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RESEARCH ARTICLE

Impact of wearing surgical face masks on heart rate and oxygen saturation levels during the Chester Step Test exercise

Chester Basamak Testinde cerrahi yüz maskesi kullanmanın kalp atış hızı ve oksijen satürasyon düzeyleri üzerindeki etkisi

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ABSTRACT

Objective: Wearing a mask is recommended during COVID-19 outbreaks as a means of source control. However, controversies persist regarding wearing masks during exercise. This study aimed to assess the impact of surgical mask use on heart rate and oxygen saturation during the Chester Step Test (CST).

Methods: This is a prospective crossover study involving 24 individuals (12 females and 12 males) aged 35.4 ± 3.9 years with prior ethical clearance obtained. All healthy participants underwent the CST with and without wearing the surgical mask. The CST comprised five stages, each lasting two minutes, progressively intensifying from low to vigorous levels. Measurements of heart rate, oxygen saturation using MIR Spirodoc, and perceived exertion based on the Borg Scale were obtained every two minutes throughout the exercise stages. Statistical analysis utilized the paired sample T-test and Wilcoxon signed-rank test.

Results: Six females and three males couldn't complete up to stage V of the test. Wearing a surgical mask resulted in significant variations than without a mask. During CST, wearing a mask resulted in reduced oxygen saturation (mean ± SD) (94.8 ± 1.8 vs. 96.0 ± 1.9, p=0.01) in stage III, increased heart rate (123 ± 16 vs. 117 ± 14, p=0.02) in stage II, and higher perceived exertion on the Borg scale in stage II [Q2(Q1-Q3)] [8(7-9) vs. 7(7-8.8), p=0.01)], stage IV [12(10-13) vs. 11(10-12), p=0.03] and stage V [13(12-13) vs. 12(10-13), p=0.01].

Conclusion: Wearing surgical masks affected heart rate in stage II, oxygen saturation in stage III and perceived exertion in stage II, IV, and V during the Chester Step Test. These findings emphasize the potential impact of mask use on physiological responses during exercise.

Keywords: Heart rate, oxygen saturation, wearing mask, Chester Step Test

ÖZ

Amaç: COVID-19 salgınlarında kaynak kontrolü amacıyla maske takılması önerilmektedir. Ancak, egzersiz sırasında maske takılması konusunda tartışmalar sürmektedir. Bu çalışma, Chester Basamak Testi (CST) sırasında cerrahi maske kullanımının kalp atış hızı ve oksijen satürasyonu üzerindeki etkisini değerlendirmeyi amaçlamaktadır.

Yöntem: Bu, 35.4 ± 3.9 yaş aralığında ve etik izin belgesi alınmış 24 bireyi (12 kadın ve 12 erkek) içeren prospektif, kesitsel bir çalışmadır. Tüm sağlıklı katılımcılara cerrahi maske var ve yokken CST uygulandı. CST, her biri iki dakika süren ve düşükten şiddetliye doğru kademeli olarak şiddetlenen beş aşamadan oluşuyordu. Kalp atım hızı, MIR Spirodoc kullanılarak oksijen satürasyonu ve Borg Ölçeği'ne göre algılanan efor

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ölçümleri egzersiz aşamaları boyunca her iki dakikada bir yapıldı. İstatistiksel analizde eşleştirilmiş örneklem T testi ve Wilcoxon işaretli sıra testi kullanıldı.

Bulgular: Altı kadın ve üç erkek testin V. aşamasına varamadı. Cerrahi maske kullanımı, maske kullanmamaya göre önemli farklılıklara yol açtı. CST sırasında maske varlığı, evre III'de oksijen satürasyonunun azalmasına (ortalama ± SD) (94.8 ± 1.8'e kıyasla 96.,0 ± 1.9, p=0.01), evre II'de kalp atım hızının artmasına (123 ± 16'ya kıyasla 117 ± 14, p=0.02) ve evre II'de [Q2(Q1-Q3)] [8(7-9)'a kıyasla 7(7-8.8), p=0.01)], evre IV'te [12(10-13)'e kıyasla 11(10-12), p=0.03] ve evre V'te [13(12-13)'e kıyasla 12(10-13), p=0.01] Borg ölçeğinde daha yüksek algılanan efora neden oldu.

Sonuç: Chester Basamak Testi sırasında cerrahi maske kullanmak, evre II'de kalp atım hızını, evre III'te oksijen satürasyonunu ve evre II, IV ve V'te algılanan eforu etkiledi. Bu bulgular, egzersiz sırasında maske kullanımının fizyolojik tepkiler üzerindeki potansiyel etkisini vurgulamaktadır.

Anahtar Sözcükler: Kalp atım hızı, oksijen satürasyonu, maske takma, Chester Basamak Testi

INTRODUCTION

Wearing a mask is recommended during COVID-19 outbreaks as an essential measure for source control. Regular exercise is known to enhance the immune system and help prevent disease. Studies have demonstrated an increase in heart rate and a decrease in oxygen saturation (SpO_2) with a mask in treadmill exercise (1-3). Fernando Pifarre's research noted decreased oxygen saturation and increased heart rate during flex test exercises when participants wore masks (4). Jaiswal et al. (5) observed a rise in heart rate and a reduction in SpO_2 in healthcare workers wearing masks for one hour compared with those not wearing masks. Similarly, various types of walk tests conducted while wearing masks revealed elevated heart rate and decreased SpO_2 levels. Most studies also reported a higher level of perceived exertion, as measured with the Borg scale, in individuals wearing masks comparing to those without masks (6-9).

Several studies examining exercise while wearing a mask, including stair climbing, cycle ergometry, and treadmill exercise have displayed no significant effects on oxygen saturation or heart rate (10-12). Moreover, studies by Keely Shaw (13) revealed no effect on oxygen saturation with vigorous exercise while wearing a mask. The use of face masks during exercise has caused controversy regarding these parameters. While research indicates no negative effect on performance during light to moderate exercise with a mask, certain types or prolonged durations of exercise may lead to a decline in cardiopulmonary function.

The Chester Step Test (CST) is a type of aerobic exercise that tests fitness and consists of different intensities of exercise (14,15). However, the impact of wearing a mask during this exercise is unknown, and there is a lack of preliminary data on the effects of exercise while wearing a mask in the Nepalese population. Therefore, it is worth investigating the heart rate and oxygen saturation in exercise while wearing a surgical face mask. This information will be useful in promoting safe and effective exercise practices.

MATERIAL AND METHODS

The study was conducted at Patan Academy of Health Sciences (PAHS), in the Physiology department from September 2023 to February 2024, after ethical approval from the institutional review board. It is a prospective crossover study. The participants consist of healthy volunteers and non-smokers aged 18-40 years. Participants were excluded if they suffered from systemic diseases like diabetes, acute or chronic respiratory disorders, cardiovascular disorders, and musculoskeletal disorders. Individuals with any other known medical/systemic conditions, pregnant females, and individuals who answered "yes" to one or more questions on the physical activity readiness questionnaire(PAR-Q) (16) were excluded too.

Study procedure

Based on inclusion and exclusion criteria, 12 male and 12 female participants were selected. After written consent from the participants, we arranged for the orientation about the Chester Step Test exercise in the physiology lab. They were called for the study for two separate

days to perform the CST exercise with and without a surgical face mask within one week. The surgical mask that complies with the European Standard EN 14683: Type IIR was used in the study. Subjects were asked to report to the laboratory of the Physiology department at about 9 AM following a light breakfast, without tea or coffee. The time required for the study for an individual for one session was 20 minutes: Initial 5 min for the resting period, 10 min for exercise, and 5 min for the post-exercise resting period.

Baseline recording

- Heart rate and oxygen saturation by portable digital spirometer (MIR Spirodoc)
- Blood pressure with the auscultatory method
- Respiratory rate by visual movement of the chest
- Height with a measuring tape
- Weight with a digital body scale (HMS Citizen 324)

The Chester Step Test

The test contains five stages, each of two minutes, and after every stage, the steps were increased by five steps (14,15). In this study, we used 20 cm of height. The details about the stages and steps with corresponding metabolic equivalents of task (METs) of the Chester Step Test are given in Table 1.

Table 1. Five stages of the Chester Step Test and predicted metabolic equivalents (METs) for 20 cm step height and setps/min

Stage	1	2	3	4	5
Steps/min	15	20	25	30	35
METs	3.9	4.9	5.8	6.8	7.8

Step up and down onto the box of 20 cm in time with the metronome beats. Every two minutes, the metronome will be increased by five steps, and the heart rate, oxygen saturation, and perceived exertion rate from the Borg scale (6-20) were recorded. The test was ended after 10 min of stepping. If heart rate was higher than 85% age-related maximum and/or the perceived exertion level was above a value of 14, then the test was stopped immediately. The Borg rating of perceived exertion (RPE) serves as a valuable tool for prescribing exercise intensity. These ratings, ranging from 6 to 20, were displayed prominently on a flexible form placed in front of the participants.

Statistical tests and analysis

Data obtained was entered in MS Excel and analysis was done using the Statistical Package for Social Sciences (SPSS-20.0). Descriptive data was expressed as mean ± SD and median Q2 (Q1-Q3). To compare the data, a paired sample t-test for parametric data, and a Wilcoxon signed-rank test for non-parametric datawere applied for statistical analysis. A p-value <0.05 was considered as statistically significant.

RESULTS

The participants' age, weight, and body mass index were 35.4 ± 3.9 years, 64.0 ± 8.9 kg, and 24.9 ± 2.9 kg/m^2, respectively. The baseline recording of heart rate, respiratory rate, oxygen saturation, and blood pressure is given in Table 2, as means ± SD or median Q2(Q1-Q3).

Heart rate, oxygen saturation, and Borg scale recording at each stage of the CST, and masked/ unmasked comparisons are presented in Table 3 as means ± SD or median Q2(Q1-Q3).

Table 2. Baseline data recorded at rest

Variables	Masked (n=24)	Unmasked (n=24)	p
Heart rate (bpm)	71.1 ± 9.8	71.4 ± 9.3	0.74
Respiratory rate (breaths per min)	16.4 ± 3.0	16.2 ± 2.2	0.73
Systolic blood pressure (mmHg)	114 ± 10	113 ± 10	0.22
Diastolic blood pressure (mmHg)	75.5 ± 8.3	75.3 ± 9.0	0.85
Oxygen saturation (%)	97(97-98)	97(97-98)	0.61

Table 3. Heart rate and oxygen saturation during different stages of the Chester Step Test

Variable	Stage	n	Masked Group	Unmasked Group	p
Oxygen saturation (%)	1	24	94.6 ± 1.7	95.2 ± 2.1	0.34
	2	24	94.6 ± 2.4	95.4 ± 2.1	0.05
	3	24	94.8 ± 1.8	96.0 ± 1.9	0.01*
	4	23	94.6 ± 2.4	95.7 ± 1.6	0.10
	5	15	94.2 ± 1.6	94.9 ± 2.2	0.10
Heart rate (bpm)	1	24	108 ± 16	103 ± 12	0.05
	2	24	123 ± 16	117 ± 14	0.02*
	3	24	128 ± 14	128 ± 14	0.86
	4	23	139 ± 17	141 ± 13	0.57
	5	15	147 ± 13	145 ± 13	0.42
Borg scale (6-20)	1	24	6 (6-7)	6 (6-6.8)	0.20
	2	24	8 (7-9)	7 (7-8.8)	0.01*
	3	24	9.5 (8-12)	9 (8-11)	0.17
	4	23	12 (10-13)	11 (10-12)	0.03*
	5	15	13 (12-13)	12 (10-13)	0.01*

**: p<0.05, significant result*

Six females and three males couldn't complete stage V of the test. Comparing the effect of wearing a surgical mask resulted in significant variations than those without the mask. During CST wearing a mask resulted in reduced oxygen saturation (p=0.01) in stage III, increased heart rate (p=0.02) in stage II, and higher perceived exertion on the Borg scale in stage II (p=0.01), stage IV (p=0.03) and stage V (p=0.01). There was a borderline significant decrease in oxygen saturation at stage II (p=0.05), and a borderline significant increase in heart rate at stage I (p=0.05) while wearing a mask. Graphical representations of participant SpO_2, heart rate, and Borg scale at different stages of the CST with and without wearing a surgical mask are given in Figure 1, Figure 2, and Figure 3, respectively.

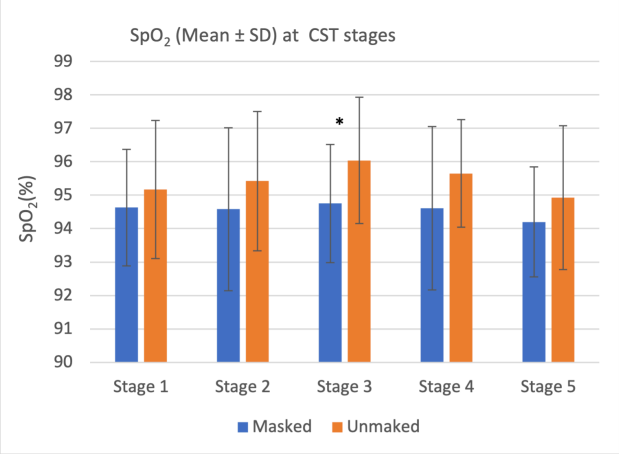

Figure 1. Participant SpO2 (Mean ± SD) at each CST stage (*: p<0.01)

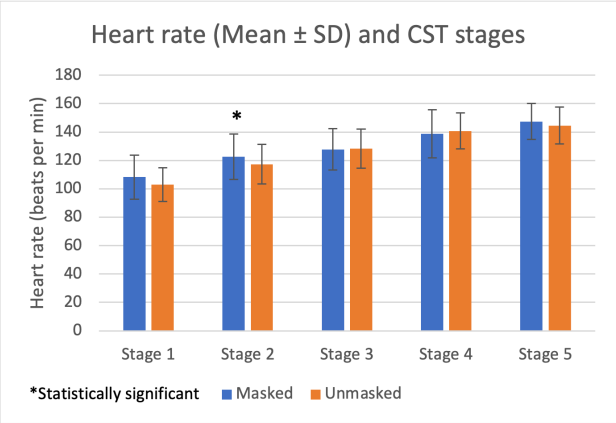

Figure 2. Participant heart rate (Mean ± SD) at each CST stage (*: p<0.02)

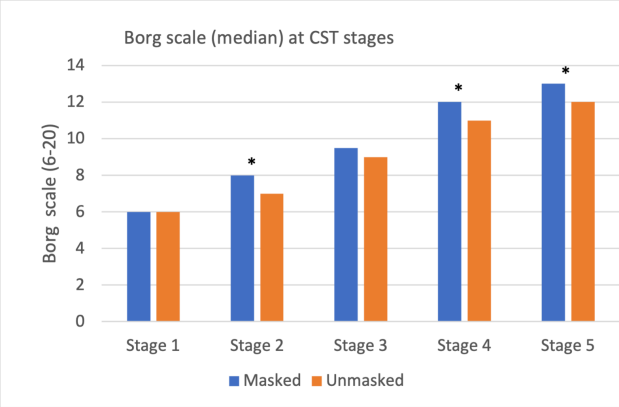

Figure 3. Participant rating of perceived exertion in Borg scale (median Q2) at each CST stage (*: p<0.01, p<0.03, p<0.01, respectively)

DISCUSSION

This crossover study investigated the immediate effects of wearing a surgical mask during the Chester Step Test on physiological responses such as the heart rate, oxygen saturation, and perceived exertion measured by the Borg scale. Our findings reveal that wearing a mask significantly affects the body's responses during exercise. Most notably, oxygen saturation dropped significantly at stage III, with a borderline decrease at stage II. Heart rate increased significantly at stage II, with a borderline increase at stage I. Perceived exertion was consistently higher in the masked condition, especially in stages II, IV, and V.

Khodarahmi et al. (2) also observed workload-dependent heart rate increases with mask use. Similarly, Jaiwal et al. (after 1-hour mask use) and Dirol et al. (during a 6-minute walk test) observed increased heart rate and reduced oxygen saturation (5,6). However, Hoffmann et al. (7) reported no change in oxygen saturation during endurance exercise, showing that results may vary depending on exercise type and duration. During exercise, it is normal to see a rise in heart rate and a slight drop in oxygen saturation, as the body works harder to deliver oxygen to the muscles. Our study revealed that these changes were more noticeable when wearing a mask. At stage II, heart rate increased significantly, and by stage III, oxygen saturation fell significantly in the masked condition. This pattern suggests that the cardiovascular system compensates first by increasing heart rate, but after a point, oxygen delivery becomes less effective.

These findings are also supported by the increase in perceived exertion (Borg scale) observed in stage II when this compensation is occurring. In the later stages of exercise, we did not find significant changes in oxygen saturation and heart rate. For instance, as heart rate increases from resting to 60% of maximum, there is typically a linear decrease in oxygen saturation. However, when the heart rate reaches 60-80%, oxygen saturation often returns to near resting levels (17). This could explain the non-significant results observed in the later stages of exercise.

The Borg scale scores were significantly higher in the masked group at stages II, IV, and V, indicating that participants felt more fatigued while wearing the mask, even if the physiological changes were modest at stages IV and V. This is likely due to the extra breathing resistance, which makes exercise feel harder (18). The significant increase in perceived effort aligns with findings from Bar-On et al. (walking protocols) and Shaw et al., who found that mask discomfort increases during certain types of exercise (9,13). At stage V of CST, many participants could not complete the test because of safety protocols, which might have slightly affected our results in later stages.

Some studies have revealed no significant differences in heart rate, oxygen saturation, or exertion between masked and unmasked exercise (10-12). These differences may be due to methodological variations. Epstein et al. (10) used cycling with fitter participants, and Poon et al. (12) studied younger individuals with likely better fitness. Majek et al. (11) used stair climbing and recorded masked and unmasked data on a single day, unlike our multi-stage test on a different day.

Overall, our study reveals that wearing a surgical mask during exercise does affect the body's responses, especially in heart rate and oxygen saturation in light to moderate intensity exercise, and makes the exercise feel more tiring. This is likely due to a mix of physical resistance from the mask and the psychological feeling of restricted breathing (19). Our study has several strengths: it helps explain how surgical masks can affect heart rate, oxygen levels, and perceived effort during different stages of exercise. These findings are especially useful for people who wear masks during light to vigorous exercise. However, there are also some limitations. We only included healthy individuals, and the sample size was small, so the results may not apply to everyone. Also, there are many different types of masks made from different materials and shapes, which could lead to different outcomes. Other studies may have found different results because of different exercise types, mask designs, or individual fitness levels. This displays the need for more research to better understand how masks affect people during exercise.

CONCLUSION

In our study, based on the intensity of different stages in the Chester Step Test, there was a significant decrease in oxygen saturation in subjects using surgical masks in stage III. Heart rates increased significantly in stage II with a surgical mask. Moreover, there is increased perceived exertion on the Borg scale in the II, IV, and V stages of the CST with a surgical mask. These findings emphasize the potential impact of mask use on physiological responses during exercise.

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Ethics Committee Approval

The approval for this study was obtained from the Institutional Review Committee – PAHS (Decision No. bss2308081791, dated 8th August 2023) and performed according to Helsinki declaration criteria.

Conflict of Interest

The authors declared no conflicts of interest with respect to authorship and/or publication of the article.

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Author Contributions

Concept: SM; design: SM, BS, SP, RJ, JB, IS; supervision: IS; materials: SM, BS,SP, RJ,JB, IS; data collection and/or processing: SM,BS, JB,IS; analysis and interpretation: SM, BS,SP, RJ,JB, IS; literature review: SM, BS,SP, RJ,JB, IS; writing manuscript: SM; critical reviews: IS, JB. All authors contributed to the final version of the manuscript and discussed the results and contributed to the final manuscript.

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