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Aerobic Capacity with the Use of N95 Mask vs Cloth Mask in Normal Healthy Individuals using YMCA 3-Minute Bench Step Test: A Crossover Observational Study

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ABSTRACT

Background: COVID-19 outbreak has led to severe restrictions and to minimize the risk of infection, wearing facemasks is recommended in public areas and can be problem while performing exercises, causing inconvenience for people. The studies done till now require space, equipments and are costly but no study has been conducted on step test which requires less space and is inexpensive. Hence, it is yet to be investigated whether there is any effect on Aerobic Capacity and Cardiorespiratory parameters of an individual after wearing N95 and Cloth mask.
Aim: This study was conducted to compare Aerobic Capacity in Normal Healthy Individuals using YMCA 3-Minute Bench Step Test while wearing N95, Cloth and no mask.
Methods: A crossover observational study design, involving 50 normal healthy participants (21-30 yrs old) from Physiotherapy OPD and Tertiary Health Care were called 3 times with 3 days of washout period in between the test and was asked to perform the test with N95, Cloth and without mask. The outcome measures like BP, HR, RR, SPO2, RPE, VO2max were assessed pre and post the test.
Results: This study revealed that when compared within the group, all 3 groups were found to have highly significance in BP, HR, RR, SPO2, RPE with P value<0.0001. In between the group comparison, there was statistical significance on RPE, HR, RR and VO2max in N95 as compared with cloth and no mask p value<0.001, whereas there is no significant difference on BP and SPO2 with p value>0.05.
Conclusion: There is reduction in VO2max and increase in HR, RR, RPE in N95 mask more as compared to Cloth mask.

Keywords: N95, Cloth, Mask, Step test, Aerobic Capacity, Cardiorespiratory Parameters.

INTRODUCTION

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), the novel coronavirus responsible for coronavirus disease (COVID-19), has infected millions of individuals worldwide, resulting in over two million deaths. There is evidence for airborne transmission via both droplets and aerosols that contact mucosal surfaces and are inhaled directly into the upper airway, potentially infecting many people.[1,2] Vaccines are available now, but as a non-

pharmacological interventions like social distancing, intensified hand hygiene and wearing of face masks are used to minimize the risk of transmission.[3,4] With the severity of the global pandemic increasing, on April 3,2020, the Centers for Disease Control and Prevention (CDC) in the United States recommended that individuals wear a face mask in public if they cannot distance at least six feet from others, to help prevent the transmission of COVID-19.[5,6,7]

Resistance to airflow is a key element of face-mask function, as it reduces forward particle velocity and, potentially, the risk of infection among people in the vicinity of an infected individual.[5,8] The Centers for Disease Control and Prevention (CDC) and World Health Organization (WHO) recommend wearing N95 masks for highly transmissible diseases like tuberculosis, SARS, and COVID-19. The N in N95 stands for NIOSH, the National Institute for Occupational Safety and Health of the United States and 95 indicates filter efficiency of particles. Thus, an N95 mask is 95% effective at filtering airborne particles including very small ones.[9,10] Cloth face masks appear to be the most common type of mask used by general public.(33) Various homemade fabric mask like cotton, silk, chiffon, flannel, various synthetics and their combinations can be used if there is scarcity of N95 mask and Surgical mask.[35] Cotton, the most widely used material for cloth masks performs better at higher weave densities (i.e., thread count) and can make significant difference in filtration efficiencies and thus provides protection against the transmission of aerosol particles.[35] Cloth mask can be reused after being decontaminated with various techniques.[34]

Workers in many professions not previously accustomed to mask use were suddenly expected to work while wearing masks. This includes grocery store and foodservice workers, bartenders, teachers, childcare providers and labourers, among others. This has led to numerous concerns, with masks being perceived as uncomfortable, cumbersome, a nuisance, or inconvenient. It has even resulted in worries that extended mask use might be unhealthy or dangerous.[7] Wearing masks for a prolonged amount of time causes a host of physiologic and psychologic burdens and can decrease work efficiency. Activity cannot be performed as long or as efficiently while wearing masks as compared to when masks are not worn. Prolonged use of N95 and surgical masks causes physical adverse effects such as headaches, difficulty breathing, acne, skin breakdown, rashes, and impaired cognition. It also interferes with vision, communication, and thermal equilibrium.

Potentially negative effects of face masks are believed to be exacerbated by exercise, face masks are not universally required during exercise, even in indoor environments as gyms and fitness centres, where the risk of a superspreading event increases.[5] People avoid wearing mask because breathing dampens the mask. If there is excessive moisture, the masks become airtight. Therefore, air is inhaled and exhaled unfiltered around the edges, losing the protective effect for both the wearer and the environment.[30] Wearing face masks during vigorous exercise might, therefore, be important for the prevention of spread of infectious respiratory droplets; however, the ability to exercise vigorously while wearing a face mask is a concern.[12]

Inadequate physical activity is responsible for about one third of deaths due to coronary heart disease, diabetes and colon cancer. Rising level of obesity is also contributing to these diseases.[27] To prevent these diseases, exercise will benefit in improving cardiovascular health, increases lung capacity and muscle strength, and improves mental health as well.[29] Exercise is effective for the prevention of obesity, diabetes, and hypertension, all of which are leading risk factors for complications if one contracts COVID-19.[13,14,15,16] To maintain a healthy lifestyle, it is important to measure and analyze one's physical fitness.[27] It is therefore important to determine if vigorous

exercise is compromised while wearing face masks in order to make exercise prescription recommendations. There are mixed results as to whether wearing a face mask impairs exercise performance. [13]

Cardiorespiratory Fitness is a fundamental component of physical fitness.[25] Cardiorespiratory fitness refers to the capacity of the circulatory and respiratory systems to supply oxygen to skeletal muscle mitochondria for energy production needed during physical activity.[26] Maximal Oxygen uptake (VO2max) is the gold standard for quantifying Cardiorespiratory Fitness.[25] It is a primary indicator of aerobic fitness, cardiovascular health, and endurance performance.[28] Maximum Oxygen Consumption (VO_{2max}) is the maximum amount of oxygen an individual can breathe in and utilize it to produce energy ie, ATP aerobically. VO_{2max} has been successfully employed in a number of fitness test.[27]

The Cardiopulmonary Exercise Test (CPET) is a recognized and standard method for assessing cardiopulmonary health. Thus provides assessment of integrative exercise responses involving the pulmonary, cardiovascular, and skeletal muscle systems.[18,19] It describes the maximal achievable level of oxidative metabolism involving large muscle groups.[20] CPET is increasingly used to assess undiagnosed exercise tolerance, exercise related symptoms, and is uniquely suited to objectively determine functional capacity and impairment.[21]

However, exhaustive CPET may not be acceptable to older individuals, in whom upto 50% may be unable or unwilling to undertake maximal exercise testing. Moreover, in older adults achievement on these testing protocols may not represent real-life functionality and exercise to exhaustion is often not achieved. Systematic Reviews and recent studies have shown that submaximal exercise tests (treadmill, cycle, step and squat tests) to predict VO_2 peak in apparently healthy adults are moderately to highly accurate.[24] Submaximal exercise testing is widely used and can be increasingly promoted in low-resource settings.[24] Submaximal exercise testing is a valuable alternative, valid, safe and highly practical approach for assessing changes in VO_2 peak.[22,24] Since the use of large equipment such as a cycle ergometer and treadmill could be difficult for field tests, various step tests have been developed and used as a surrogate method to estimate maximal oxygen consumption (VO_{2max}). There are different types of step tests: Incremental multi-stage and single-stage step tests. In incremental step tests, either the step box height or stepping rate is increased in an incremental manner, and various responses of participants during and after exercise are used to estimate VO_{2max}. Although incremental step tests consider more variables such as heart rate responses, stepping rate or step height reached, and rate of perceived exertion (RPE) which is related to the participants' aerobic capacity, incremental step tests generally take a longer duration and elicit more physical stress. Conversely, single-stage step tests mostly take a shorter duration and also only use heart rate recovery to estimate VO_{2max}. Among single-stage step tests, the Tecumseh step test, YMCA 3-min step test have been used widely.[26]

Submaximal Step Tests provide a safe, simple and ecologically valid means of assessing VO_2max in the general population.[23] Step tests require minimal equipment, no calibration, are easy to administer in limited spaces and for large number of people and can be administered by personnel with little or no formal training in exercise physiology, which make them a suitable alternative to CPETs to estimate Cardiorespiratory Fitness. It is suitable for testing in group settings simultaneously.[26,28] It is widely used field test for estimating VO_{2max}.[28]

Step Test is an inexpensive modality for predicting cardiorespiratory fitness by measuring the HR response to stepping at a fixed rate and/or a fixed step height or by measuring post exercise recovery HR. [27] In

this study, we will be using YMCA 3-Minute Bench Step Test. It is a Submaximal Step test.[26] It is a valid test to calculate VO2max. [26] The height of the step box is 30cm.[26]

The purpose of this study is to determine if the subjects can exercise safely and thus can adjust their exercise training while following the current recommendations of wearing a mask in public. Therefore, this research will be helpful to elucidate the precise use of N95 mask and Cloth mask on Aerobic Capacity in Normal Healthy Individuals using Submaximal Step Test. The aim of this study is to compare Aerobic Capacity in Normal Healthy Individuals using YMCA 3-Minute Bench Step Test while wearing N95 mask, Cloth mask and no mask. The primary objective is to assess use of N95 mask/Cloth mask/No mask on Maximum Aerobic Capacity (VO_{2max}) in Normal Healthy Individuals using YMCA 3-Minute Bench Step Test and then comparing the difference between these 3 groups. The secondary objectives are to assess use of N95 mask/Cloth mask/No mask on Cardiorespiratory parameters (Heart rate using palpatory method of Radial pulse, Blood Pressure using Sphygmomanometer, Respiratory Rate by Observation, Oxygen Saturation using Pulse Oximeter, RPE using Borg scale) in Normal Healthy Individuals using YMCA 3-Minute Bench Step Test and then comparing the difference between these groups.

MATERIALS & METHODS

Mask:

a) N95- White colour three layered mask with 2 elastic red head band and noseclip; non woven material, free size (NIOSH Certified) -Magnum Company. [Figure 1]

Figure 1

b) Cloth – Green colour single layer mask with 2 elastic ear band, pure cotton material, length x width (17.5cm x16cm). [Figure 2]

Figure 2

Pulse Oximeter, BP Apparatus, stepper-30cm height, Stethoscope, Metronome, Chair, Water bottle, Napkin, Screening Form, Consent Form, Participant Information Sheet, Pen, Stopwatch were used. The study was a crossover observational study conducted at K. J. Somaiya Hospital and Medical college and also at K. J. Somaiya College of Physiotherapy OPD. Normal Healthy Individuals in the age group (21-30 years old) [26], both male and female were included and who were willing to participate in study. Convenient sampling method was used and sample size was 50. The outcome measures used in the study were VO2max, BP, HR, RR, SPO2, RPE. Participants who have had Surgical condition/ Medical condition (DM/ Respiratory/Cardiac) that would interfere with the ability to exercise, Pregnant women, BMI > 24.9 kg/m^2,

Neurological conditions (balance issues, gait abnormalities), Orthopaedic conditions affecting the subject's ability to perform step test were excluded.

Ethical clearance was obtained from institutional sub-ethical committee of K. J. Somaiya Hospital. All precautions pertaining to COVID-19 were followed and required permissions were sought from the concerned authorities. Written informed consent was obtained from subjects. Subjects who had fulfilled the inclusion criteria were included in the study. All the participants were informed about test procedure, method of testing and instructions on how to perform test was given. While performing the test if subject experiences cramps, requests to stop, severe fatigue (if RPE reaches above 15) was used to terminate the test.[27] All participants were tested in comfortable, quiet and calm environment. The participants were asked to refrain from strenuous exercise for 24 h, drinking alcohol and caffeine for 4 h and eating or drinking (except water) for 2 h before the test. Pre evaluation was taken and participants were asked to rest for atleast five minutes and measured basal parameters (BP, HR, RR, SPO_2, RPE). Each participant was called for three times with 3 days of washout period in between to perform the test. Each participant was asked to perform YMCA 3-Minute Bench Step Test with N95 Mask, with Cloth Mask and without Mask. The sequence was decided by chit picking method. Post Parameters were taken (BP, HR, RR, SPO_2, RPE) and VO_{2max} was calculated.

TEST PROCEDURE:

YMCA 3-MINUTE BENCH STEP TEST: This test was performed for 3 minutes. The height of the step box was 30cm. Participants were instructed to step up and down on a step box 72 times in 3 minutes (step up-up-down-down). Stepping rate was synchronized to a metronome set at 96 beats per minute (4 clicks = one step cycle) for stepping rate of 24 steps per minute. After 3 minutes of stepping, participants immediately sat down in a chair while heart rate recovery was monitored for 1 minute. [25,26] VO_{2max} was calculated using an equation which is valid.[26]

VO_{2max}:

Male: $84.5 – (10.2 \times 1) - (0.4 \times age) – (0.1 \times weight) – (0.1 \times HRR_{30s})$

Female: $84.5 – (10.2 \times 2) – (0.4 \times age) – (0.1 \times weight) – (0.1 \times HRR_{30s})$

HRR_{30s}-(Heart rate recovery at 30 sec after cessation) [26]

Down **Up** **Up** **Down**

Figure 3- YMCA-3 Minute bench step test- N95 Mask

Down **Up** **Up** **Down**

Figure 4- YMCA 3-minute Bench step test- Cloth Mask

Data was collected after which it was tested statistically to draw a conclusion.

STATISTICAL ANALYSIS

Data of 50 samples was collected and recorded in the Excel 2016 spreadsheet and was analysed using GraphPad InStat Software (version 3). Qualitative variables were expressed as absolute number and percentage, and the Quantitative variables were expressed as mean and standard deviation. Shapiro-Wilk test was used to analyse t normality of the data. Since the data has not passed the normality, Wilcoxon signed rank test was used within the group and Friedman's test was used for intergroup comparisons.

DATA ANALYSIS AND INTERPRETATION

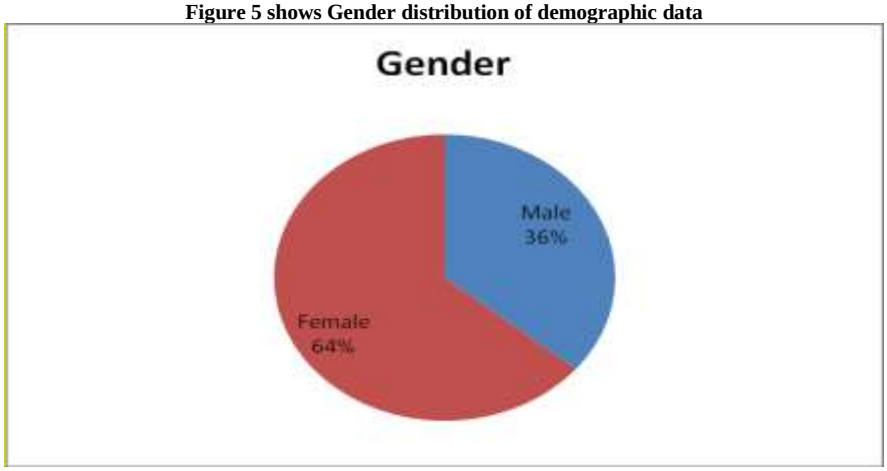
Table:1 Descriptive Statistics for Age Distribution

Age (Years)	Study Group
Minimum	21.0
Maximum	30.0
Median	24.0
Mean	24.26
Standard Deviation	2.664

Table 2- Gender Distribution

Gender	No. of Participants	Percentage
Females	32	64%
Males	18	36%
Total	50	100

Figure 5 shows Gender distribution of demographic data

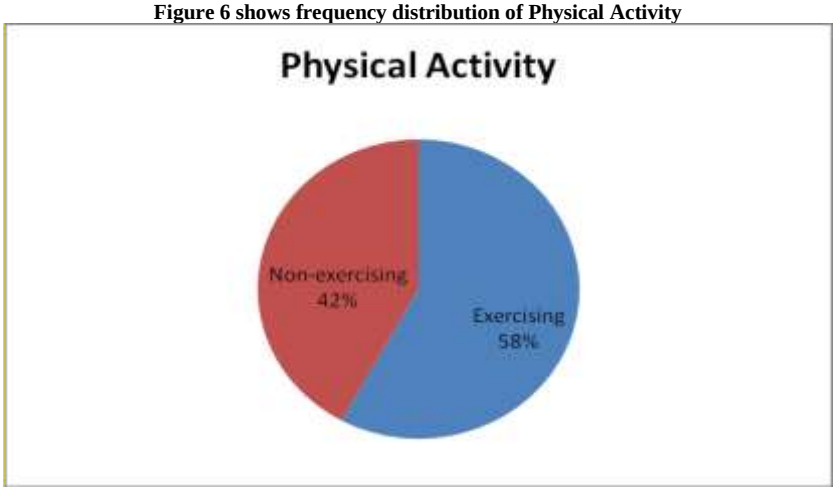


Interpretation: Out of the total samples collected, female patients participated in study were 64% and male patients were 36%.

Table: 3 – Physical Activity

	No. of Participants	Percentage
Exercising	29	58%
Non-Exercising	21	42%

Figure 6 shows frequency distribution of Physical Activity



Interpretation: Out of the total samples collected, non-exercising individuals were 42% whereas exercising individuals were 58%.

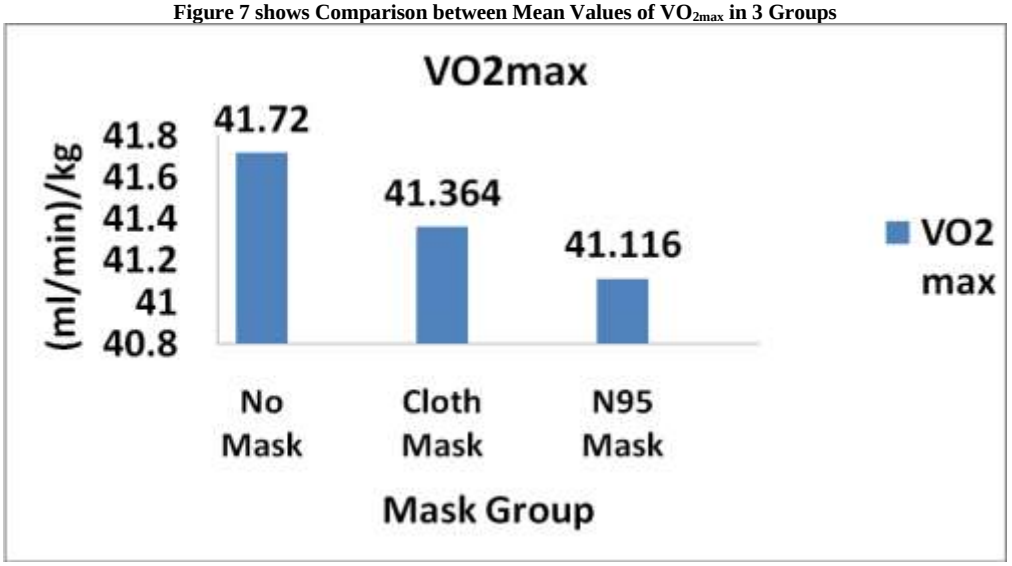
Table:4- Descriptive Statistics of Parameters

		No Mask	Cloth Mask	N95 Mask
VO_{2max} (ml/min)/kg	Mean	41.72	41.36	41.11
	Standard Deviation	±5.02	±4.92	±4.92
	Minimum	35.7	35.4	35.1
	Maximum	49.77	49.17	48.97
SBP (mm of Hg)	Mean	6.2	8.12	8.56
	Standard Deviation	±0.72	±1.02	±0.99
	Minimum	4	6	8
	Maximum	8	12	12
DBP (mm of Hg)	Mean	5.72	6.20	6.26
	Standard Deviation	±0.99	±0.78	±0.82
	Minimum	2	4	4
	Maximum	6	8	8
HRR (beats/min)	Mean	30.18	33.86	36.22
	Standard Deviation	±3.51	±3.56	±3.51
	Minimum	24	28	31
	Maximum	38	42	46
		No Mask	Cloth Mask	N95 Mask
RR (breaths/min)	Mean	6.68	9.64	12.5
	Standard Deviation	±1.51	±2.02	±1.91
	Minimum	2	6	8
	Maximum	10	15	17
SPO_2 (%)	Mean	0.16	0.16	0.24
	Standard Deviation	±0.37	±0.37	±0.47
	Minimum	0	0	0
	Maximum	1	1	2
RPE	Mean	3.28	5.32	7.1
	Standard Deviation	±1.72	±1.50	±1.09
	Minimum	1	3	5
	Maximum	7	9	10

Table 5: Comparison of Cardiovascular parameters within the group.

	No Mask		Cloth Mask		N95 Mask		P value (Within the group)	Significance
	Pre	Post	Pre	Post	Pre	Post		
SBP	115.84	122.04	115.68	123.8	116.2	124.76	<0.0001	Highly Significant
DBP	75.32	81.04	75.48	81.00	75.68	81.94	<0.0001	Highly Significant
HRR	74.72	104.9	74.68	108.54	74.8	111.02	<0.0001	Highly Significant
RR	16.28	22.96	16.28	25.92	16.28	28.78	<0.0001	Highly Significant
SPO2	99.02	98.86	99.02	98.86	99.02	98.78	<0.0001	Highly Significant
RPE	6	9.28	6	11.32	6	13.1	<0.0001	Highly Significant

Figure 7 shows Comparison between Mean Values of VO_{2max} in 3 Groups



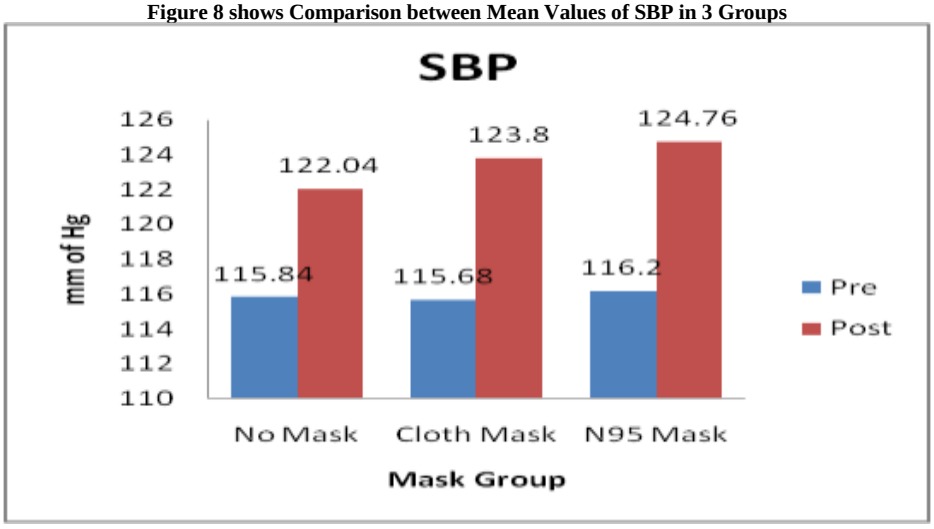
Post Hoc test: Dunn's Multiple Comparisons Test
If the difference between rank sum means is greater than 23.948 then the P value is less than 0.05.

Table 6- Aerobic Capacity in between the group comparison

Rank Sum			
Comparison	**Difference**	**Pvalue**	**Significance**
NM vs. C	51.000	P<0.001	Significant
NM vs. N95	99.000	P<0.001	Significant
C vs. N95	48.000	P<0.001	Significant

Interpretation: There is statistically significant difference between the 3 groups on VO_{2max} as shown in Figure 7 and table 6.

Figure 8 shows Comparison between Mean Values of SBP in 3 Groups



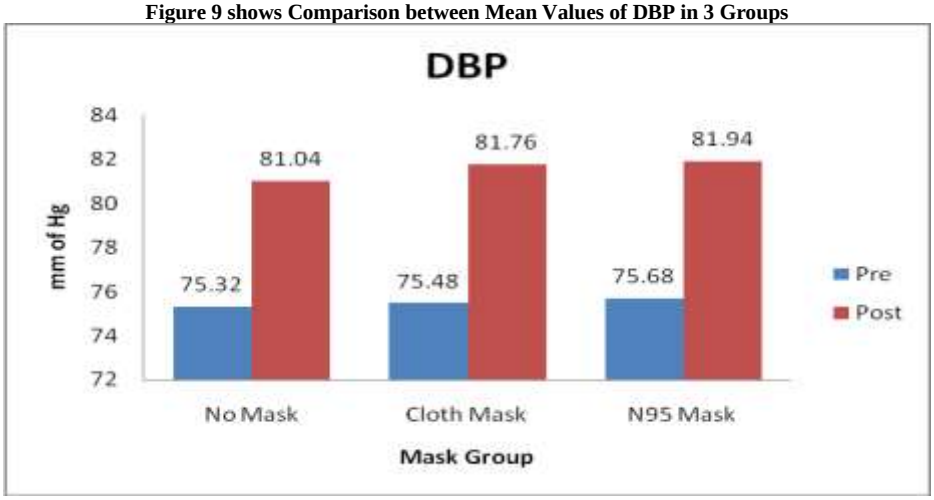
Post Hoc test: Dunn's Multiple Comparisons Test
If the difference between rank sum means is greater than 23.948 then the P value is less than 0.05.

Table 7- SBP in between the group comparison

Rank Sum			
Comparison	**Difference**	**Pvalue**	**Significance**
NM vs. C	-63.000	<0.001	Significant
NM vs. N95	-76.500	<0.001	Significant
C vs. N95	-13.500	P>0.05	Not Significant

Interpretation: There is a significant difference between NM vs C and NM vs N95 on SBP, whereas in C vs N95, there is no significant difference statistically as shown in Figure 8 and table 7.

Figure 9 shows Comparison between Mean Values of DBP in 3 Groups



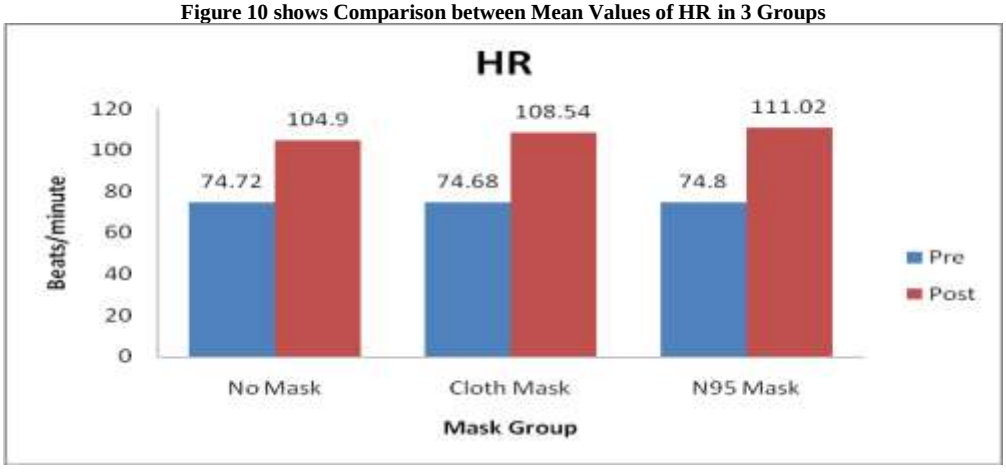
Post Hoc test: Dunn's Multiple Comparisons Test
If the difference between rank sum means is greater than 23.948 then the P value is less than 0.05.

Table 8- DBP in between the group comparison

Rank Sum			
Comparison	**Difference**	**Pvalue**	**Significance**
NM vs. C	--62.000	P<0.0001	Significant
NM vs. N95	-74.500	P<0.0001	Significant
C vs. N95	-12.500	P>0.05	Not significant

Interpretation: There is significant difference between NM vs C and NM vs N95 whereas there is no significant difference between C vs N95 mask group as shown in Figure 9 and table 8.

Figure 10 shows Comparison between Mean Values of HR in 3 Groups



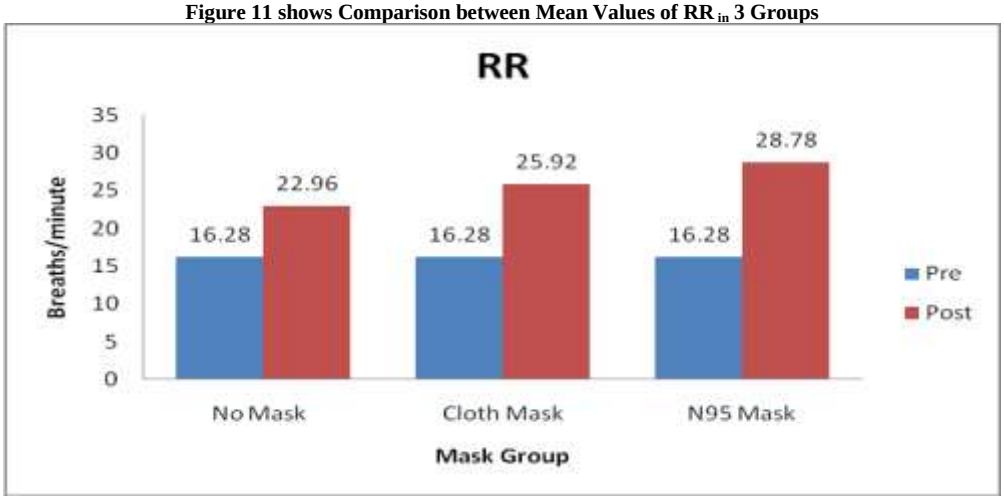
Post Hoc test: Dunn's Multiple Comparisons Test
If the difference between rank sum means is greater than 23.948 then the P value is less than 0.05.

Table 9- HR in between the group comparison

Rank Sum			
Comparison	**Difference**	**Pvalue**	**Significance**
NM vs. C	-52.000	P<0.001	Significant
NM vs. N95	-96.500	P<0.001	Significant
C vs. N95	-44.500	P<0.001	Significant

Interpretation: There are statistically significant difference between the 3 groups on Heart rate as shown in Figure 10 and table 9.

Figure 11 shows Comparison between Mean Values of RR_{in} 3 Groups



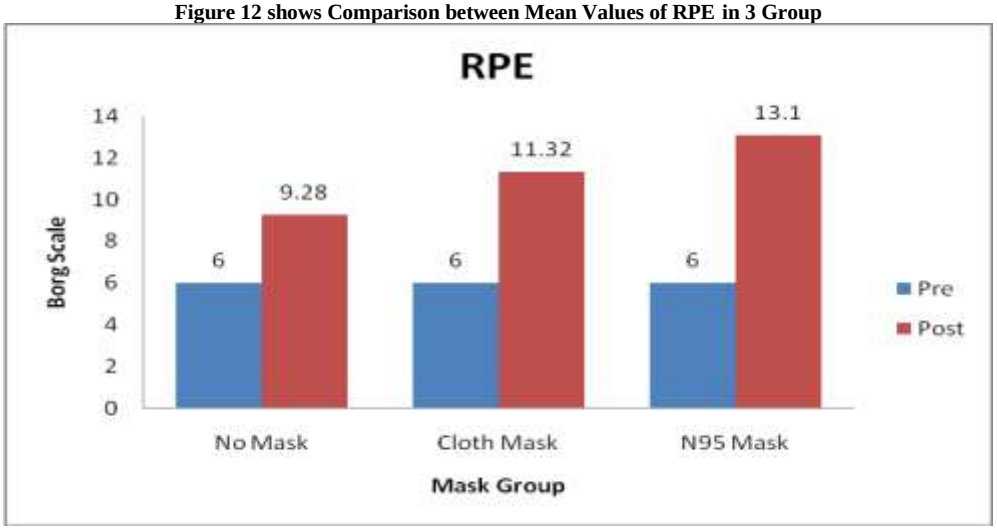
Post Hoc test: Dunn's Multiple Comparisons Test
If the difference between rank sum means is greater than 23.948 then the P value is less than 0.05.

Table 10- RR in between the group comparison

Rank Sum			
Comparison	**Difference**	**Pvalue**	**Significance**
NM vs. C	-50.000	P<0.001	Significant
NM vs. N95	-100.00	P<0.001	Significant
C vs. N95	-50.000	P<0.001	Significant

Interpretation: There is a statistically significant difference between the 3 groups on RR as shown in Figure 11 and table 10.

Figure 12 shows Comparison between Mean Values of RPE in 3 Group



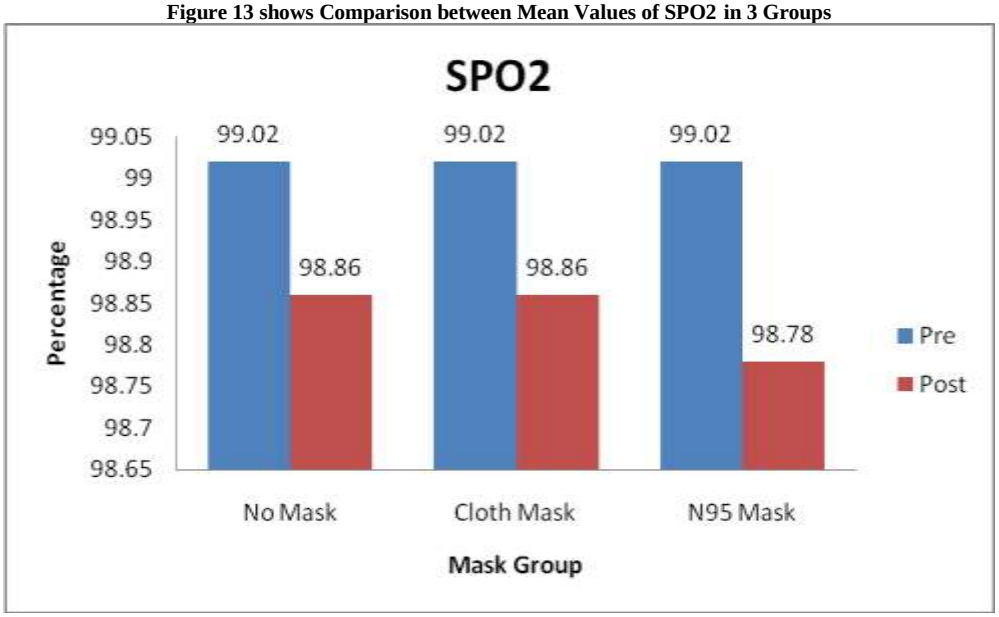
Post Hoc test: Dunn's Multiple Comparisons Test
If the difference between rank sum means is greater than 23.948 then the P value is less than 0.05.

Table 11- RPE in between the group comparison

Rank Sum			
Comparison	**Difference**	**Pvalue**	**Significance**
NM vs. C	-50.000	P<0.001	Significant
NM vs. N95	-100.00	P<0.001	Significant
C vs. N95	-50.000	P<0.001	Significant

Interpretation: There is statistically significant difference between the 3 groups on RPE as shown in Figure 12 and table 11.

Figure 13 shows Comparison between Mean Values of SPO2 in 3 Groups



Post Hoc test: Dunn's Multiple Comparisons Test
If the difference between rank sum means is greater than 23.948 then the P value is less than 0.05.

Table 12- SPO_2 in between the group comparison

Rank Sum			
Comparison	**Difference**	**Pvalue**	**Significance**
NM vs. C	0.000	P>0.05	Not significant
NM vs. N95	-6.000	P>0.05	Not Significant
C vs. N95	-6.000	P>0.05	Not Significant

Interpretation: There is no statistically significant difference between the 3 groups on SPO_2 as shown in Figure 13 and table 12.

RESULT

Figure 5 shows out of the total samples collected, female patients participated in study were 64% and male patients were 36%.

Figure 6 shows out of the total samples collected; non-exercising individuals were 42% whereas exercising individuals were 58%.

Figure 7 signifies mean value of VO_{2max} in No mask was 41.72, cloth mask was 41.36 and in N95 mask was 41.11. There was statistically significant reduction in VO_{2max} with N95 mask as compared with Cloth and No mask group. However, the changes seen

in all 3 groups were not clinically significant.

Figure 8 signifies mean value of SBP in No mask, cloth mask and N95 mask group are 6.2, 8.12 and 8.56 respectively. The changes seen were not statistically significant.

Figure 9 signifies mean value of DBP in No mask was 5.72, in cloth was 6.20 and in N95 mask group was 6.26. The changes seen were not statistically significant.

Figure 10 signifies mean value of HR in No mask group was 30.18, 33.86 was in cloth mask whereas in N95 mask 36.22. There was statistically significant difference on HR in N95 mask as compared with Cloth and No mask group. However, clinically it was not significant.

Figure 11 signifies mean value of RR in No mask group was 6.68, which increased to 9.64 in cloth mask and further increased to 12.5 in N95 mask group. There was statistical and clinically significant difference on RR more in N95 mask as compared with Cloth and No mask group

Figure 12 signifies mean value of RPE in No mask group was 3.28 which increased to 5.32 in cloth mask and further increased to 7.1 in N95 mask group. There was statistical and clinically significant difference on RPE more in N95 mask as compared with Cloth and No mask group.

Figure 13 signifies mean value of SPO_2 in No mask was 0.16, Cloth mask was 0.16 and in N95 mask group was 0.24. The changes seen were not statistically significant.

DISCUSSION

The current study aimed to compare Aerobic Capacity in Normal Healthy Individuals using YMCA 3-Minute Bench Step Test while wearing N95 mask, Cloth mask and no mask.

50 participants were screened and selected for the study according to the inclusion and exclusion criteria from Physiotherapy OPD and Tertiary Health Care Centre within the age group of 21-30 years old. This study included group of normal healthy individuals. 64% were females and 36% were males. Participants performing physical activity (exercising group) and those not being active (non-exercising group) during COVID-19 were 58% and 42% respectively. There were no dropouts during the study.

The participants were asked to perform YMCA 3-Minute Bench Step Test, after wearing a mask and when the mask is taken off.

The participants were assessed on the basis of outcome measures (pre and post): VO_{2max}, BP, HRR, RR, SPO_2, RPE.

Mean value of VO_{2max} in No mask was 41.72, cloth mask was 41.36 and in N95 mask was 41.11. There was statistically significant reduction in VO_{2max} with N95 mask as compared with Cloth and No mask group. However, the changes seen in all 3 groups were not clinically significant.

Anything covering the mouth/nose has the potential to increase the resistive work of breathing.[5] Wearing a mask has its own advantages and indisputable protective effects against infections. However, there are also potential risks and side effects that require attention. This specifically applies to the use in the general population. From a medical standpoint, there is a theoretical possibility of an airflow obstruction when wearing a mask.[43] In healthy adults, the work of breathing at rest and during light exercise is minimal (1-3% of whole body VO_2) and is almost exclusively the result of inspiratory elastic work. As ventilation increases during exercise, the work of breathing rises in a curvilinear manner, primarily because of the increased resistive work secondary to increased airflow, reaching 20-30 times resting levels during exercise.[5]

A study by Sven Fikenzer et al. (2020), conducted on the effect of wearing a surgical vs N95 face mask on cardiopulmonary exercise capacity in 12 healthy males. It was reported that during ergometer incremental exertion test, pulmonary function and ventilation were significantly reduced with the use of either mask. Cardiopulmonary exercise capacity

was also reduced with mask wearing and participants also reported discomfort while wearing the mask, especially N95. It is important to note, however, that these studies examined very high intensity exercise, a level likely higher than an average workout for most individuals. [6,7]

A hypothesis was proposed in 2020 by Chandrasekaran et al. that wearing a face mask during exercise would increase rebreathing of carbon dioxide or that oxygen consumption would be compromised, both of which would lead to lower arterial oxygen saturation of hemoglobin. Chandrasekaran et al. also proposed that face masks might provide resistance to breathing, making work of breathing more difficult. Some evidence from previous studies supported these physiological effects.[13]

Mean value of RR in No mask group was 6.68, which increased to 9.64 in cloth mask and further increased to 12.5 in N95 mask group. There was statistical and clinically significant difference on RR more in N95 mask as compared with Cloth and No mask group.

Similarly, Mean value of RPE in No mask group was 3.28 which increased to 5.32 in cloth mask and further increased to 7.1 in N95 mask group. There was statistical and clinical significant difference on RPE more in N95 mask as compared with Cloth and No mask group.

When wearing very dense masks without valves (N95), breathing occurs against an airflow resistance.[43] N95 masks are perceived as more uncomfortable than other face mask. In particular, breathing resistance, heat, tightness and overall discomfort are the items with the greatest influence on subjective perception. This finding is in agreement with the literature published in 2005 by Li Y, Tokura H on the effects of wearing N95 and surgical facemasks on heart rate, thermal stress and subjective sensations.[42]

Wearing of face mask is perceived as subjectively disturbing and is accompanied by an increased perception of exertion. It is likely that the masks negatively impact on the dynamics of perception especially at the limit of exercise tolerance. In addition to the severe impact on ventilation, the data suggest the associated discomfort as a second important reason for the observed impairment of physical performance.[6]

If wearing a face mask increases dyspnea during exercise as a result of CO2 rebreathing, this effect is attributable to the perception of increased ventilation rather than the increased PaCO2.[5]

Rebreathing of small volume of exhaled gas (i.e., ~50-100ml of added dead space) while wearing a face mask during exercise would increase dyspnea because of effect of CO_2. During exercise with large applied additional dead space (i.e., 600ml), healthy adults have higher end-tidal PCO2, higher minute ventilation and more dyspnea than they have during exercise without additional dead space, however, the relationship between minute ventilation and dyspnea remains unaltered.[5]

In addition, the auxiliary breathing muscles have been described to induce an additional afferent drive which can contribute to an increase of the fatigue effect.[6] The retained moisture from the exhaled breath and facial sweat accumulation within the mask can also result in a loosening of its seal to the face and a potential increase in breathing resistance due to blockage of pores in the mask that could increase the work of breathing.[44]

To support this, there was study conducted by Simon Driver et al. (2020), effects of wearing a cloth face mask on performance, physiological and perceptual responses during a graded treadmill running exercise test was a Randomised controlled trial of healthy adults aged 18-29 years. The results suggested that there was significant decrease in exercise time, maximum oxygen consumption, minute ventilation, increase in heart rate and dyspnoea. There was significant difference between rating of perceived exertion existed between the different stages of the CPET as participant's exercise intensity increased.[33]

Another study conducted in 2021 by Keely A. Et al. The impact of face masks on performance and physiological outcomes during exercise: a systematic review and meta-analysis. This systematic review and meta-analysis were conducted on the impact of wearing a mask during exercise. 22 studies were conducted. Healthy participants (620 females and 953 males) were included and was assessed on exercise performances and physiological parameters. This study concluded that surgical and N95 mask did not impact exercise performance but increases RPE and dyspnea. End Tidal CO2 and heart rate slightly increased.[50]

Mean Values of HRR in No mask group was 30.18, 33.86 was in cloth mask whereas in N95 mask 36.22. There was statistically significant difference on HR in N95 mask as compared with Cloth and No mask group. However, clinically it was not significant.

Heart rate is a suitable parameter for the objective determination of a load intensity. Particularly at medium load intensities, it provides reliable information about the physiological stress on the body (increased physiological effort). An increase in Heart rate can be a decisive factor and thus can lead to difficulty in sustaining a given load intensity. If heart rate is just within the range of the lactate steady state i.e. the balance between lactate production and lactate utilization in the body, a minimal increase can lead to an excessive rise in the lactate level and the exercise must be stopped. This limit is very individual, but can it is within the range of the load intensities at hand. Thus, if a certain intensity is required during aerobic endurance exercise, the target heart rate should be adjusted downwards when wearing a facemask. The increased heart rate during exercise with a mask might be the result of increased work of breathing.[41]

A literature by Lass et al. (2020) tested the effects of a surgical face mask on cardiopulmonary parameters during exercise at maximal lactate steady state in 14 healthy men. The results showed that the use of surgical face masks led to an increase in airway resistance and Heart rate during exercise.[44]

Mean value of SBP in No mask, cloth mask and N95 mask group were 6.2, 8.12 and 8.56 respectively. That of DBP in No mask was 5.72, in cloth was 6.20 and in N95 mask group was 6.26. Similarly, Mean value of SPO_2 in No mask was 0.16, Cloth mask was 0.16 and in N95 mask group was 0.24. The changes seen were not statistically significant on BP and SPO_2 in N95 mask as compared to Cloth and No masks.

A literature was published in 2021 by Hoffmann C., Effects of a facemask on Heart rate, Oxygen saturation, and rate of perceived exertion. This study was conducted on 38 sports students where subjects completed two endurance run test, once with and once without facemask at the same speed. The results showed that heart rate and RPE were significantly higher at the end of the test with mask. In contrast, the oxygen saturation showed no significant difference.[41]

A study conducted in 2022 by Katharina Grimm et al. Blood gas levels, cardiovascular strain and cognitive performance during surgical mask and filtering face piece application. This randomized crossover trial was conducted on 23 healthy individuals with 48-hour washout period. Interventions included a 20-min sitting period and 20 min steady state cycling on an ergometer at 77% of maximal heart rate and was assessed on hemodynamic (heart rate, blood pressure), metabolic outcomes (pulse derived oxygen saturation, capillary carbon dioxide (Pco2), and oxygen partial pressure (Po2) , lactate , PH, base excess), subjective response (ability to concentrate , arousal, perceived exertion) and cognitive performance (Stroop test). The results showed that compared to NM, both masks didn't show any comparative effect on hemodynamic, metabolic, subjective or cognitive outcomes.[49]

It was found that in non exercising individuals showed there was more reduction in Aerobic Capacity when

compared with exercising individuals and also there was increase in cardiorespiratory parameters like RR, RPE and Heart rate.

Factors leading to this effect would be inadequate physical activity and gender. [5,36] Compared with males, females have smaller lungs and rib cages and disproportionally smaller large conducting airways. These sex differences in respiratory system morphology affect the integrative response to exercise by influencing work of breathing, dyspnea, blood-gas homeostasis and cardiovascular function.[45] Male typically have a higher minute ventilation and generate airflow at a given relative, but not absolute exercise intensity. Because the external resistance offered by a face mask is flow dependent, males may have a greater increase in work of breathing because of higher absolute flows while wearing a face mask.[5]

Prior Physical Activity meeting current guidelines was associated with decreased odds for hospitalisation, ICU admission and death among patients with COVID-19. The magnitude of risk for all outcomes associated with being consistently inactive exceeded the odds of smoking and virtually all the chronic diseases, indicating physical inactivity may play a crucial role as a risk factor for severe COVID-19 outcomes. For instance, because physical inactivity is associated with increase in BMI and greater risk of diabetes, both comorbidities associated with severe COVID-19 outcomes, the association of Physical Activity with negative COVID-19 outcomes may be larger than indicated. Hence pandemic control recommendations should include regular physical activity across all population groups. [36]

To sum up, Exercisers may either need to persist through increased discomfort or lower their exercise intensity while wearing a mask if discomfort exists. Additionally, wearing loser cloth masks made with wicking materials that do not hold moisture should improve comfort during exercise.[7] This is important when fitness centers open up during COVID-19 since respiratory droplets may be propelled further with heavy breathing during exercise.[13] The decision to wear a mask will likely need to be made individually and with consultation with physician, given the individual's particular circumstances. Individuals with pre-existing chronic diseases such as diabetes, hypertension and obesity (metabolic syndrome) are at an increased risk of hospitalisation. Therefore, the importance of wearing masks is underscored to help protect this vulnerable population. That said, if an individual with a chronic disease is unable to safely wear a mask, the responsibility may fall to the otherwise healthy individuals to ensure that they are wearing masks to protect the vulnerable.[7]

CONCLUSION

Based on the findings of this study, it was concluded that there is effect on aerobic capacity and cardiorespiratory parameters after using N95 mask when compared with Cloth and no mask use, thus affecting an individual's capacity to exercise.

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