Effect of Mask and Workload on Physiological Responses

Abdallah Alrashdan
Department of Industrial Engineering, College of Engineering, Alfaisal University, Riyadh , Saudi Arabia
aalrshdan@alfaisal.edu

Atef M.Ghaleb
Department of Industrial Engineering, College of Engineering, King Saud University, Riyadh , Saudi Arabia.
amag16@gmail.com

Amal AlHussain, Najla Alkuhaimi , Hala Alnesseyan, Shahad Aljarbouea
Department of Industrial Engineering, College of Engineering, Alfaisal University, Riyadh , Saudi Arabia

Abstract

Because of the Coronavirus (COVID-19) and due to strict laws to limit the spread of the virus, it has become necessary and for everyone to wear masks, but some people perform tasks that require high effort, especially those who work in the field of health care, so it may affect them to wear masks for long periods during the effort. Therefore, The objective of this research is to find out the effect of wearing masks on work capacity. Work capacity will be measured by heart rate and rating of perceived exertion (RPE). To achieve the purpose of this study, A total of ten students of Alfaisal University were recruited in the study. A two-way repeated measures design was be conducted. The independent variables which were studied in this experiment were : 1) Mask (with and without), 2) intensity of the workload (low, medium, and high). The dependent factors for this study were: 1) Heart rate 2) Rating of perceived exertion. A randomized complete block design with factorial treatment combinations was utilized in this study. Each participant was considered as a block and performed the six experiments in random order. The results show that mask and intensity of workload have significantly effected the heart rate and perceived excursion. The study suggested to increased the rest periods to overcome the fatigue based on different workload during wearing the mask.

Keywords
COVID-19; Heart Rate; Mask; Work Capacity

1. Introduction

The use of facemasks by international, national and local authorities is widely recommended following the outbreak of the 19 COVID pandemic [1]. The goal is to reduce the excretion of the respiratory gout in pre-symptomatic and asymptomatic people. The evidence for the effectiveness of face masks in the prevention of respiratory virus infection or improving clinical outcomes is missing [2,3]. The question of whether fine-particle aerosols and environmental factors such as temperature and humidity have a significant role in spreading infectious respiratory diseases is a matter of scientific discussion [4]. As long as no active treatment or vaccination against COVID-19 is available, public health policy should focus on using non-pharmacological measures such as social distancing, general cleanliness and germ-killing activities. For that, many people have worn facemasks during person-to-person contact in order to avoid the spread of germs. Health professionals in particular must wear masks for a long time. In addition to health care professionals, information on cardiopulmonary effects of facemasks in healthy adults could be important for different groups of individuals (5). Respiratory virus particles, which are found in breathing droplets, can be spread through various types of physical activity [6, 7]. For that, the main aim of this paper is to find out the effect of wearing masks on work capacity. Work capacity will be measured by heart rate and rating of perceived exertion (RPE). Consequently, the study has hypothesized that the mask and intensity of workload have a significant effect on the heart rate and perceived exertion.

2. Methods

2.1. Study Design

The study used the experimental study design for achieving the determined objectives, integrating into a quantitative approach. The rationale for selecting this particular study design is twofold, such as it is found to provide results in an easy to comprehend form and that too statistically [8]. Secondly, this research design has been effective in deriving concrete and complete results for the other similar researches [9].

2.2. Participants

The population of the study constitutes students enrolled at Alfaisal University, KSA. Based on the inclusion criteria, a total of 10 students were recruited(2 male and 8 female) with a mean age of 21.6 years and standard deviation of 2.1 years . The average body mass was 58.2 kg with a standard deviation of 5.7 kg, and average stature was 159.4 cm with a standard deviation of 1.7 cm.
The followings were the inclusion criterias for this study: (1) participants who have not experienced any back or lower and upper limb problems; (2) participants who have not experienced heart disease; and (3) participants who have not experienced breathing problems; (4)participants who are taking medications that do not affect the cardiorespiratory systems will included in the study. The participants will be asked to sleep well and to avoid consuming caffeinated drinks 4 h before the experiment.

2.3. Experiment Design

A randomized complete block factorial design was used. Each participant was considered as a block. Analysis of variance (ANOVA) was performed to assess the effects of independent variables (Mask, the intensity of workload) on dependent variables (Heart Rate and Perceived Exertion) using SPSS Package [10]. If an interaction between two independent variables appears, the simple effect technique by Keppel 1982 [11], was used to analyze it.
Two levels of Mask (with and without), three intensities of workload ((low, medium, and high) were used in this study, as shown in Table 1, producing 6 combinations (2*3) of experimental conditions, as shown in Table 2. Each participant replicated each condition, which resulted in 6 runs for every participant.

Table 1. Levels of Independent Variables

variables / levels	1	2	3
Mask	with	without	-
Intensity of workload	Low (1 km/hr)	Medium (3km/hr)	High (5km/hr with 5 degree inclined)

Table 2. Six Combinations for Independent Variables.

Experimental Conditions	Mask	Intensity of workload
1	1	1
2	1	2
3	1	3
4	2	1
5	2	2
6	2	3

2.4. Dependent variables

2.4.1 Heart rate:

Many researchers have shown that heart rate is directly proportional to workload [12-15]. The heart rates of the participants was measured using a heart rate monitor.

2.4.2 Rating of perceived exertion

The rating of perceived exertion (RPE) scale was used to measure the intensity of work being performed. Borg developed the RPE; the RPE scale runs from 6–20 [16].

2.5. Procedures and Data Collection

To achieve the purpose of this study, the following protocol was followed:
Each participant was asked to perform an experiment. Each participant had did the experiment 6 times because we have two independent variables: 1) Mask (with and without), 2) intensity of the workload (low, medium, and high), and the orders of the experimental sessions were randomized. Besides, before the experiment, participants must sleep well and enough and stay away from smoking for at least four hours before starting the experiment. For every session of the five minutes pre-work rest, the heart rate at rest was measured. Then the participant was asked to do one condition for 5 minutes then he was take 5 minutes for recovery between two sessions and he was do the next session and so on. For every session there was 5 minutes pre-work rest we measured the rest heart rate then after the session we measured the heart rate immediately, then there was 5 minutes to recover and we measured the recovery heart rate. Besides, after each session, the participant's rating of perceived exertion (RPE) was obtained. The only principal researcher will be performed all measurements on all participants on all test days.

Figure 1. Experiments setup

3. Results

3.1. Heart rate

It was observed that two main variables; Mask ($F = 5.55$, $p < 0.022$) and intensity of the workload ($F = 30.89$, $p < 0.0001$) had a significant effect on the heart rate of participants, as shown in Table 3. The experiment reveals that heart rate was significantly higher with mask (mean (SD) =117.1 (15.56) beats/min), when compared to without mask (mean (SD) = 107.63 (14.53) beats/min). Moreover, the heart rate was significantly higher at high intensity of the workload (mean (SD) = 133.5 (15.55) beats/min), when compared to medium intensity of workload (mean (SD) = 108.05 (14.72) beats/min) and low intensity of workload (mean (SD) = 95.55 (15.36) beats/min). As shown in Figure 2.

Table 3. Summary of heart rate results

Main Factors	Levels	Mean of Heart Rate (beats/min)	Std. of Heart Rate (beats/min)	P-value
Mask	With	117.1	15.56	0.022
	without	107.63	14.53	
Intensity of workload	Low	95.55	15.36	0.0001
	Medium	108.05	14.72	
	High	133.5	15.55	

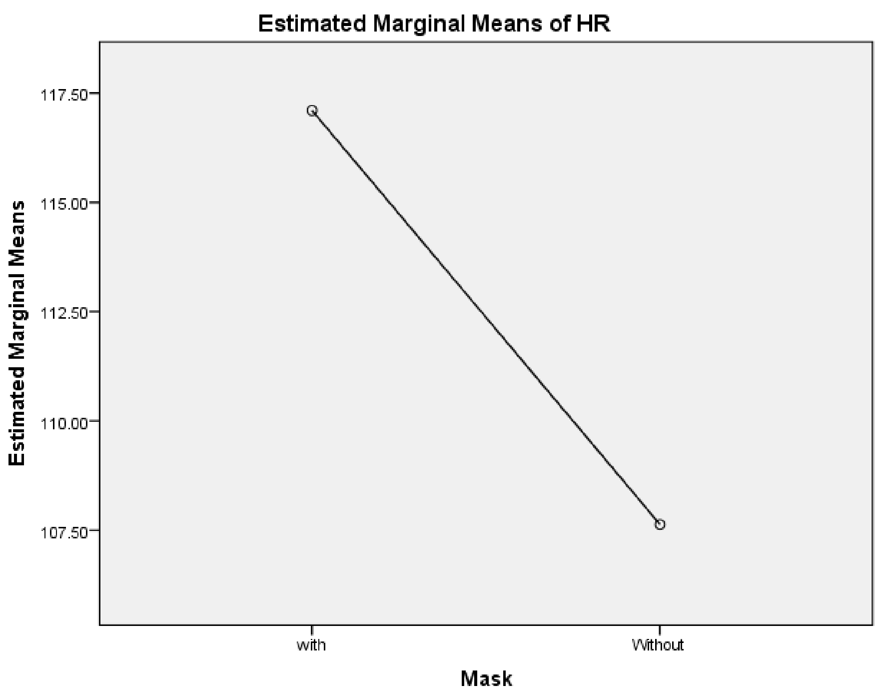

Figure 2. effect of Mask on heart rate

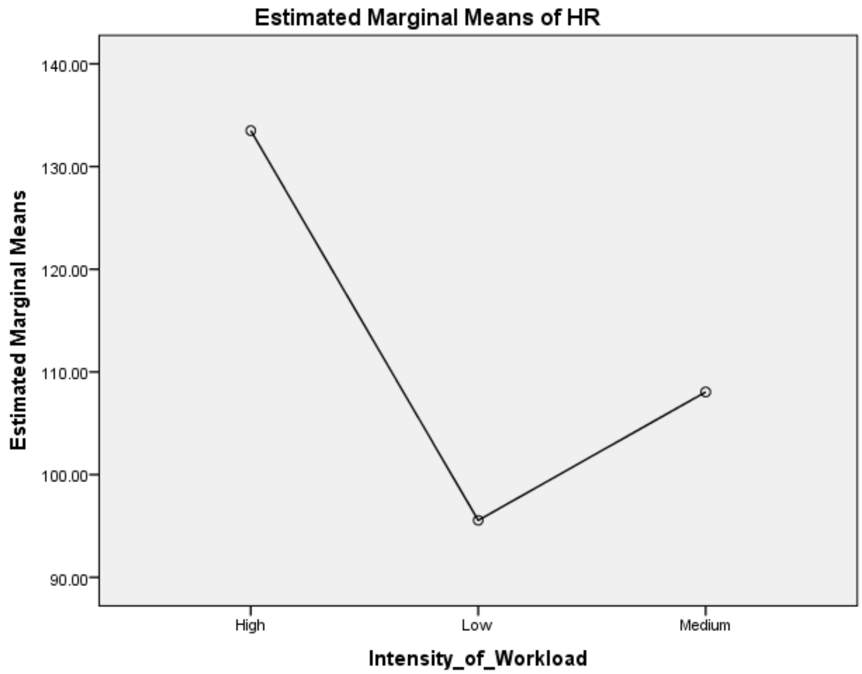

Figure 3. effect of Intensity of Workload on heart rate

3.2. Rating of Perceived Exertion (RPE)

The two main factors Mask ($F = 10.7$, $p < 0.002$) and Intensity of workload($F = 106.75$, $p < 0.0001$) had a significant effect on RPE. The RPE was significantly less without mask (mean, SD = 10.67, 1.61) when compared to with mask (mean, SD = 12.03, 1.65). Additionally, the RPE was significantly less when Intensity of workload was low (mean, SD = 7.8, 1.98) when compared to medium (mean, SD = 11.00, 2.013) or high (mean, SD = 15.25, 1.96).

4. Discussion

The primary purpose of this research was to study the influence Intensity of workload while wearing mask on physiological responses (HR) and stress level (rating of perceived excretion). The hypotheses of this study stated that mask and Intensity of workload have significant effect on heart rate and rating of perceived exertion. The findings of the study showed that the physical demand was increased- with the increase of intensity of workload and also when worn the mask. The results were demonstrated in terms of increase in mean heart rate. Moreover, high intensity of workload resulted in the increase if autonomic activities significantly. These outcomes are consistent with results shown previous studies [10,17,18]. The heart rate increased when exceedingly regular parasympathetic modulation happens [19]. That is definitely what occurred at the physical activity. The current findings of this study are justified as a physical task since it can be classified as a steady-state of psychophysical research. The results of this study showed that the participants worked under a significant amount of physiological stress, which is evident from the high level of HR work.

In this experiment, the rating of perceived exertion was highly significant with high levels of intensity od workload, and when worn mask that is as indices to intensity of work; the literature supports this result for the intensity of workload [3, 20].

The findings could be used for updating the health and safety conditions guideline, increasing interventions in the form of education, and awareness programs, which could help reduce the medical expenditure, improve work productivity, and achieve sustainable development.

5. Conclusions

This paper provided evidence that the mask increased the intensity of workload in tasks. The findings show that it affected the physiological responses represented in the form of heart rate. The results revealed that it was necessary to take a rest or working at low intensity of work load when wearing the mask. Although worn mask ,at these days because of COVID-19 , was shared across all cities and countries. However, none of the researchers studied the effect of mask on workers who work in the health care. It directs the future to examine the capabilities of workers when wearing different types of masks. Notably, it emphasized the integration of electroencephalogram (EEG), electrocardiogram (ECG), and hypoxic ventilator response (HVR) as the dependent variables in future researches, which could help expand the research area further.

Conflicts of Interest: There are no conflicts of interest to disclose.

Acknowledgment

This work was supported by a Boeing Research Grant (324129) at Alfaisal University, KSA.

References

3 Adams, J. (2020). Recommendation regarding the use of cloth face coverings, especially in areas of significant community-based transmission.

4 World Health Organization. (2020). Advice on the use of masks in the context of COVID-19: interim guidance, 5 June 2020 (No. WHO/2019-nCov/IPC_Masks/2020.4). World Health Organization.

5 Xiao, J., Shiu, E. Y., Gao, H., Wong, J. Y., Fong, M. W., Ryu, S., & Cowling, B. J. (2020). Nonpharmaceutical measures for pandemic influenza in nonhealthcare settings—personal protective and environmental measures. Emerging infectious diseases, 26(5), 967.

6 Shiu, E. Y., Leung, N. H., & Cowling, B. J. (2019). Controversy around airborne versus droplet transmission of respiratory viruses: implication for infection prevention. Current opinion in infectious diseases, 32(4), 372-379.

7 Fikenzer, S., Uhe, T., Lavall, D., Rudolph, U., Falz, R., Busse, M., ... & Laufs, U. (2020). Effects of surgical and FFP2/N95 face masks on cardiopulmonary exercise capacity. Clinical Research in Cardiology, 109(12), 1522-1530.

8 Leung, N. H., Chu, D. K., Shiu, E. Y., Chan, K. H., McDevitt, J. J., Hau, B. J., ... & Seto, W. H. (2020). Respiratory virus shedding in exhaled breath and efficacy of face masks. Nature medicine, 26(5), 676-680.

9 Blocken, B., Malizia, F., van Druenen, T., & Marchal, T. (2020). Towards aerodynamically equivalent COVID19 1.5 m social distancing for walking and running. Questions and Answers. Website Bert Blocken, Eindhoven University of Technology (The Netherlands) and KU Leuven (Belgium). Disponibile su: http://www. urbanphysics. net/COVID19. html (ultimo accesso 21 aprile 2020).

10 Creswell, J. W., & Creswell, J. D. (2017). Research design: Qualitative, quantitative, and mixed methods approaches. Sage publications.

11 Mavor, M. P., & Graham, R. B. (2019). The effects of protective footwear on spine control and lifting mechanics. Applied Ergonomics, 76, 122-129.

12 Ghaleb, A. M., Ramadan, M. Z., Badwelan, A., & Saad Aljaloud, K. (2019). Effect of ambient oxygen content, safety shoe type, and lifting frequency on subject's MAWL and physiological responses. International journal of environmental research and public health, 16(21), 4172.

13 Keppel, G. Design and Analysis: A Researcher's Handbook, 2nd ed.; Prentice-Hall, Inc.: Englewood Cliffs, NJ, USA, 1982.

14 Al-Ashaik, R. A., Ramadan, M. Z., Al-Saleh, K. S., & Khalaf, T. M. (2015). Effect of safety shoes type, lifting frequency, and ambient temperature on subject's MAWL and physiological responses. International Journal of Industrial Ergonomics, 50, 43-51.

15 Boocock, M. G., Monnington, S., & Pinder, A. D. J. (1998). Balance of Risk between Weight of Load and Frequency of Lift: A Study of the Psychophysical and Biomechanical Parameters of Repetitive Handling. Health and Safety Laboratory.

16 Ramadan, M. Z. (1990). Effects of task and environment-related variables on individuals' lifting capabilities while wearing protective clothing.

17 Singh, J., Kalra, P., & Walia, R. S. (2012). Study of maximum acceptable weight of lift for indian male industrial workers. Age (years), 33(28), 30.

18 Borg, G. (1970). Perceived exertion as an indicator of somatic stress. Scandinavian journal of rehabilitation medicine.

19 Ghaleb, A. M., Khalaf, T. M., Ramadan, M. Z., Ragab, A. E., & Badwelan, A. (2020). Effect of cycling on a stationary bike while performing assembly tasks on human physiology and performance parameters. International Journal of Environmental Research and Public Health, 17(5), 1761.

20 Ghaleb, A. M., Ramadan, M. Z., Mansour, L., Al-Tamimi, J., & Aljaloud, K. S. (2020). Effect of hypoxia, safety shoe type, and lifting frequency on cardiovascular and ventilation responses. International Journal of Industrial Ergonomics, 80, 103032.

21 Vuksanović, V., & Gal, V. (2007). Heart rate variability in mental stress aloud. Medical engineering & physics, 29(3), 344-349.

22 Ghaleb, A. M., Ramadan, M. Z., & Aljaloud, K. S. (2019). Effect of Ambient Oxygen Content and Lifting Frequency on the Participant's Lifting Capabilities, Muscle Activities, and Perceived Exertion. International Journal of Health and Medical Engineering, 13(12), 489-493.