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The Usage of Medical Mask During Brisk Walking Increases Salivary Cortisol Levels and Has A Negative Correlation to Physical Fitness

July Ivone[1]*, Stella Tinia Hasianna[2], Grace Young[3], Evelyn Calista[3]

[1]Department of Public Health, Faculty of Medicine, Universitas Kristen Maranatha
[2]Department of Physiology, Faculty of Medicine, Universitas Kristen Maranatha
[3]Faculty of Medicine, Universitas Kristen Maranatha

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Abstract

Most health organizations recommend that people should wear masks when conducting outdoor physical activities, including exercise, during the COVID-19 pandemic. This study aimed to determine the effect of using a medical mask during brisk walking on salivary cortisol levels and its correlation with physical fitness. The study used experimental, analytical, and quantitative methodologies. Twenty-eight male subjects, aged 17-25 with a normal BMI, participated in this study. The measured data were salivary cortisol hormone levels and physical fitness index after performing brisk walking with and without using a medical mask. Salivary cortisol levels were measured after carrying out exercise using the ELISA and Delta Biologicals Salivary Cortisol kit. Physical fitness was evaluated using the Harvard Step-Up Test. Data analysis was conducted using the Wilcoxon test. A correlation analysis was performed to examine the relationship between the physical fitness index and changes in cortisol levels. After using a medical mask, the average cortisol level was 23.53 ng/mL, higher than without using a medical mask, which was 11.35 ng/mL (p=0.000). The correlation test results showed a significance value of 0.029 and a Pearson Correlation value of -0.414. Physical fitness correlated negatively with increased salivary cortisol levels during brisk walking using a medical mask. Medical mask is an important preventive measure in high-risk situations for airborne disease transmission. However, alternative safety measures may be more appropriate to be applied during moderate-intensity physical exercises, such as choosing outdoor locations with safe social distancing.

✉ Correspondence Address : Jl. Surya Sumantri no. 65, Bandung
E-mail : julyivone@gmail.com

INTRODUCTION

In December 2019, a cluster of pneumonia cases caused by a novel virus was identified in Wuhan City, China. This virus had been identified as severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2), leading to coronavirus disease 2019 (COVID-19). The disease had spread globally and had been declared a pandemic by the World Health Organization (WHO). SARS-CoV-2 infection can present with a range of symptoms, from asymptomatic cases to moderate and severe manifestations, including cough, fever, and shortness of breath. Severe cases may progress to complications, such as acute respiratory distress syndrome, acute cardiac issues, multiple organ dysfunction syndrome, septic shock, and death (Iddir et al., 2020).

Until 23 August 2024, 775,867,547 cases of COVID-19 had been confirmed worldwide and caused 7,057,145 deaths (World Health Organization, 2024). In Indonesia, up to the same date, there were 6,829,399 confirmed cases of COVID-19 with 162,059 deaths (World Health Organization, 2024). Although COVID-19 infections are no longer the primary focus, the event has imparted valuable lessons, leading to significant adaptations across daily life. These include the recognition of the importance of avoiding crowded environments, enhancement of hygiene and sanitation practices, and the critical role of mask-wearing in preventing the transmission of airborne diseases (Centers for Disease Control & Prevention, 2021; Woods et al., 2020).

According to the World Health Organization (WHO) and the U.S. Centers for Disease Control and Prevention (CDC), maintaining emotional well-being involves preserving relationships with family and loved ones. Additionally, it is essential to care for our physical health by consuming a balanced diet, ensuring sufficient sleep, and engaging in a regular physical activity (Ting & Villanueva, 2020). The World Health Organization (WHO) recommends engaging in either 150 minutes of moderate-intensity physical activity or 75 minutes of vigorous-intensity physical activity each week. Performing a regular physical activity is beneficial for enhancing immune functions and reducing the risk of comorbid conditions, such as obesity, hypertension, and cardiovascular diseases, which can exacerbate COVID-19 severity. Physical activity can thus play a role in improving the body defense against viral infections (World Health Organization, 2020).

As the Centers for Disease Control and Prevention (CDC) and the American College of Sports Medicine (ACSM) suggested, one example of moderate-intensity physical activities is brisk walking at 3-4 mph. Brisk walking is a straightforward activity that contributes to overall health and fitness and effectively increases physical activity levels. Brisk walking offers numerous health benefits, including improved cardiovascular fitness and mental well-being. It is an accessible form of moderate-intensity exercise that can help manage weight, reduce the risk of chronic diseases, and boost overall stamina. Additionally, brisk walking promotes better mood and stress relief, improving overall emotional and physical health (Hasianna, Ivone, Christanti, & Calista, 2022; Linda S Pescatello, Ross Arena, Deborah Riebe, 2014).

Medical masks are effective in preventing the spread of the coronavirus (Ippolito et al., 2020). However, wearing a medical mask during physical activity can obstruct the airway, compromising oxygenation and comforts. Studies have shown that using a medical mask may increase carbon dioxide levels (hypercapnia) (Epstein et al., 2020). Hypercapnia disrupts homeostasis, activating peripheral chemoreceptors. This disruption triggers the hypothalamic-pituitary-adrenal (HPA) axis, leading to increased secretion of ACTH and cortisol by the anterior pituitary and adrenal glands (Kisielinski et al., 2021).

The release of adrenaline and cortisol hormones significantly impacts the body metabolic response during physical exercise. Cortisol, which responds to stress, interacts intricately with the hypothalamic-pituitary-adrenal (HPA) axis. During exercise, the hypothalamus secretes corticotropin-releasing hormone (CRH), which stimulates the anterior pituitary to release adrenocorticotropic hormone (ACTH), prompting the adrenal cortex to release cortisol (Thau & Sharma, 2019).

Research by Chandrasekaran et al. (2020) recommends that social distancing is preferable to wearing facemasks during exercise, advocating for the optimal use of facemasks rather than its overuse during carrying out physical activities. Exercising with a facemask may reduce available oxygen and increase air trapping, hindering effective carbon dioxide exchange. This hypercapnic hypoxia condition could create an acidic environment, increase cardiac load, promote anaerobic me-

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tabolism, and strain renal function. These factors may impair physical fitness, ultimately preventing the primary goal of exercise, for instance improving health, from being achieved (Chandrasekaran & Fernandes, 2020).

This study was conducted to investigate the effects of wearing a medical mask during exercise on cortisol levels and physical fitness, aiming to contribute to the scientific data regarding recommendations for mask use during performing physical activities.

METHODS

Participants and Samples

Subjects were selected using consecutive sampling, including those who met the inclusion criteria and consented to participate. The inclusion criteria for this study were male subjects aged 18-25 years with a normal BMI who were willing to participate from the beginning to the end of the study. Exclusion criteria included the use of medications that affect cortisol levels, such as antihistamines and corticosteroids, as well as having asthma, cardiovascular diseases, musculoskeletal issues, or chronic lung diseases. For safety purposes, a COVID-19 rapid antigen test was administered before each procedure, and only those with non-reactive results were allowed to proceed. Thirty male participants were enrolled in the study, but two were excluded due to reactive COVID-19 test results.

Materials and Apparatus

In this study, individual heart rates were measured by using a smartwatch. A metronome guided the pace for the Harvard Step-Up Test. The Physiology Laboratory provided the bench for the Harvard Step-Up Test at the Faculty of Medicine, Maranatha Christian University. Saliva samples were collected post-exercise using Salivette tubes, while cortisol levels were tested using the Delta Biologicals Salivary Cortisol kit. The Sensi-Mask 4 Ply Double Filter Earloop Surgical Mask was the medical mask used.

Procedure

This study was approved by the Ethics Commission of the Faculty of Medicine, Maranatha Christian University, under reference numbers 015/KEP/III/2021 and 017/KEP/III/2021. Recruitment was conducted among Faculty of Medicine, Maranatha Christian University, students who met the inclusion criteria. After explaining the study, informed consent was obtained from willing participants. Participants were instructed to avoid strenuous physical activity and to sleep for six to eight hours the night before the study. On the day of the study, a rapid COVID-19 test was performed. Only subjects with a negative result were allowed to proceed. All exercise procedures were conducted on a safe, non-slippery surface, with warm-up exercises performed beforehand and cool-down exercises afterward. Participants engaged in a 30-minute brisk walk, maintaining a pace that achieved their target heart rate. The walking protocol involved continuous stepping, ensuring each step was completed with the front foot touching the ground before the rear foot left (Ciravegna et al., 2019). Following the exercise, subjects collected 0.5-1 ml of saliva in a Salivette tube for cortisol analysis. The study was repeated one week later, with participants wearing a medical mask.

Data Collection and Analysis

The physical activity was conducted through brisk walking within a moderate-intensity range, determined by measuring the Target Heart Rate (THR) at 64%-76% of the maximum heart rate. The maximum heart rate was calculated using the formula 220 minus the participant (Bushman, 2023).

Salivary cortisol was collected in salivettes. The salivettes used were push caps with swabs made of polypropylene, specifically designed to analyze salivary cortisol. All saliva samples were frozen at −20°C until they were ready for assay. Before analysis, the samples were thawed and centrifuged for 10 minutes at 3500 rpm. Salivary cortisol was measured in ng/mL using the ELISA method.

Physical fitness was assessed using the Harvard Step-Up Test, which involved stepping up and down on a bench or staircase for a maximum of 5 minutes at a metronome pace of 120 beats per minute (bpm). The test was stopped when the participant became fatigued or could not maintain the metronome pace and the duration was recorded. Recovery heart rates were measured at 1-1.5 minutes, 2-2.5 minutes, and 3-3.5 minutes after the test. The recommended bench or stair height for the Harvard Step-Up Test is 50.8 cm. The physical fitness index was then calculated by multiplying the total stepping time in seconds by 100 and dividing by twice the

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sum of the three heart rate measurements (Malamassam et al., 2019). The resulting Physical Fitness Index score was interpreted according to the interpretation provided in Table 1.

Table 1. Physical Fitness Index

Rating	Physical Fitness Index
Excellent	>90
Good	80-89
Average	65-79
Below average	55-64
Poor	<55

The study used experimental, analytical, and quantitative methodologies. Statistical analysis was performed using SPSS version 22.0. Data were analyzed using the Wilcoxon test with a significance level set at α = 0.05. A correlation test examined the relationship between the physical fitness index and the increase in cortisol levels.

RESULT

Table 2 presents the average results of salivary cortisol levels and the physical fitness index following 30 minutes of brisk walking, both with and without wearing a medical mask. The mean of salivary cortisol level among the 28 participants was 11.35 ng/ml (standard deviation of 8.29) without a medical mask and 23.53 ng/ml (standard deviation of 13.84) when using a medical mask. The Shapiro-Wilk normality test indicated that the salivary cortisol data were not normally distributed. Consequently, a Wilcoxon test was taken, revealing a significant difference (p-value = 0.000).

For the physical fitness index, the mean value without a medical mask was 24.09 (standard deviation of 9.39), while with a medical mask, it was 37.50 (standard deviation of 9.81). The Shapiro-Wilk normality test showed that the physical fitness index data were normally distributed. Subsequent analysis using a paired t-test demonstrated a highly significant difference between the two conditions (p-value = 0.000).

The Pearson Correlation Test was performed in Table 3 to assess the correlation between the physical fitness index and cortisol levels during brisk walking. The Pearson correlation analysis revealed a significant negative correlation between increased cortisol levels and the Physical Fitness Index, with a correlation coefficient -0.414 (p=0.029). Higher cortisol levels are associated with lower physical fitness index scores.

Table 2. The Effect of Mask Use on Saliva Cortisol Levels and Physical Fitness Index

Parameter		Mean	SD	Sig.
Saliva Cortisol Level	Pre-test	11.35	8.29	0.000
	Post-test	23.53	13.84	
Physical Fitness Index	Pre-test	12.42	9.39120	0.000
	Post-test	6.02	9.81273	

Table 3. The Effect of Mask Use on Saliva Cortisol Levels and Physical Fitness Index

	Pearson Correlation	Sig.
Increased Cortisol Levels	-0,414	0,029
Physical Fitness Index	-0,414	0,029

DISCUSSION

This study was conducted during the COVID-19 pandemic in response to the recommendation for using medical masks during all outdoor activities, including physical exercise. The research was driven by curiosity regarding the impact of this guideline. Although mask-wearing is no longer mandated, specific populations are still required to wear masks as part of their daily activities. The World Health Organization (WHO) recommends using non-medical or medical masks for individuals aged 60 years or older and those with underlying comorbidities linked to a poorer COVID-19 prognosis in specific situations. These include living in overcrowded environments or settings, such as refugee camps, slums, or similar conditions. The recommendation also applies to individuals using public transport or working in roles that require close contact with many people, such as social workers, cashiers, and servers. Additionally, the general population is advised to wear masks in public spaces, including grocery stores, workplaces, social gatherings, mass events, and enclosed settings, such as schools, religious institutions, and other areas with widespread or suspected COVID-19 transmission where other containment measures, like physical distancing and contact tracing, are limited or una-

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vailable (Royo-Bordonada, García-López, Cortés, & Zaragoza, 2021).

Medical masks during physical activity can obstruct the airway, potentially compromising oxygenation and comforts. This obstruction may activate peripheral chemoreceptors, which in turn, trigger the hypothalamic-pituitary-adrenal (HPA) axis, leading to increased secretion of adrenocorticotropic hormone (ACTH) by the anterior pituitary and cortisol by the adrenal glands (Epstein et al., 2020; Wood, Clow, Hucklebridge, Law, & Smyth, 2018a).

This study demonstrated a significant increase in salivary cortisol levels among 28 participants after wearing a medical mask during brisk walking, compared to brisk walking without a mask. The mean of salivary cortisol level increased from 11.35 ng/mL before the test to 23.53 ng/mL after the test with a mask, indicating a notable rise in cortisol levels associated with mask use. Statistical analysis using the Wilcoxon test revealed a significant increase in cortisol levels when wearing a medical mask during brisk walking ($p < 0.001$), suggesting that mask usage during exercise heightens physiological stress.

The findings of this study align with the widely accepted theory that moderate physical activities, such as brisk walking, increase cortisol levels (Budde, Machado, Ribeiro, & Wegner, 2015). In addition, another study found a significant correlation between a decrease in oxygen levels and fatigue ($p < 0.05$). These findings suggest that extended mask-wearing by the general population could have important implications and consequences in various medical fields (Kisielinski et al., 2021).

Zhixing Tian et al. (2020) reported that medical masks can impact the stress response and elevate stress indices by inhibiting breathing and affecting autonomic nervous system regulation (Tian, Kim, & Bae, 2020). Short-term activation of the stress response is adaptive and necessary for normal functioning, but repeated activation can lead to cortisol dysregulation and disruptions in circadian rhythms, which are associated with various physical and psychological health issues (Wood et al., 2018a).

The correlation test between the physical fitness index and increased cortisol levels yielded a significance value of 0.029 ($p < 0.05$), indicating a relationship between physical fitness and cortisol levels. The Pearson correlation coefficient of -0.414 ($r = 0.26 – 0.50$) reflected a moderate negative correlation, suggesting that higher cortisol levels are associated with lower physical fitness during exercise with a mask. Cortisol levels are associated with physical activity intensity, with cortisol being a catabolic hormone contributing to muscle tissue breakdown and fatigue (Wood, Clow, Hucklebridge, Law, & Smyth, 2018b). Consistent with this study, research by Wood et al. (2020) found a relationship between physical fitness and cortisol secretion in non-athletic healthy individuals, with the "fitter" group exhibiting lower overall cortisol output. This finding suggests that physical fitness in a non-athletic population may play a crucial role in mitigating the negative impacts of stress on health (Wood et al., 2018a).

CONCLUSION

Medical mask use during brisk walking increases salivary cortisol levels and negatively correlates to physical fitness. Medical masks are crucial for preventing airborne disease transmission in high-risk scenarios. However, other safety measures, such as exercising outdoors with an adequate social distancing, may be preferable during carrying out moderate-intensity physical exercise. This study limitations include the subject diverse physical conditions, habits, and environments and its focus on the acute effects of a single exercise session. Future research could investigate the chronic effects of medical mask use during physical activity or seek ways to minimize the adverse effects of mask-wearing during exercise. Although the COVID-19 pandemic has mainly been addressed, mask use remains relevant in various daily activities, such as for medical professionals or individuals exposed to high levels of air pollution.

CONFLICT OF INTEREST

The authors declared no conflict of interest.

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