Original Article

Wearing a surgical mask does not affect the anaerobic threshold during pedaling exercise

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ABSTRACT

The effect of wearing a surgical mask on cardiopulmonary function and anaerobic threshold (AT) has not been reported. Thus, we aimed to determine whether cardiopulmonary function and AT vary while wearing surgical masks. Six healthy men were enrolled and underwent the cardiopulmonary exercise (CPX) stress test under two different conditions (with and without a commercially available surgical mask) to evaluate their AT. To confirm that there was no breath leakage, a gas mask connected with a respiratory gas analyser was worn over the surgical mask when the participants performed the CPX. The AT was measured by the V-slope method. Moreover, the AT time, exercise load, oxygen consumption, and ventilation values after the CPX were determined. No significant differences were found between the two conditions. The number of complaints of respiratory distress, however, was significantly higher while wearing a surgical mask. The exercise intensity achieved by each participant was equivalent, irrespective of whether they wore the surgical mask; therefore, wearing a surgical mask does not affect cardiopulmonary function during vigorous exercise.
Keywords: Exercise; Cardiac rehabilitation; Cardiopulmonary function.

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INTRODUCTION

Aerobic exercise, using a bicycle ergometer or a treadmill, is a typical training program for whole-body endurance improvement (Bouaziz et al., 2015). It is recommended for the prevention from a cardiovascular disease development by lowering the triglycerides and low-density lipoprotein cholesterol levels (Koba et al., 2011). Moreover, it helps to maintain and improve the cardiopulmonary function, as it is widely implemented in disease prevention, health promotion, and sports performance improvement based on the lifestyle (Moholdt et al., 2012). Moreover, it is suggested as an exercise therapy for the elderly, as it increases the cardiopulmonary function, which may reduce the cardiovascular disease-related mortality (Moholdt et al., 2012; Blair et al., 1995).

However, it is extremely difficult to determine the suitable aerobic exercise intensity required for optimal improvement with minimal aerobic or even biomechanical strain (Amorim et al., 2015). The anaerobic threshold (AT), the point at which the energy required for physical activity can no longer be primarily produced by the aerobic system and must be compensated by an upregulation in anaerobic energy production during the gradual increase in exercise intensity, can be calculated using a respiratory gas analyser. It is, therefore, considered an index for determining the appropriate aerobic exercise intensity for long-duration exercise rehabilitation (i.e., an exercise intensity that is proportionate to the individual's motor ability to perform safe and beneficial exercise) (Beaver et al., 1986), which gains more importance by considering that anaerobic exercise cannot be performed by the elderly with cardiovascular diseases (Patel et al., 2016). Therefore, performing the cardiopulmonary exercise (CPX) stress test is desirable, as it may indicate the appropriate exercise load that would not cause excessive burden on the cardiopulmonary function and prevents the subsequent risk to the mental and physical function impairment in daily life.

Conversely, wearing a surgical mask during long-duration exercise may be uncomfortable, as reflected by reports of respiratory distress in patients performing exercise when wearing the mask. The surgical mask is a hygiene-related product that is widely used for infection prevention, as it obstructs particles, such as pollen and dust, from entering the body. In particular, the surgical mask has a high face adhesion index and high bacterial and particulate filtration efficiency but induces respiratory resistance due to the structure of the product (Patel et al., 2016). Thus, exercise using a surgical mask is expected to increase respiratory distress.

Although it has been reported that respiratory distress is enhanced by respiratory restriction associated with the surgical mask, there is no report examining the effect of the product on the cardiopulmonary function. Indeed, this aspect must be considered when prescribing the appropriate aerobic exercise intensity at the rehabilitation site if it is established that the respiratory restriction associated with the surgical mask affects the cardiopulmonary function (Jung HC et al., 2019). Therefore, this study aimed to evaluate whether cardiopulmonary function and AT vary when surgical masks are worn. We hypothesized that the AT will be attained sooner during aerobic exercise while wearing a surgical mask.

MATERIALS AND METHODS

Participants

This study was conducted at our institution from September 24 to September 27, 2015. The participants were six healthy male staff members of the hospital who did not perform regular exercise (mean age, 24.0 ± 2.1 years; mean height, 171.0 ± 8.8 cm; mean weight, 61.2 ± 9.0 kg). They were asked to refrain from eating, smoking, and vigorous physical activity from 2 h before CPX performance. The participants verbally agreed to undergo the CPX test, and all signed an agreement form after written informed consent was provided.

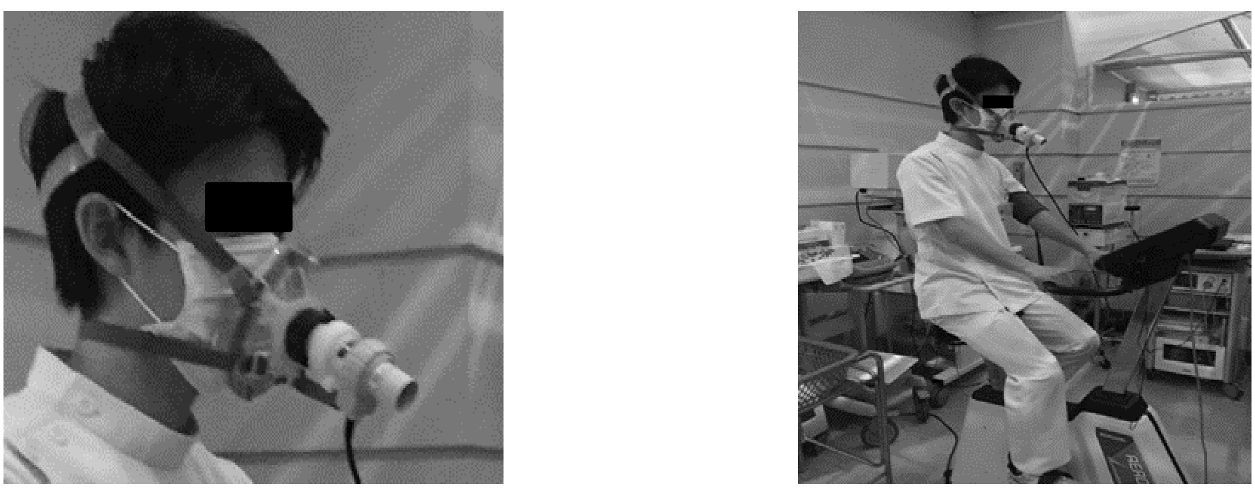
All procedures performed in this study were in accordance with the Declaration of Helsinki and its later amendments or with the comparable ethical standards. The participants were informed orally and in writing regarding the purpose, methods, and expected dangers of the study and assured of personal information protection. Moreover, before the initiation of each CPX test, the presence or absence of physical conditions and pain was verbally confirmed.

Cardiopulmonary exercise test

The participants performed the CPX with and without surgical mask-wearing (Saraya Co., Ltd., Osaka, Japan) in random order (Table 1). The interval between the two procedures was more than 1 week. The participants wore a gas mask over the surgical mask and performed CPX with an exhaled gas analyser (Minato Medical Science, Osaka, Japan). Additionally, it was confirmed that there was no breath leakage while wearing the surgical mask (Figure 1). The exercise load was measured on a bicycle ergometer (Aerobike 75xlii, Konami, Tokyo, Japan). After 4 min of rest without moving on the ergometer, the participants gradually pedalled and warmed up for another 4 min. The test proceeded to continuous pedalling exercises at a gradual load of 20 W per min. The participants were instructed to perform pedalling exercises to the limit and raise their hands when they reached it. They remained on the bike for subsequent cooling down at a load of 20 W for 4 min before exercise completion. We measured the following variables: AT, as measured by the V-slope method; AT-occurrence time (AT time); power (W); oxygen consumption (VO2), and ventilation amount (VE). Moreover, leg fatigue and breathing difficulty assessments were performed using a modified Borg scale (rate of perceived exertion, RPE) every min.

Table 1. Technical features of the surgical masks.

Bacteria Filtration Efficiency (%)	≥ 98
Submicron Particulate Filtration Efficiency (%)	≥ 98
Respiratory resistance (mmH_2O/cm^2)	< 4



Note: The gas mask was secured to prevent breath leakage. The masks were adjusted to enable breathing through the gas mask.

Figure 1. Cardiopulmonary exercise test.

Statistical analysis

The experimental data are expressed as mean ± standard deviation. For all statistical analyses, SPSS version 25.0 (IBM Inc., Armonk, NY, USA) was used. A paired t-test was conducted to compare the surgical mask-wearing and mask-free conditions.

RESULTS

There were no significant differences in the following parameters when comparing the surgical mask-wearing and mask-free conditions: AT time (12.5 ± 1.2 min vs. 11.9 ± 1.5 min, $p = .1$); power (108.0 ± 37.9 W vs. 104.0 ± 30.6 W, $p = .2$); VO_2 (1398.8 ± 376.5 mL/min vs. 1209.5 ± 332.2 mL/min, $p = .8$); VE (34.1 ± 7.2 l/min vs. 32.2 ± 5.9 l/min, $p = .3$); and RPE (6.3 ± 2.2 vs. 5.0 ± 1.8; $p = .1$). However, the RPE value, which measures the perceived breathing difficulty, significantly increased when wearing a surgical mask (6.6 ± 1.5 vs. 4.6 ± 1.0; $p = .04$).

DISCUSSION

This study aimed to analyse the effect of wearing or not a surgical mask on respiratory restriction after performing CPX. We hypothesized that the AT would be attained sooner in the surgical mask-wearing condition.

Our results suggested that breathing restriction by wearing a surgical mask did not affect the cardiopulmonary function because there was no significant difference in the AT time between the surgical mask-wearing and mask-free conditions. The AT is an indicator of aerobic capacity and can be determined by gradually increasing the exercise intensity at the rehabilitation sites. As the patients with heart and respiratory diseases have low AT, it was hypothesized that the AT could be further compromised when wearing a surgical mask and that additional modifications in the exercise intensity are required for the safe rehabilitation of these patients (Matsumura et al., 1983; Koike et al., 1992). However, considering that there were no differences in the respiratory values after exercise with and without wearing a mask, it may not be necessary to apply these practices in patients with heart and respiratory diseases. Moreover, exercise performed when wearing a mask has the same effect as normal aerobic exercise.

Further, the respiratory pain levels, as measured by the Borg Scale, were significantly higher after exercising with a surgical mask. Dyspnoea is considered to be involved in the stimulation of the sensory receptors, and higher respiratory muscle activity is required in case of dyspnoea than for normal ventilation (Berger et al., 2002; Kido et al., 2013). However, this study did not show significant changes in the VE, suggesting that the cause of dyspnoea did not stem from respiratory muscle activity. Similar findings have been previously reported, suggesting that respiratory restrictions caused by masks are affected by the brain function and may have an effect on fatigue (Motoyama et al., 2016). Conversely, another study reported that high respiratory distress and discomfort is a result of increased facial temperature while wearing a surgical mask (Luximon et al., 2016). Under these conditions, the discomfort to the head and face increases and has been correlated with respiratory resistance (Li et al., 2015). Additionally, there were complaints of discomfort in 75% of the 372 households whose residents wore a surgical mask, attributed to increased heat and humidity (Canini et al., 2010). Therefore, dyspnoea that resulted from wearing a surgical mask can be caused by various other factors apart from the increased respiratory muscle activity.

In contrast, surgical masks that are developed exclusively for training are considered beneficial for respiratory muscle function and wearing of such masks is suggested as a training method to improve the overall endurance (Porcari et al., 2016). Although the surgical mask caused respiratory resistance, there was no significant difference in the VE, suggesting that exercise training with surgical masks does not affect the endurance and respiratory function improvement compared to the mask-free condition. Additionally, training combined with breathing resistance and sustained physical exertion was reported to be beneficial for improving the endurance and respiratory muscle function (Kido et al., 2013).

In summary, this study evaluated the effect of wearing a surgical mask during pedalling on the AT. Exercise while wearing a surgical mask did not decrease the AT time of the examined participants. Therefore, as similar exercise load intensity was achieved with and without wearing surgical masks, it is suggested that performing exercise when wearing a surgical mask does not affect the cardiopulmonary function.

However, our study had some limitations. First, there were only six participants, and it is necessary to consider the recruitment of more participants to obtain more data in the future studies. Further, as commonly used face masks were used in addition to the surgical masks, it is necessary to consider the effects of other types of face masks. Moreover, this study was intended for healthy men who do not perform exercise regularly, making it important to study an alternative demographic population, such as patients, because it is not necessarily possible to obtain the same results for elderly people and patients with heart and respiratory diseases.

CONCLUSIONS

This study evaluated the effect of pedalling movements on the AT while wearing a surgical mask. The results suggested that, although the perceived respiratory stress increased, wearing a surgical mask did not affect the cardiopulmonary function. Therefore, it is not necessary to consider the respiratory restrictions when assigning aerobic exercise intensity when wearing a face mask in healthy individuals. However, as the results of the RPE evaluation revealed that the respiratory pain had increased, the patients may consider that it is useless to perform an exercise at high intensity. Therefore, sports trainers, including physiotherapists, should not increase the burden by suggesting wearing of a surgical mask; it must be explained that the exercise intensity is a significant parameter when performing bouts of exercise.

AUTHOR CONTRIBUTIONS

Atsuya Otsuka: Research conception or design, data collection, analysis and interpretation of data, writing a paper. Junya Komagata: Supervision (writing a paper). Yuta Sakamoto: Supervision (writing a paper).

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DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

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