EFFECTS OF N-95 VS SURGICAL VS NO MASK ON CARDIOPULMONARY

EXERCISE CAPACITY IN HEALTHY VOLUNTEERS.

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ABSTRACT:

Introduction: The aim of the this randomized crossover trial was to study the effect of N-95 vs. surgical vs. no mask on cardiopulmonary exercise capacity in healthy adults. **Methods:** 80 healthy male and female volunteers between the age of 18 to 25 years were recruited for the study. Outcome measures like Heart Rate (HR), SpO2, Blood Pressure (BP), Respiratory Rate (RR), and VO2max were used. Queens College Step Test (QCST) was performed to assess the cardiopulmonary exercise capacity. Each subject performed the test thrice, one with "no mask", one with "3 ply surgical mask" and one with "N-95 mask". **Result:** Immediately post QCST, significant increase was seen in HR (bpm) in N-95 vs. surgical mask: 115 ± 5.8 vs. 108 ± 3.2 (p <0.0001); surgical vs. no mask: 108 ± 3.2 vs. 103 ± 2.9 (p <0.0001) and N-95 vs. no mask: 115 ± 5.8 vs. 103 ± 2.9 (p <0.0001) respectively. Systolic BP (mmHg) showed statistically significant increase in N-95 vs. surgical: 150 ± 5.6 vs. 145 ± 5.6 (p <0.0001); N-95 vs. no mask: 150 ± 5.6 vs. 137 ± 6.2 (p <0.0001) and surgical vs. no mask: 145 ± 5.6 vs. 137 ± 6.2 (p <0.0001), RR (breaths/min) also showed statistically significant increase in N-95 vs. surgical: $40+/-1.8$ vs. $35+/-1.8$ (p <0.0016); N-95 vs. no mask: 40 ± 1.8 vs. 28 ± 1.2 (p <0.0001) and surgical vs. no mask: 35 ± 1.8 vs. 28 ± 1.2 (p <0.0001). VO_2max (ml/kg/min) also was showed statistically significant reduction N-95 vs. surgical: $32+/-5.6$ vs. $37+/-6.2$ (p <0.0001); N-95 vs. no mask: 32 ± 5.6 vs. 40 ± 5.9 (p <0.0001) and surgical vs. no mask: 37 ± 6.2 vs. 40 ± 5.9 (p <0.0001) respectively. **Conclusion:** N-95 and surgical facemasks have shown a negative impact on HR, Systolic BP, RR, VO_2max parameters in healthy young subjects during the QCST when compared to no mask.

KEYWORDS: N-95 mask, surgical mask, cardiopulmonary exercise capacity, VO_2max

INTRODUCTION

Following the emergence of SARS-COVID-19 pandemic, along with social distancing using facemasks are amongst the most crucial precautions to take in order to stop the spread of COVID-19.[1] Different factors like the type of mask, the intensity of the activity and the environment will have an effect on the individual. N-95 face masks are thought to be more effective than surgical masks at reducing exposure to viral infections because they firmly fit the wearer's face and are particularly good at filtering small airborne particles. [2] However it has been shown that prolonged and continuous use of mask can have a significantly negative impact on the cardiopulmonary function such as increase in the airway resistance, hypoxia, carbon dioxide retention, increased heart load, insufficient coronary perfusion and increased anaerobic metabolism to state a few.[2,3] K Albouaini states that when engaging in everyday low-intensity activities, face masks were largely safe to use. [4] However, previous research also indicated that masks may reduce exercise tolerance. [5,6]

Uncertainty exists regarding the effect of different types of masks on cardiopulmonary exercise capacity during exercise. As people still need to wear masks for extended periods of time during the on-going pandemic, as N-95 mask and 3 ply mask are the most common masks used, this randomized crossover trial aims to study the effect of N-95 vs. surgical vs. no mask on cardiopulmonary exercise capacity in healthy adults.

Material & Method:

This study included 80 healthy male and female volunteers between the age of 18 to 25 years. Institutional Ethical Clearance was obtained. Subjects failing to pass the IPARQ questionnaire and with professional sports experience were excluded from the study. Demographic details like name, age, gender, weight, BMI were gathered using the subject record sheet. Outcome measures like heart rate (HR), Oxygen saturation (SpO2), Blood pressure (BP), Respiratory Rate (RR) and VO_2max were used. Queens College Step test (QCST) was performed with a metronome using a step stool of 16.25 inches in order to assess the cardiopulmonary exercise capacity. Each subject performed the test thrice, one with "no mask", one with "3 ply surgical mask" and one with "N95 mask". All the participants wore the same brand of 3 ply surgical and N-95 mask. The order was randomly assigned using the SPSS tool. The metronome was set at a fixed rate of 22 steps per minute for women and 24 steps per minute for men. At the end VO2 max was calculated using formula for Indian population:

·   For women- 65.81-(0.1847*PR per min)

·   For men- 111.33-(0.42*PR per min)

A one-day washout period was given between tests.

All the data was analyzed using SPSS 22 for windows. Descriptive statistics was calculated for the entire demographic data along with all the parameters. Normality Testing was performed using Kolmogorov Smirnov test, data was found to be normally distributed. The data were expressed as means and standard deviations. 3-way Anova was used to compare between N-95, surgical and no mask groups and Paired-t test was used to compare within the groups. P value of <0.05 was considered statistically significant.

RESULT:

40 males and 40 females were recruited in the study. Baseline characteristics of subjects are shown in table 1. Mean age was 22.9 ± 0.9 years for male and 22.42 ± 0.8 years for females. The average BMI was 21.09 ± 1.61 kg/m^2 for males and 21.08 ± 0.8 kg/m^2 for females. Parameters of QCST in individuals wearing N-95 mask, surgical mask and no mask groups at rest and immediately post-test are shown in Table 2. Immediately post QCST, significant increase was seen in HR (bpm) in N-95 vs. surgical mask: 115 ± 5.8 vs. 108 ± 3.2 (p <0.0001); surgical vs. no mask: 108 ± 3.2 vs. 103 ± 2.9 (p <0.0001) and N-95 vs. no mask: 115 ± 5.8 vs. 103 ± 2.9 (p <0.0001) respectively. SpO2 (%) did not show any statistical significant reduction in N-95 vs. no mask (p <0.967), surgical vs. no mask: (p <0.823) and N-95 vs. surgical mask (p <0.142) respectively. Systolic BP (mmHg) showed statistically significant increase in N-95 vs. surgical: 150 ± 5.6 vs. 145 ± 5.6 (p <0.0001); N-95 vs. no mask: 150 ± 5.6 vs. 137 ± 6.2 (p <0.0001) and surgical vs. no mask: 145 ± 5.6 vs. 137 ± 6.2 (p <0.0001), however diastolic BP (mmHg) findings were not statistically significant in N-95 vs. no mask (p <0.189) and surgical vs. no mask (p <0.128) and N-95 vs. surgical mask (p <0.1189). RR (breaths/min) also showed statistically significant increase in N-95 vs. surgical: $40+/-1.8$ vs. $35+/-1.8$ (p <0.0016); N-95 vs. no mask: 40 ± 1.8 vs. 28 ± 1.2 (p <0.0001) and surgical vs. no mask: 35 ± 1.8 vs. 28 ± 1.2 (p <0.0001). VO_2 *max* (ml/kg/min) also was showed statistically significant reduction in all the three groups. In N-95 vs. surgical: $32+/-5.6$ vs. $37+/-6.2$ (p <0.0001); N-95 vs. no mask: 32 ± 5.6 vs. 40 ± 5.9 (p <0.0001) and surgical vs. no mask: 37 ± 6.2 vs. 40 ± 5.9 (p <0.0001) respectively.

Table 1: Baseline characteristics

Demographic Data (Mean ± SD)	Males	Females
Age (years)	22.9± 0.9	22.42 ± 0.8
Height (cm)	1.71 ± 0.1	1.62± 0.1
Weight (kg)	62.2± 5.3	56.0± 5.2
BMI (kg/m^2)	21.09± 1.61	21.08± 0.8
Heart Rate (bpm)	75.5±3.5	78.3 ±3.8
Systolic Blood Pressure (mmHg)	116.7±5.9	117.4±6.4
Diastolic Blood Pressure (mmHg)	79.3±3.9	78.8±3.2

Table 2: Parameters of Queens Step Test in N-95 mask, surgical mask and no mask groups

Parameters	N-95	Surgical Mask	No mask	P value	N-95 vs. Surgical mask	N-95 vs. No mask	Surgical mask vs. No mask
At rest							
HR (bpm)	75±3.8	75±3.4	75±3.4	1.000	1.000	1.000	1.000
Systolic BP (mmHg)	121±5.6	120±5.6	117±5.9	0.943	0.378	0.982	0.423
Diastolic BP (mmHg)	79±3.7	79±3.4	79±3.6	0.948	0.736	0.846	0.924
RR (breaths/min)	21±1.3	20±0.9	16±1.2	0.399	0.474	**0.0001**	**0.0001**

Immediately Post Test							
HR (bpm)	115±5.8	108±3.2	103±2.9	**0.0001**	**0.0001**	**0.0001**	**0.0001**
SpO2 (%)	96±2	96±1	98±1	0.876	0.142	0.967	0.823
Systolic BP (mmHg)	150±5.6	145±5.6	137±6.2	**0.0001**	**0.0001**	**0.0001**	**0.0001**
Diastolic BP (mmHg)	84±3.3	83±3.3	82±3.3	0.772	0.189	0.128	0.945
RR (breaths/min)	40±1.8	35±1.8	28±1.2	**0.0001**	**0.0016**	**0.0001**	**0.0001**
VO$_2$max (ml/kg/min)	32±5.6	37±6.2	40±5.9	**0.0001**	**0.0001**	**0.0001**	**0.0001**

DISCUSSION:

This study was undertaken to compare the effects of N-95 vs. surgical vs. no mask on the cardiopulmonary exercise capacity in healthy volunteers. Both N-95 and surgical masks have shown statistically significant changes in HR, systolic BP, RR, VO$_2$max exercise parameters when compared to no mask group. Study done by Shein et al found an increase in HR when compared with surgical mask and no mask in healthy young adults.[6] Lässing et al also reported similar findings following 30 min cycling at 50% max load.[7] Similar effects were observed in our study. After wearing masks, the airway resistance increases thus creating a negative intra-thoracic pressure increasing cardiac preload [8] along with increase in cardiac afterload due to increase in trans-mural left ventricular pressure resulting in compensatory increase in HR.[9]

Driver S et al in a randomized controlled trial of healthy adults performing maximal cardiopulmonary exercise test on a treadmill following the Bruce protocol with and without a cloth face mask found that SpO2 reduced by 2%; however the finding was not clinically significant.[10] Chen et al. also found that wearing either a surgical mask or N-95 was associated with increased respiratory muscle effort however there was no difference in SpO2 value in either of the groups.[11] Our study also demonstrates similar findings in healthy

volunteers performing QCST. Although in our study, SpO2 was not significantly different between groups, there was an overall decrease at the end of QCST when compared to baseline SpO2; however it remained within normal limits. It is also important to note that in individuals with COPD, Kyung et al found SpO2 levels were lower when wearing an N95 mask compared to a no mask condition. [12]

Umutlu et al conducted Cardiopulmonary exercise test along with walk test on 14 sedentary volunteers showing significant increase in both systolic BP and diastolic BP after wearing masks ($p < 0.01$). [13] Another randomized crossover study in 17 healthy men and 8 healthy women who underwent a submaximal cycling test with surgical and no mask done by Boldrini et al found increased BP with surgical mask group. [14] Our study also showed significant increase in systolic BP. This can be attributed to significant increase in blood flow to the myocardium during exercise along with excitation of the sympathetic nerve leading to the enhancement of cardiac systolic function, increase of stroke volume, HR, cardiac output and BP. [8] However in this study we did not find any statistically significant difference in diastolic BP. As stated by David R, after submaximal exercise testing, the vascular conductance increases enhancing the capacity for vasodilation resulting in greater outflow of blood from the arterial compartment to the venous compartment during diastole. [15] This may be part of the explanation for why diastolic pressures remained almost the same despite wearing a mask or not.

This study showed statistically significant increase in RR in N-95 vs. surgical vs. no mask group. Different types of masks offer different respiratory resistance, leading to larger dead space and greater influence on the ventilatory function along with ventilation efficiency. [16] Previous studies found that the use of N-95 respirators leads to a mean increment of 126% and 122% in inspiratory and expiratory flow resistances respectively as well as an average 37% decrease in the volume of air exchange in the N95 masks. [17] The increase of respiratory resistance after wearing masks would increase the work done by respiratory muscles and affecting the gas exchange and ventilation efficiency thus increasing RR as seen in our study.

Fikenzer et al. tested the effect N-95 and surgical mask during progressive cycle ergometer stress test in 12 healthy men using a metabolic testing mask on top of the facemask. They observed a reduction of the VO_2 max of 13% with the more fitted N-95 mask and a reduction of only 4% with the surgical mask however latter difference did not reach statistical significance (p= 0.063). [2] However Driver et al in their study found that cloth face masks lead to a 29% decrease in VO_2max ($p < 0.001$). [10] The increase of respiratory resistance

decreases the concentration of inhaled oxygen causing the respiratory muscles to do extra work and increased oxygen consumption, along with the heat and humidity of the mask during exercise resulting in decrease in VO_2max. [18,19]

CONCLUSION

Both N-95 and surgical facemasks have shown a negative impact on HR, Systolic BP, RR, VO_2max parameters in healthy young subjects during the QCST when compared to no mask. However, no significant difference was found in SpO2, Diastolic BP regardless of mask condition. These results provide an important recommendation for wearing different masks while performing exercises of varying intensity during the ongoing pandemic. However more future studies should focus on exploring the effect of different masks in subjects with cardiopulmonary disease conditions. These data are important for recommendations on wearing facemasks at work or during physical exercise.

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