASK

Interpretation: Table 11 shows that while exercising without mask, 80 subjects completed the protocol, and 26 did not.

| Completed Protocol (Without Mask) | Yes | No |
|---|---|---|
| n=106 | 80 | 26 |

FIGURE 11: REPRESENTATION OF NO. OF SUBJECTS WHO COMPLETED THE PROTOCOL WHILE EXERCISING WITHOUT MASK IN PERCENTAGE



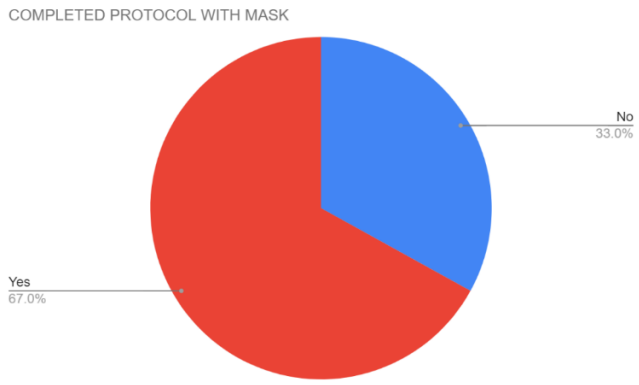

Interpretation: Figure 11 shows that while exercising without mask, 75.5% subjects completed the protocol, and 24.5% did not.

TABLE 12: NO. OF SUBJECTS WHO COMPLETED THE PROTOCOL WHILE EXERCISING WITH MASK

Interpretation: Table 12 shows that while exercising with mask, 71 subjects completed the protocol, and 35 did not.

| Completed Protocol (With Mask) | Yes | No |
|---|---|---|
| n= 106 | 71 | 35 |

FIGURE 12: REPRESENTATION OF NO. OF SUBJECTS WHO COMPLETED THE PROTOCOL WHILE EXERCISING WITH MASK IN PERCENTAGE



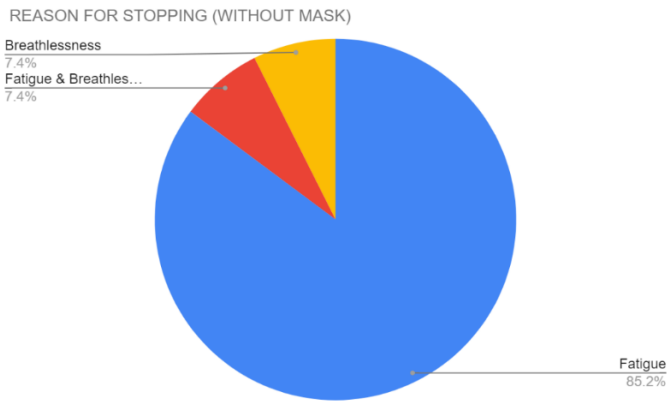

Interpretation: Figure 12 shows that while exercising with mask, 67% subjects completed the protocol, and 33% did not.

TABLE 13: REASON FOR STOPPING THE EXERCISE WHILE EXERCISING WITHOUT MASK

Interpretation: Table 13 shows that 23 subjects stopped because of fatigue, 2 because of breathlessness and 2 because of both fatigue and breathlessness.

| Reason for stopping | Fatigue | Breathlessness | Fatigue & Breathlessness |
|---|---|---|---|
| Without Mask | 23 | 2 | 2 |

FIGURE 13: REPRESENTATION OF REASON FOR STOPPING THE EXERCISE WHILE EXERCISING WITHOUT MASK IN PERCENTAGE



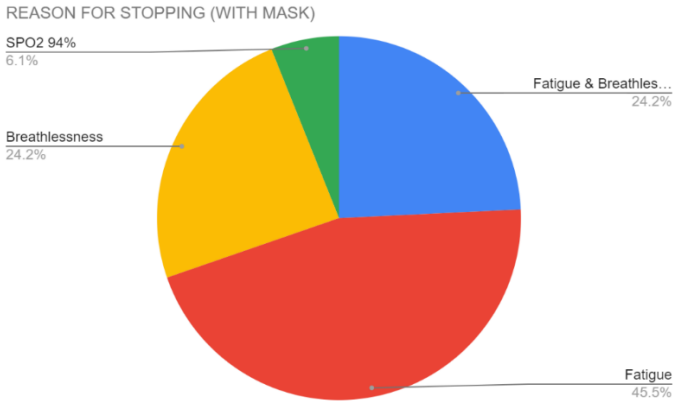
Interpretation: Figure 13 shows that 85.2% subjects stopped because of fatigue, 7.4% because of breathlessness and 7.4% because of both fatigue and breathlessness.

TABLE 14: REASON FOR STOPPING THE EXERCISE WHILE EXERCISING WITH MASK

Interpretation: Table 14 shows that 15 subjects stopped because of fatigue, 8 because of breathlessness, 8 because of both fatigue and breathlessness, and 2 because $SPO_2$ dropped to 94%.

| Reason For Stopping | Fatigue | Breathlessness | Fatigue & Breathlessness | $SPO_2$ 94% |
|---|---|---|---|---|
| With Mask | 15 | 8 | 8 | 2 |

FIGURE 14: REPRESENTATION OF REASON FOR STOPPING THE EXERCISE WHILE EXERCISING WITH MASK IN PERCENTAGE




Interpretation: Figure 14 shows that 45.5% subjects stopped because of fatigue, 24.2% because of breathlessness, 24.2% because of both fatigue and breathlessness, and 6.1% because $SPO_2$ dropped to 94%.

**RESULT & DISCUSSION-**

COVID-19 is known to be transmitted through invisible respiratory droplets that can be carried in the air for a prolong period of time [5]. The physical protection for individuals is necessary to kerb virus transmission, and one common and widely used method is wearing of masks [5].

Participation in some form of physical activity is a core component of maintaining a healthy lifestyle, and routinely exercising in a safe environment is an important strategy for healthy living [1].

In this study, 106 subjects, between the age group 18-25 years were included. They performed exercise on treadmill following Bruce Protocol until exhaustion. The exercise was performed twice by each individual, once without wearing mask and then while wearing cloth mask on two consecutive days. The vitals were monitored throughout the test using pulse oximeter and the pre and post exercise values were noted. The level of exertion was noted through Borg scale of rate of perceived exertion.

The results show that out of 106 participants, 28 participants are male, and 78 participants are female. 7 are 18 years old, 14 participants are 19 years old, 25 participants are 20 years old, 25 participants are 21 years old, 26 participants are 22 years old, 6 participants are 23 years old, 2 participants are 24 years old, and 1 participants are 25 years old.

On comparing the mean of pre and post values of $SPO_2$ while exercising without mask, mean for pre $SPO_2$ is 98±0.6325 %, and for post $SPO_2$ is 97.849±0.7782 %

On statistical analysis, no significant effect was seen (p=0.081).

On comparing the mean of pre and post values of PR while exercising without mask, mean for pre PR is 89.132±12.749 beats/min, and for post PR is 147.169±13.689 beats/min.

On comparing the mean of pre and post values of $SPO_2$ while exercising with mask, mean for pre $SPO_2$ is 97.953±0.6953 %, and for post $SPO_2$ is 97.142±1.099 %

On statistical analysis, a significant effect was seen (p<0.001).

On comparing the mean of pre and post values of PR while exercising with mask, mean for pre PR is 89.028±15.022 beats/min, and for post PR is 152.556±13.756 beats/min.

On comparing the mean values of $SPO_2$ post exercise between exercising without and with mask, a significant difference was seen (p<0.001).

On comparing the mean values of PR post exercise between exercising without and with mask, no significant difference was seen (p=0.0047).

On comparing the mean values of RPE post exercise between exercising without and with mask, the mean for RPE in exercise without mask was 12.443±2.107, while mean with mask on was 14.537±2.306

On statistical analysis, a significant difference was seen (p<0.001).

On comparing the mean for time to exhaustion, the mean without mask was 17.05±1.876 minutes and mean with mask was 16.72±2.287 minutes.

On statistical analysis, no significant change was seen.

While exercising with mask, out of 106, 80 participants completed the protocol and 26 participants did not complete the protocol. 23 participants stated fatigue as a reason for stopping, 2 stopped due to breathlessness and 2 because of both fatigue and breathlessness. While exercising with mask, out of 106, 71 participants completed the protocol and 35 participants did not complete the protocol. 15 participants stated fatigue as a reason for stopping, 8 stopped due to breathlessness, 8 because of both fatigue and breathlessness, and 2 participants stopped because oxygen saturation dropped to 94%.

This concludes that wearing a mask while exercising has a statistically significant effect on $SPO_2$ and RPE.
Though it is statistically significant, clinically, a drop of 1 % cannot be considered significant.
Muscle metabolism highly depends on the uninterrupted $O_2$ supply and $CO_2$ exchange with the atmosphere [7].
During moderate to vigorous intensity exercise, anaerobic metabolism predominates and requires substantial $O_2$ supply after cessation of the activity for the conversion of lactic acid [7].
The face mask forms a closed circuit for the inspired and expired air, though not completely airtight. Rebreathing of the expired air increases arterial $CO_2$ concentrations and increases the intensity of acidity in the acidic environment [7].
Besides, light activity, like walking with a MET value of 2, could increase the amount of inhaled $CO_2$ and decrease the amount of $O_2$ via an N95 mask, increasing the work of breathing. Therefore, we could assume this effect to magnify when performing any aerobic or resistance exercise at a higher workload [7].
The resistance offered to the inspiratory and expiratory flow, for prolonged periods (about 10 mins), could result in respiratory alkalosis, increased lactate levels and early fatigue [7].
Poor saturation of hemoglobin would be anticipated due to increased partial pressure of $CO_2$ at higher exercise intensity [7].
This acidic environment would unload $O_2$ faster at the muscle level, but due to higher heart rate and reduced affinity at the alveolar junction, the partial pressure of $O_2$ would substantially fall, creating a hypoxic environment for all vital organs [7].
In a study done by J. Lässing, et al, in 14 young healthy men to check the effect of surgical face mask on cardiopulmonary parameters during steady state exercise, it was concluded that there is a significant increase in airway resistance, reduced oxygen uptake, and increased heart rate during continuous exercise. But in this study, double incremental exertion test and constant load tests were performed [13].
In a study performed by Simon Driver, et al, on 31 young healthy adults using maximal exercise treadmill testing concluded that face masks led to a 14% reduction in exercise time and 29% decrease in $VO_2$max, attributed to perceived discomfort associated with mask-wearing [14].

**CONCLUSION-**

The study concludes that there is a significant reduction in $SPO_2$ while exercising with mask.
The range of oxygen saturation drop while exercising with mask was within the normal limits (97.953-97.142). The $SPO_2$ of only 2 subjects went below 95%.
Hence, though the results are statistically significant, it may not be clinically significant.

**LIMITATIONS-**

- Small population was included in the study.
- Study included young healthy individuals, so the results may not be valid for other age groups.
- According to Bruce protocol, the grade of inclination should go up to 20%, but due to the unavailability of required resource, the maximum grade of inclination was 15%.

**CLINICAL IMPLICATION-**

While exercising with mask, the drop in oxygen saturation is within the normal limit, but the perceived level of exertion is more while exercising with mask.
If the person is comfortable and it is required to wear mask while exercising, they can continue as there is no clinically significant drop in saturation.
The study was performed in healthy individuals, so the drop in $SPO_2$ is not clinically relevant, but if an individual has some underlying cardiorespiratory condition, the oxygen drop may be a point of concern.

**FUTURE SCOPE OF STUDY-**

- The study can compare difference in $SPO_2$ while exercising wearing mask between male and female.
- The study can be done in all age groups.
- The study can be done on people suffering from cardiorespiratory conditions.

***REFERENCES-***

1. Epstein D, Korytny A, Isenberg Y, Marcusohn E, Zukermann R, Bishop B et al. Return to training in the COVID-19 era: The physiological effects of face masks during exercise. Scandinavian Journal of Medicine & Science in Sports. 2020;31(1):70-75.
2. Brosnahan S, Jonkman A, Kugler M, Munger J, Kaufman D. COVID-19 and Respiratory System Disorders. Arteriosclerosis, Thrombosis, and Vascular Biology. 2020;40(11):2586-2597.
3. Chu D, Duda S, Solo K, Yaacoub S, Schunemann H. Physical Distancing, Face Masks, and Eye Protection to Prevent Person-to-Person Transmission of SARS-CoV-2 and COVID-19: A Systematic Review and Meta-Analysis. Journal of Vascular Surgery. 2020;72(4):1500.
4. Shafaghi A, Rokhsar Talabazar F, Koşar A, Ghorbani M. On the Effect of the Respiratory Droplet Generation Condition on COVID-19 Transmission. Fluids. 2020;5(3):113.
5. Wang Y, Deng Z, Shi D. How effective is a mask in preventing COVID-19 infection?. MEDICAL DEVICES & SENSORS. 2021;4(1).
6. Shaw K, Butcher S, Ko J, Zello G, Chilibeck P. Wearing of Cloth or Disposable Surgical Face Masks has no Effect on Vigorous Exercise Performance in Healthy Individuals. International Journal of Environmental Research and Public Health. 2020;17(21):8110.
7. Chandrasekaran B, Fernandes S. “Exercise with facemask; Are we handling a devil's sword?” – A physiological hypothesis. Medical Hypotheses. 2020;144:110002.
8. CDC. Science brief: Community use of masks to control the spread of SARS-CoV-2 [Internet]. Centers for Disease Control and Prevention. 2022 [cited 2022 May 22].

9. Abboah-Offei M, Salifu Y, Adewale B, Bayuo J, Ofosu-Poku R, Opare-Lokko E. A rapid review of the use of face mask in preventing the spread of COVID-19. International Journal of Nursing Studies Advances. 2021;3:100013.
10. WHO. Coronavirus disease (COVID-19): Masks [Internet]. www.who.int.
11. Blocken B, Malizia F, Van Druenen T, Marchal T. Towards aerodynamically equivalent COVID19 1.5 m social distancing for walking and running [Internet]. 2020.
12. Jones N, Qureshi Z, Temple R, Larwood J, Greenhalgh T, Bourouiba L. Two metres or one: what is the evidence for physical distancing in covid-19?. BMJ. 2020;:m3223.
13. Lässing J, Falz R, Pökel C, Fikenzer S, Laufs U, Schulze A et al. Effects of surgical face masks on cardiopulmonary parameters during steady state exercise. Scientific Reports. 2020;10(1).
14. Driver S, Reynolds M, Brown K, Vingren J, Hill D, Bennett M et al. Effects of wearing a cloth face mask on performance, physiological and perceptual responses during a graded treadmill running exercise test. British Journal of Sports Medicine. 2021;56(2):107-113.
15. Chan N, Li K, Hirsh J. Peripheral Oxygen Saturation in Older Persons Wearing Nonmedical Face Masks in Community Settings. JAMA. 2020;324(22):2323.
16. Person E, Lemercier C, Royer A, Reychler G. Effet du port d'un masque de soins lors d'un test de marche de six minutes chez des sujets sains. Revue des Maladies Respiratoires. 2018;35(3):264-268.
17. Smith R, Hofmeyr R. Perioperative comparison of the agreement between a portable fingertip pulse oximeter v. a conventional bedside pulse oximeter in adult patients (COMFORT trial). South African Medical Journal. 2019;109(3):154.
18. Ahrens T, Tucker K. Pulse Oximetry. Critical Care Nursing Clinics of North America. 1999;11(1):87-98.
19. Cunha JP. What Is a Good Oxygen Rate by Age? Causes, Symptoms & Chart [Internet]. eMedicineHealth. 2021
20. Kim T. T test as a parametric statistic. Korean Journal of Anesthesiology. 2015;68(6):540.
21. Harris GD. Exercise testing special protocols. In: Exercise Stress Testing for Primary Care and Sports Medicine. New York, NY: Springer New York; 2009. p. 45–54