

BRIEF REPORT

EFFECTS OF FACE MASK WEARING ON ATHLETE PERFORMANCE IN THE COVID-19 ERA

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Abstract. In the COVID-19 era, the prevalence of wearing face masks by athletes while exercising and examination of reasons for not wearing them and of association of maximum ambient temperature on performance while wearing mask were investigated by a self-administered web-based questionnaire. Primary data was correlated with secondary data such as average temperature, which were obtained from open sources. Athletes ($n = 633$, 84.7% male, 45.8% 20-29 years of age) from 188 countries participated in the survey conducted between June and July 2020. The majority of athletes (70.8%) wore masks while exercising and 66.8% of athletes reported mask wearing adversely affected their performance, in particular among all users of N95, FFP2 or equivalent mask and 90.9% of those wearing surgical mask. Adverse performance is significantly associated with highest ambient temperature in the respective country (p -value <0.001). In conclusion, wearing a face mask during the COVID-19 pandemic adversely impacted high-intensity exercise performance in athletes due to discomfort and restriction in breathing, and high ambient temperature was also a negative factor.

Keywords: athlete performance, hypoxia, surgical face mask, high-intensity exercise, temperature, COVID-19

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INTRODUCTION

The Coronavirus disease 2019 (COVID-19) pandemic has taken the world by surprise. Since the start

of the pandemic in December 2019, various sectors such as aviation, finance, agriculture, education, and healthcare have been adversely affected (Nicola

et al, 2020). The sports industry is no exception with major sporting events such as Euro 2020 tournament and the Tokyo 2020 Olympics being postponed or cancelled as with Formula One Grand Prix of Bahrain resulting in as yet undetermined financial loss (Nicola *et al*, 2020).

Wearing face mask reduces airborne transmission of the virus (Chan and Yuen, 2020; Eikenberry *et al*, 2020). In a systematic review by Chu *et al* (2020), physical distancing and wearing a face mask are associated with lower risk of infection; however, wearing masks is associated with discomfort, reduced communication clarity and reduced empathy of care providers, although this is imperative for patients and members of the healthcare system. Face masks and other coverings function by trapping coarse respiratory droplets, which may or may not contain virus and N95 mask is more effective against finer aerosols (Eikenberry *et al*, 2020). One of the significant drawbacks to wearing a mask is that the material covering nose and mouth gradually becomes damp, partially from sweat and water vapor during exhalation, potentially reducing the mask's effectiveness and also making wearing uncomfortable (Blanco and Janse, 2020).

Athletes are also required to wear face masks during training and exercise (Mercurio *et al*, 2020). Here, the frequency of athletes wearing face masks (FFP2, N95, surgical or equivalent) or cloth face covering while exercising was determined as well as reasons for not wearing a mask. In addition, association of maximum ambient temperature and

performance while wearing a mask was examined. The expected outcome was that athletes were not wearing masks during training due to increased temperature or reduced performance.

MATERIALS AND METHODS

Study design and participants

Information was collected using a self-administered web-based questionnaire originally drafted in English and translated into 10 languages, namely, Arabic, Chinese, French, German, Italian, Japanese, Portuguese, Russian, Spanish and Turkish. The target number of participants is 600 to achieve a 4% margin of error at a 95% confidence level.

The study protocols were approved by the Biomedical Ethics Committee, Umm Al Qura University (approval no. HAP002K012202010462). Prior consent was obtained from all participants and names were redacted.

Data collection

The survey was conducted using a web-based Google Form (Alphabet Inc, Mountain View, CA) from June through July 2020. Respondents were provided with a survey link through different sports associations, and each participant was limited to one occasion. The self-administered survey consisted of socio-demographic questions (age, gender and country), whether they exercise with a face mask at gym and/or fitness center ("yes" or "no"), type of face mask used (FFP2, N95, surgical or equivalent, or cloth face covering), reasons for not wearing face mask ("breathing restriction" and/or "

discomfort"). The average maximum ambient temperature in June of each participant country was obtained from the World Meteorological Organization (2020).

Statistical analysis

Data were analyzed using a Statistical Package for the Social Sciences (SPSS) version 24.0 (IBM Corp, Armonk, NY). A chi-squared test was used to analyze differences among types of mask, between exercising with and without face mask, and in performance. A point-biserial correlation was employed to determine association between performance while wearing a mask and maximum average ambient temperature. A p -value of <0.05 is considered significant.

RESULTS

Athletes ($n = 633$, 85% males) from 188 countries participated in the study conducted on-line between June and July 2020. The majority of participating athletes who completed the survey were 20-29 years of age (46%), 71% wore masks (61% surgical type) while exercising, which 94% reported adversely affected their performance, while 76% of those not wearing a mask attributed the reason to both breathing restriction and discomfort (Table 1). All participants who wore FFP2, N95 or equivalent mask indicated it affected performance compared to 90.9% of athletes who wore surgical masks. Performance is negatively correlated with maximum ambient temperature in June 2020 for the respective country (point-biserial correlation $r_{pb} = -0.435$, p -value <0.001).

DISCUSSION

To the best of our knowledge, no validated survey has addressed the effect of face masks on athletes' exercise performance during the COVID-19 pandemic. Since the beginning of COVID-19 pandemic the public is recommended to wear face and maintain appropriate distance from one another outside homes and within work and recreation places (Chan and Yuen, 2020; Eikenberry *et al*, 2020). This practice together with such hygiene practices as frequent hand washing are effective measures against the spread of severe acute respiratory syndrome (SARS) in 2003 (Cheng *et al*, 2020).

The survey revealed almost all athletes wearing FFP2, N95 or equivalent, or surgical masks responded reduced exercise performance. Performing strenuous cycling exercise by healthy young volunteers while wearing a surgical or an N95 mask was reported to be safe with insignificant physiological stress responses (heart and respiratory rates and oxygen saturation) and in perceived exertion scores compared to those not wearing face mask (Epstein *et al*, 2021). Fikenzler *et al* (2020) found insignificant differences in stroke volume, cardiac output and heart rate of cardiopulmonary exercise capacity among participants with or without surgical or FFP2/N95 face masks; however, participants wearing surgical masks have significantly lower blood lactate acid level compared to those not wearing masks, but surprisingly, no overall differences among the groups regarding peak lactate levels. Johnson *et al* (1995) noted although wearing

Table 1
 Characteristics of participating athletes in survey (June - July 2020)

Characteristic	Number (%)
Gender (<i>n</i> = 633)	
Male	536 (84.7)
Female	97 (15.3)
Age (years) (<i>n</i> = 633)	
15-19	12 (1.9)
20-29	290 (45.9)
30-39	246 (38.9)
40-49	32 (5.0)
50-59	28 (4.4)
≥60	25 (3.9)
Wearing a mask while exercising (<i>n</i> = 633)	
Yes	448 (70.8)
No	185 (29.2)
Type of mask (<i>n</i> = 448)	
Cloth	106 (23.6)
Surgical	275 (61.4)
N95, FFP2 or equivalent	67 (15.0)
Performance affected by wearing a mask (<i>n</i> = 448)	
Yes	423 (94.4)
No	25 (5.6)
Reason for not wearing a mask while exercising (<i>n</i> = 185)	
Breathing restriction	28 (15)
Discomfort	16 (9)
Both	141 (76)

surgical or N95 masks differs from wearing respiratory masks while undertaking cycling exercise, there are no significant incremental exercise effects on lactate and ventilation thresholds and suggested increase of blood

lactate accumulation may be due to hypoventilation, higher mask carbon dioxide levels and lower oxygen levels due to the dead mask volume. Thus, it may be safe to assume that hemodynamic and metabolic changes

may not be causes of reduced exercise performance.

This may not be the case with pulmonary parameters. Johnson *et al* (2000) observed that imposing conditions with dead volume by wearing a respirator result in a proportional reduction in performance time, a 19% drop for every 350 ml of external dead volume. Fiksenzer *et al* (2020) also found a significant reduction of forced expiratory volume, peak expiratory flow, maximum power, and ventilation in participants wearing masks and, importantly, these parameters are highly impaired in those wearing N95 or FFP2 masks compared to regular surgical masks; in addition, all participants reported considerable discomfort while wearing a mask. Epstein *et al* (2021) concluded wearing a mask while exercising resulted in a mild but significant increase in end-tidal carbon dioxide levels (EtCO_2), more prominent in those wearing N95 respirators and after heavier workouts.

Effect on exercise performance while wearing face mask can also be linked to thermal stress. Li *et al* (2005) examining the effects of four types of N95 and surgical masks on thermo-physiological responses and subjective perception of discomfort while exercising observed a markedly higher heart rate while wearing nano-treated and untreated N95 masks compared to surgical masks; microclimate and skin temperatures inside surgical facemasks are lower than that of the N95 masks; absolute humidity inside surgical masks is much lower than inside N95 masks; and test ten participants reported lower tightness, itchiness, fatigue, odor, and saltiness while

wearing surgical compared to N95 mask, accompanied by a higher subjective preference. Similarly, Scarano *et al* (2020) using a thermal infrared imaging to examine participants facial heat while wearing a surgical or N95 mask reported a significant increase in humidity, heat, and breathing difficulty in individuals wearing N95 compared to surgical masks. It was previously reported wearing a face mask causes oxygen reduction and increased carbon dioxide levels as in the case of a reduction in arterial oxygen saturation in surgeons (wearing masks) during surgeries and increased expired carbon dioxide in pregnant healthcare workers wearing N95 masks, but it could be argued these changes stem from work-related stress (Beder *et al*, 2008).

Environmental ambient temperature plays a role in exercise performance. The present study show exercise performance is significantly negatively correlated with highest recorded ambient temperature in the region where participant resides. Nielsen *et al* (1987) reported exercising while wearing a protective mask at an ambient temperature of $\leq 27^\circ\text{C}$ is 100% acceptable as is working out in a cool environment with a mask air temperature of $\geq 27^\circ\text{C}$, but warm and humid air has a significant role in decreasing acceptance of wearing a mask. More recently, No and Kwak (2016) noted physiological responses and endurance to perform an exercise are different between warm and cold environment, with oxygen uptake and heart rate at rest and during submaximal exercise being higher in a cool ($10 \pm 1^\circ\text{C}$) or hot ($35 \pm 1^\circ\text{C}$) environment compared to a moderate

environment ($22\pm 1^{\circ}\text{C}$); and moreover, lower blood lactate concentrations and longer time to exhaustion are associated with a moderate environment compared to cool or hot environment. Dehydration, hyperthermia, cardiovascular strain, and reduced cardiac output are associated with exercising in a hot environment (González-Alonso *et al*, 2008).

The causes of athletes not wearing N95 or FFP2 fac mask while exercising may be associated with several factors. Lee and Wang (2011) found 126% and 122% increase in inspiratory and expiratory flow resistance respectively and a 37% reduction in air exchange volume with use of N95 mask. Increased skin temperature, absolute humidity and reduced subjective preference are linked to N95 mask wearing (Li *et al*, 2005). Elevated EtCO_2 during workouts while wearing N95 masks may subject athlete to acute respiratory acidosis, resulting in decreased exercise tolerance, headache, confusion, and in extreme cases, hemodynamic instability (Azuma *et al*, 2018), but such symptomatic changes reported by the latter and other researchers remain debatable (Chandrasekaran and Fernandes, 2020). However, the results of the present study are in agreement with the findings of Epstein *et al* (2020) and Greenhalgh *et al* (2020) that a short training period may not be sufficient to result in respiratory acidosis, but may cause a slight shortness of breath. Shaw *et al* (2020) also observed wearing a face mask during vigorous exercise has no noticeable effects on blood or muscle oxygenation or exercise performance. However, the effects of wearing N95 mask for prolonged

periods on athletic performance and hemodynamics should be evaluated to gain a better understanding of possible adverse effects.

In summary, the study shows athletes should wear surgical masks while exercising as it had a lower impact on cardiopulmonary performance and facial heat development compared to wearing FFP2, N95 or equivalent masks. In order to minimize the effect of heat, athletes should preferably workout in colder environment. Performing high-intensity exercises while wearing face masks may lead to discomfort, breathing restrictions and impaired fitness levels. Thus, policymakers may have to reconsider healthcare requirement of wearing face mask by athletes during exercise and replace with social distancing and training in open areas.

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CONFLICTS OF INTEREST DISCLOSURE

The authors declared no conflicts of interest.

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