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Effect of High Intensity Interval Training Under Mask on Forced Vital Capacity in Football Players

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ABSTRACT

International Journal of Exercise Science 16(6): 576-586, 2023. The purpose of the study was to investigate the effect of high interval training (HIIT) under mask on forced vital capacity in football players. Fourteen male football players (age 20 ± 2 years) were randomized into the without mask group (CON) or with the 2 difference mask groups [Surgical mask (SM), FFP2 mask (FM)]. HIIT program were implemented six movements in each session three times per week. Body composition, forced vital capacity and percutaneous oxygen saturation test were taken before and after 4 weeks intervention. The results show that forced vital capacity was statistically significant increased with both types of masks (SM: 5.68 ± 1.07 L; FM: 5.26 ± 0.86 L; CON: 4.66 ± 0.48 L, $p < 0.01$). Additionally, not significant difference in percutaneous oxygen saturation (SpO_2) was found, and fat free mass (SM: 54.45 ± 4.01 kg; FM: 57.08 ± 4.38kg; CON: 58.34 ± 1.81 kg, $p<0.01$) were statistically significant changed with SM and CON but not FM. In conclusion, wearing surgical masks and FFP2 face mask during high-intensity interval exercise showed certain positive impacts on cardiopulmonary function. This short-term high-intensity interval training can be used to improve forced vital capacity performance among football players. This finding can be applied to develop the strength of breathing muscles in the future.

KEY WORDS: Mask, high intensity interval training, forced vital capacity

INTRODUCTION

Due to the COVID-19 situation and high levels of fine particulate matter (PM2.5) in the air, wearing a mask was advised. The COVID-19 pandemic has impacted every aspect of life and triggered a surge in demand for facemasks to protect against transmission. Regular exercise in a safe environment is an important strategy for staying healthy during this crisis. Cardiorespiratory fitness is defined by the body's ability to process oxygen, distribute it to the body systems efficiently and maintain exercise intensity it is imperative to practice continuously to help optimize performance for the competition of football players. The aim of the use of face masks is to reduce respiratory droplet excretion from individuals, thereby reducing respiratory virus infections [22, 24, 26]. Currently, the use of a face mask is mandatory for physical exercise in sports centers. Surgical and FFP2 masks are the most widely used types of face masks, but they meet different filtration requirements. The FFP2 mask filters small airborne particles and provides less face-seal leakage, so it is more efficacious at reducing viral infections than surgical masks. So, FFP2 face masks provide superior protection to surgical face masks [35, 6, 16]. However, despite the fact that masks can effectively minimize virus transmission, they are seen as uncomfortable, and wearing a face mask while exercising can limit airflow and lower oxygen levels, resulting in breathing difficulties and shortness of breath [5, 19]. As a result, there have been concerns that wearing a mask for an extended period of time could be hazardous or dangerous, particularly when doing higher-intensity activities.

At present, controversy about mask-wearing during exercise issues, and masks have been applied in exercise to professional athletes, for helping to improve athletic performance in competition. Wearing a face mask could have an effect on human physiological functions, particularly cardiopulmonary function, according to some recent research [38, 5, 8]. Other research report that wearing a mask during intense exercise had no obvious effect on the exercise performance of healthy young people, such as blood or muscle oxygenation and exercise performance [34]. The respiratory system is one of the important components of physical fitness to supply of oxygen to the muscles. The most important part of inhalation & exhalation are the muscle that helps in breathing which consists of a group of main muscle such as diaphragm muscle, intercostal muscle. In addition, Searching for new ways to improve the body's ability to utilize oxygen uptake is a significant facet of exercise science. Exercising high intensity intervals at altitude has been proven to increase VO_{2max}, as well as generate many other physiological adaptations, including ventilator adaptations, such as increasing forced vital capacity (FVC) [12, 25, 3, 14, 4, 31]. FVC is the amount of air that can be forcefully blown out after full inspiration. So, football players require strength and endurance and take a long time to the competition. And the respiratory system is an indicator of physical fitness to supply oxygen to the muscles. Most of the training for aerobic capacity involves a variety of training styles, such as Continuous training, Interval training, and Circuit training. However, the influence of masks on human cardiopulmonary function during exercise remains unclear.

Additionally, high-intensity interval training (HIIT) has recently been used as an alternative to traditional endurance training to alter cardiorespiratory fitness, as represented by maximal oxygen uptake (VO_{2max}) and muscle metabolism. This regimen of training is characterized by 2–6 weeks of short duration (10–30 seconds), repeated efforts at near-maximal to supramaximal work rates, interspersed with periods of recovery [1, 18]. HIIT has historically been used by elite athletes [3, 14]. HIIT has significantly increased VO_{2max}. HIIT's benefits have been extensively studied led to improved football performance, substantiated as distance covered, level of work intensity, number of sprints, and number of involvements with the ball during a match [14]. According to previous study, there is little research on the effectiveness of HIIT under masks in football players. Hence, it is important to assess the potential effects of different face masks in these football players. The purpose of this study is to determine the effect of high intensity interval training under mask on forced vital capacity in football players.

METHODS

Participants

This study is a randomized experimental design. Fifteen male football players (ages 12-22 years old) volunteered to participate in the study. Participants were eligible if they met the following inclusion criteria: age 18–22 years, individual maximal oxygen consumption (VO_{2max}) > 42.5 mL/kg/min, and without no dangerous comorbidities or contagious diseases that would hinder participation. The following are exclusion criteria: cardiovascular disease, respiratory disease, acute illness, unstable hypertension, and angina. Having had a musculoskeletal injury, and a history of fractures of the lower limb within the past 3 months. An a priori power analysis using statistical software (G*power V 3.1.9.4) was completed to determine an adequate sample size. All participants were divide in three groups (Surgical mask: SM = 5 male, FFP2 mask FM = 5 male, without mask CON = 5 male). On their first visit to the laboratory, each subject underwent a medical check-up consisting of a physical activity readiness questionnaire measurement. This study was approved in advance by the Human Research Ethics Committees, Khon Kaen University reference No. HE652123. Each participant voluntarily provided written informed consent before participating. This research was carried out fully in accordance to the ethical standards of the International Journal of Exercise Science [27].

Protocol

Participants visited the laboratory two times. All testing sessions were performed at the same time during the day for each individual the protocol was explained in the first training session. All tests were performed at the same time of day, at least 48 h apart from each other, and completed within two weeks. During the test period, subjects were instructed to continue their normal training routine but to abstain from strenuous and prolonged (> 30 min) exercise 24 h prior to the assessment. Each participant was given a thorough explanation of the testing procedures and workout routines, and questions were welcomed. All tests were carried out in standardized laboratory under constant environmental conditions (60% humidity and 20 – 22 °C). The participants were blinded with regard to their respective test results to avoid influence by an anticipation bias.

Morphological measurements included body height, body weight, fat mass, and fat-free mass using a stadiometer and bioelectrical impedance method (InBody Body Composition Analyzer, Tanita Company). BMI was measured calculated based on body height and weight. Before the measurement, participants were asked to refrain from drinking excessive amounts of water.

Spirometry was performed in accordance with recommended standards [36], Spirometry was performed using the Quark Spiro (Cosmed Pulmonary Function Equipment; Italy). Pulmonary function test followed the COSMED Quark Series, Spirometry was performed in a standing position before any warm-up, and a nose clip was used during spirometry testing to prevent respiration throughout the nasal passage while performing the testing maneuver. Pulmonary function tests were performed three times for each participant and the best technique was accepted on the same day immediately after anthropometric measurements.

The 4-week intervention was carried out under close observation at the laboratourium of North Eastern University, Thailand. Exercise interventions commenced one week after the last measurement day. Prior to the intervention, a familiarization trial is provided to acquaint the participants with the training procedure. Training and recovery times will be recorded manually using a digital stopwatch by the same researcher. Both the face mask groups and the control group are conducted three times per week on Mondays, Wednesdays, and Fridays for eight weeks. If the participants are unable to attend a scheduled exercise day, the exercise is performed on the next day and monitored by the same researcher. Participants' three groups performed four sessions of a HIIT program by performing multiple functional exercises using their own body weight. Six movements were implemented in each session, consisting of Squat Jump, Push up, Jumping lunge, Skipping, Burpee, and Butt kickers. In addition, the day before each test, eligible subjects are required to refrain from engaging in excessive physical activity or high alcohol consumption the day before each test.

Participants' HR is monitored during the session using a chest-strap heart rate monitor (Polar Team H10), and the Polar Team wearable participant monitoring system will display an accurate real-time heart rate on the iPad. To ensure that the interventions are carried out at the proper exercise intensity.

The maximum heart rate (HR_{max}) of each session is considered to be exercise periods by 30s at 90 – 95% interspersed by 15-second recovery periods at 50 – 55% of the HR_{max} that were recorded during the test Age-max cardiac prediction was calculated as (220 - age) x percent intensity (90 - 95 percent for HIIT and 50 - 55 percent for recovery periods). All of the sessions started with a standardized 10-minute warm-up and ended with a 10-minute cool-down, for a total of 40 minutes.

Blood oxygen saturation (SpO_2) analyses are collected immediately 2 min after the intervention test and analyzed using a fingertip pulse oximeter on the right index. All tests are carried out under standardized laboratory conditions, and the tests are conducted in an environmentally controlled room (22 – 23 ◦C). All participants who met the research's eligibility requirements made a total of 24 visits to the intervention site.

Two different face masks were compared in this study. We used typical and widely used disposable FFP2 protective face masks (Careable Biotechnology Co., Ltd., Guangdong, China) The FFP2 mask has many layers. It's usually white and shaped to fit around the mouth and nose snugly, and surgical masks (Savant Engineering Co., Ltd., Thailand), the surgical mask is a standard blue or white medical face mask with a CE label. It's single-use with three layers of protection. both with ear loops. FFP2 protective face masks and surgical masks were used for this study. The subject was then instructed to close their nose, mouth, and chin when wearing a face mask and tighten them with head straps to ensure that were covered. During the test period, the subject is not allowed to remove their masks during the experiment, and the correct fitting and leak tightness were confirmed before each test was started. The masks are tightly fitted around the face of each participant using an adjustable plastic mask strap extender.

Table 1. Baseline basic characteristics of the subjects.

Variables	SM (*n* = 4)		FM (*n* = 5)		Control (*n* = 5)	
	Pre-test	Post-test	Pre-test	Post-test	Pre-test	Post-test
Age (years)	20.20 ± 1.30	20.2 ± 1.30	19.40 ± 1.14	19.40 ± 1.14	19.60 ± 1.14	19.60 ± 1.14
Height (cm)	171.60 ± 6.76	171.60 ± 6.76	175.80 ± 3.83	175.80 ± 3.83	175.00 ± 5.09	175.00 ± 5.09
Body mass (kg)	62.48 ± 5.20	60.37 ± 4.64	64.22 ± 6.56	64.06 ± 6.23	65.44 ± 3.09	64.72 ± 2.94
Fat mass (kg)	5.58 ± 1.44	5.92 ± 2.15	6.76 ± 2.52	6.98 ± 3.11	6.22 ± 3.24	6.38 ± 2.82
Fat free mass (kg)	56.90 ± 4.01	54.45 ± 3.05*#	58.00 ± 4.07	57.08 ± 4.38	59.22 ± 2.31	58.34 ± 1.81*#
BMI (kg/m2)	21.20 ± 0.71	20.92 ± 0.99	20.74 ± 1.51	20.68 ± 1.46	21.40 ± 1.37	21.16 ± 1.55

BMI, body mass index; kg, kilogram; cm, centimeter; m, meter, and the values were shown in mean ± standard deviation. *Significant differences between SM and CON ($p < 0.05$), #Significant differences pre and post-test ($p < 0.05$)

Statistical Analysis

The data analysis, the statistical package SPSS Version 28 software was used. Data were presented as mean ± SD. The paired samples t-test was used to compare pre training and post training variables in each group. ANOVA was used to compare variables between groups. The statistical significance was tested at the level of $p < 0.05$.

RESULTS

Baseline Characteristics: Fifteen male football players participated in the study, in which 1 subject were drop out of the study. As a result, 14 male football players were recruited in this study, there were not significant different in age, height, body mass, fat mass or BMI between each group, but the result that were statistically significant with reduced fat free mass in SM and CON group when comparing the test results from pre and post-test and between groups (Table 1).

Forced vital capacity (FVC): Data in this study indicate a statistically significant with increased forced vital capacity of the Pulmonary function test ($p = 0.009$, $p = 0.01$) when comparing the test results from before SM (3.97 ± 0.52), FM (4.08 ± 0.96), CON (4.28 ± 0.64) and after SM (5.68 ± 1.07), FM (5.26 ± 0.86), CON (4.66 ± 0.48) the 4-week high intensity interval training (Figure 1).

Percutaneous oxygen saturation (SpO_2): The statistical analysis of percutaneous oxygen saturation indicates not significant difference ($p = 0.98$) between before (96.80 ± 0.52 %) and after (97.65 ± 0.21 %) the 4-week HIIT training (Figure 2).

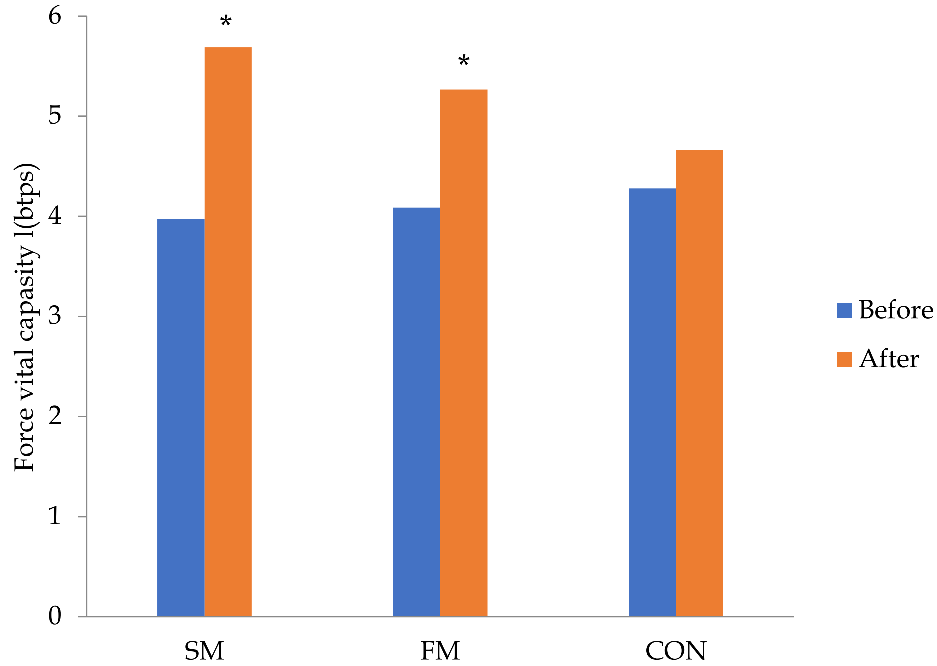

Figure 1. Effects of wearing a surgical mask (SM), a FFP2 mask (FM) and no mask (CON) on forced vital capacity (FVC); *: $p < 0.05$ = pre-post analysis.

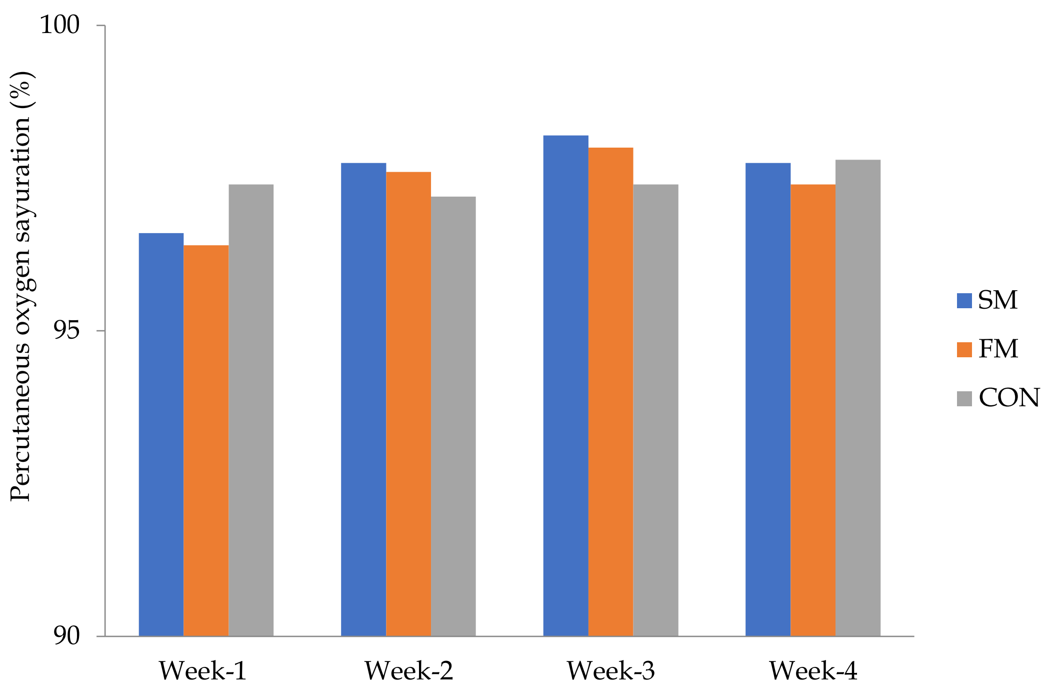

Figure 2. Effects of wearing a surgical mask (SM), a FFP2 mask (FM), and no mask (CON) on percutaneous oxygen saturation (SpO_2).

DISCUSSION

Football is a sport that requires strength and endurance and takes a long time to 90 min to complete. Distances covered at the top level are in the order of 10–12 km for the field players [37]. Aerobic metabolism is the predominant system. Especially, the respiratory system is one of the important components of physical fitness to supply oxygen to the muscles.

This study hypothesizes that short-term high-intensity interval training leads to improvements in pulmonary performance in football players. The study data indicates that short-term high-intensity interval training not significantly changes in analyzed pulmonary parameters between groups. This may be due to this study's 4-week high-intensity interval training program being a relatively short intervention. However, FFP2 mask and surgical mask show positive effects compared to pre-post training. Interestingly, both masks significantly increased pulmonary parameters at rest (FVC). These changes are consistent with an increased airway resistance [21]. This may be due to an anticipation of higher breathing resistance and subsequent adaptation. The higher workload for respiratory muscles compared to exercise with no mask is likely leading to the exertion of these muscles and consecutively strengthening maximum pulmonary function [9], and different types of masks cause different respiratory resistance, which leads to more significant respiratory resistance [17]. Previous studies had shown that after wearing N95 filter masks, the inspiratory and expiratory resistance increased by 0.43 and 0.23 mmH_2O, respectively [31].

Our results are not in accordance with a previous study [29, 39, 11, 10, 32, 20]. That analyzed the effect of surgical or ffp2 mask wearing during Incremental exercises session on cardiopulmonary exercise capacity or the effects of medical face masks on performance in well trained athletes. Showing a decrease in this forced vital capacity when the participants wore a mask. Furthermore, training characteristics can influence physiological and performance variables when wearing a mask.

The results are consistent with Cali Dunham et al. which determined that high-intensity interval training increased inspiratory muscle strength among 15 fifteen healthy subjects assigned to either a 4-week high-intensity interval training program or whole-body exercise training. Theoretically, HIIT can cause participants to hyperventilate, Due to the increased demand for oxygen during exercise, the intensity or duration of training increases along with the need for circulation by working muscles. Additionally, increased blood flow and respiratory muscle activity are required for increased respiration [38], especially, in stimulating the respiratory muscles to work harder than usual such as the diaphragm and the muscles between the ribs. The increased demand placed on the respiratory muscles during HIIT with whole-body exercise training may have contributed to respiratory muscle strength [9]. This result agrees with the study of Barnas et al (1991) [2] found that regular training for trunk muscles was good for air ventilation, effective for oxygen taking, increasing durability of breathing muscles, stronger breathing muscles, especially respiratory muscles. Based on the theory of muscle strength training, when having high intensity interval trained, changes can be obviously seen [25, 3, 14].

This means when we use parts of our body or muscles were trained, it was the way to allow muscles to work against the higher-than-normal resistance. The muscles must adjust their internal condition to overcome the resistance. The result of training was that respiratory muscles become stronger and more endurable which were related to Fox and Mathews (1981) [13.] These techniques of training can be used to improve the strength of breathing muscles very well.

Additionally, the result that were significant difference with reduced fat free mass in SM and CON group when comparing the test results from pre and post-test and between groups but not FM (Table 1). However, no dietary restrictions were imposed on participants in our study. In this study, this contrasts with the known effect of HIIT exercise, generally resulting in a reducing FM and an increase in FFM [7, 23, 28]. Similarly, to whole-body HIIT involves high execution speed and short resting periods that thereby promote muscle hypertrophy [15, 33]. Interestingly, although there was no increase in muscle mass in our study, the increase in FVC is due to the increased strength of the more efficient respiratory muscles was directly attributed to the mask effect, especially in the HIIT period of exercise.

In this study, the result of percutaneous oxygen saturation showed that there were not significant differences between groups during the post-intervention period ($p > 0.05$). However, the 4-week high-intensity interval training program in this study is relatively short compared to other studies in the high-intensity intervals. Therefore, longer training could result in greater or significant changes in forced vital capacity between groups.

To summarize, surgical masks and FFP2 masks had a certain influence on the Pulmonary function of football players during HIIT exercises, which was mainly due to the limitation of increased airway resistance.

In conclusion, this study found that wearing surgical masks and FFP2 face mask during high-intensity interval exercise showed certain positive impacts on cardiopulmonary function and suggests that short-term high-intensity interval training can be used to improve forced vital capacity performance among football players. This finding can be applied to develop the strength of breathing muscles in the future.

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