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Research Article

Examination of the Effects of Wearing Surgical Masks during Emergency Operations in a Hot Environment on the Body of Paramedics

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Abstract

Objectives: We aimed to investigate the effects of continuous overloading on the human body while wearing a surgical mask in a hot environment, specifically examining the risk of heatstroke, its evaluation methods, and associated physical tendencies.

Methods: This prospective observational study involved 28 healthy adult male firefighters. The physical effects were assessed by measuring several biomarkers and physiological parameters: Liver Fatty Acid-Binding Protein (L-FABP), salivary amylase, core body temperature, axillary temperature, body water content, muscle mass, body mass index, body fat percentage, and body weight. Measurements were taken before and after an exercise protocol that progressively increased in intensity within an artificial climate chamber set at a Wet-bulb globe temperature of 28°C.

Results: As exercise intensity increased, there were significant elevations in participants' core temperature ($p<0.001$), axillary temperature ($p<0.001$), and heart rate ($p<0.001$). Conversely, the SpO_2 levels significantly decreased ($p<0.001$). The salivary amylase levels significantly increased ($p<0.001$) from baseline to post-experiment. L-FABP was positive in 64.3% of the analyzed cases. A significant difference was observed in body fat percentage ($p=0.007$).

Conclusions: Engaging in emergency activities in hot environments while wearing surgical masks is a significant factor contributing to the risk of heatstroke. Therefore, the use of wearable sensors and other monitoring devices, alongside established measurement markers, can facilitate the early detection of heatstroke risk among emergency personnel wearing masks.

Keywords: Face mask; Heatstroke; Paramedic; Pre-hospital care.

Introduction

Prehospital emergency care is a critically important area within emergency medicine, where Emergency Medical Technicians (EMTs), including paramedics, are frequently exposed to infection risks while treating diverse patient populations. Consequently, infection control measures for EMTs are essential. In Japan, the Fire and Disaster Management Agency has issued a "Manual for Infection Control Measures for EMTs," which designates mask-wearing as a standard infection control practice [1]. The emergence of the COVID-19 pandemic has further underscored the necessity of mask usage, contributing to increased stress and fatigue among EMTs.

Additionally, Japan has experienced a rise in average temperatures annually [2-3]. In particular, hot and humid summer conditions elevate the risk of heatstroke and the physical strain associated with wearing masks, necessitating appropriate countermeasures. EMTs must deliver suitable care based on the severity of a patient's condition; however, the act of wearing a mask during emergency interventions can lead to increased stress, elevated respiratory effort, and greater physical fatigue. Firefighters, in particular, are reported to be at a high risk for exertional heat stroke [4].

The chest compressions that EMTs perform during lifesaving measures, such as Cardiopulmonary Resuscitation (CPR) in cases of cardiac arrest, require significant physical exertion. The cumulative fatigue experienced by EMTs can severely impair the quality of CPR and the overall effectiveness of these lifesaving interventions [5-10]. Furthermore, the conditions within ambulances during summer months can be particularly challenging, heightening the risk of heatstroke for EMTs. The increasing volume of emergency calls [11] further constrains the time available for rest, meals, and rehydration, complicating efforts to manage the health and well-being of EMTs.

Considering these issues, there is currently insufficient evidence regarding the impact of working in hot environments on the physiological condition of EMTs or whether this exposure can lead to heatstroke. Therefore, it is crucial to investigate the effects of heat on EMTs in hot environments and to identify the risk of heatstroke at an early stage, as part of appropriate measures for emergency activities. Additionally, it is necessary to develop an activity plan that balances heatstroke prevention strategies with the demands of emergency response.

Lifesaving interventions in emergency situations are time-sensitive, which complicates data collection on such activities in Japan. To address this, our study utilized an artificial climate chamber to control temperature and humidity, simulating a hot emergency environment. We investigated the impact of exercise while wearing a mask on the physical condition of EMTs by measuring 11 physiological parameters.

The findings of this research are anticipated to contribute to the development of effective measures and labor management programs for emergency activities. Thus, our aim was to examine the effects of continuous physical overload on EMTs while wearing a surgical mask in a hot environment.

Materials and methods

Participants

This is a prospective observational study of humans. This study included 28 healthy adult male fire department employees who had not previously applied for the position. Notably, all participants wore masks (3M surgical masks; bacterial filtration efficiency: 98%; particle filtration efficiency: 98%; and virus filtration efficiency: 98%; Hakujuji Co., Ltd., Tokyo, Japan).

Exclusion criteria

(1) A history of the disease being treated or digestive system disease.

(2) Cold symptoms, dehydration, or other physical discomfort.

(3) Unsuitability as test participants as confirmed by the principal investigator.

Criteria for discontinuing the target

(1) Core body temperature >39.5℃.

(2) Transcutaneous oxygen saturation (SpO_2) <92%.

(3) Borg Scale >19 (very tight).

(4) Onset of heatstroke symptoms [12].

(5) If the participants request that the program be canceled.

Methods

The participants wore laboratory coats (made of 100% polyester) for the experiment. The measurements were taken in an artificial climate chamber where the weather conditions could be adjusted. The indoor environment was defined as a hot environment when the wet-bulb globe temperature (WBGT: 0.7x wet-bulb temperature+0.3x globe temperature) was ≥ 28℃, which is considered to be a risk of heatstroke occurring in all daily activities. A temperature and humidity SD data logger (A&D Company, Tokyo, Japan) was used to measure the WBGT. The participants stopped eating 6 h before the experiment, and an ingestible capsule thermometer (e-Celsius, Body Cap, Calvados, France) was used to accurately measure their core body temperature.

After assessing the physical conditions of each participant-including body weight, Heart Rate (HR), blood pressure, axillary temperature, Body Mass Index (BMI), body water content, muscle mass, body fat percentage, and SpO_2-each participant was placed in an artificial climate chamber set to a WBGT of 28°C. Participants rested in a seated position for 20 min. Subsequently, each participant underwent light exercise (20% exercise intensity, equivalent to a slow walk) and a moderately strenuous exercise load (60% exercise intensity, comparable to running) for 20 min each on a treadmill (S & ME Co., Ltd. BIOMILL VO-2000, Asheville, NC, USA), all while wearing masks.

Exercise intensity was determined using the Karvonen method, where the target heart rate was calculated as follows: (target heart rate=[{220-resting heart rate} × 77%]+resting heart rate). The exercise load was controlled using the treadmill and the Bruce protocol, with speed and incline increasing every 2 min, maintained for a total of 20 min after reaching the target heart rate.

The Liver Fatty Acid-Binding Protein (L-FABP) levels and body composition metrics (body weight, BMI, body water content, muscle mass, and body fat percentage) salivary amylase levels, core body temperature, axillary temperature, HR, and SpO_2 assessed before and after the experiment. The experiment was halted when any of the following criteria were met: core temperature reached 39.5°C, SpO2 dropped below 93%, the Borg Scale (a subjective exercise intensity scale) indicated a rating of 19, or if the safety of any participant was compromised. A detailed outline of the experiment is presented in Figure 1.

The purpose and procedures of the study were thoroughly explained to the participants prior to the experiment, and informed written consent was obtained from all participants.

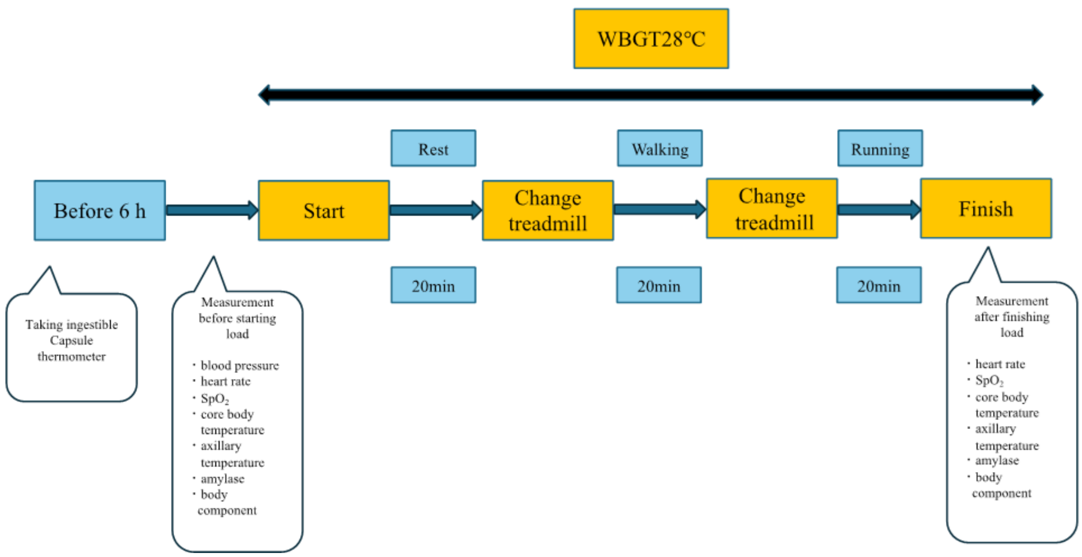

Figure 1: An experimental plan to verify the effects of increased exercise intensity on the body.

Body composition

Body composition was measured twice, before and after the experiment, using the multifrequency bioelectrical impedance method with a four-pair electrode bioelectrical impedance device (InBody 770, InBody Japan Inc., Tokyo). In addition, several physical parameters, including body weight, muscle mass, body water content, BMI, and body fat percentage, were measured.

Heart rate and saturation of percutaneous oxygen

To measure the HR and respiratory status, the SpO_2 was measured over time. The HR and SpO_2 were measured using a Masimo Radical-7 monitor (Masimo Corp., Irvine, CA, USA).

Core body temperature and axillary temperature

The core body temperature was measured using an ingestible capsule thermometer, and the body surface temperature was measured using an axillary thermometer. Core body temperature was measured using an e-Celsius (BodyCap), and axillary temperature was measured using a Thermometer C_20_7 (Terumo Corporation, Tokyo, Japan).

Salivary amylase

Analysis was conducted on values within the measurement range of the salivary amylase monitor (10–200 klu/L). The salivary amylase levels were measured in each participant by collecting saliva samples before and after the experiment using a salivary amylase monitor (Nipro Corporation, Osaka, Japan).

Liver fatty acid-binding protein measurement

Furthermore, to estimate the level of dehydration, we measured the concentration of L-FABP in urine. Urine samples (0.1 mL) were collected from each participant before and after exercise, and the concentration of L-FABP in the urine was analyzed using an enzyme-linked immunosorbent assay with the Human L-FABP Test POC Kit (CMIC Holdings Co., Ltd. Tokyo, Japan) following the manufacturer's instructions.

Outcomes

The main evaluation item examined the effects of 11 parameters on the body in hot and humid environments. The secondary endpoint was to investigate whether wearing a surgical mask during emergency activities is a risk factor for exertional heatstroke.

Statistical analysis

The effects on the body when continuous overloading occurred were divided into two groups, before and after the experiment, and the measured parameters were examined for significant effects. Statistical analysis was conducted using the Mann–Whitney U and Kruskal–Wallis tests. Statistical analysis was performed using IBM SPSS® Statistics version 29 (IBM Corp., Armonk, NY, USA), and statistical significance was set at $p<0.05$.

Results

Patient characteristics

Twenty-eight healthy adult male firefighters with a median age of 26.0 years (24.0–29.5 years) and a median BMI of 22.9 (22.5–24.0) kg/m^2 participated in this experiment. The participants had normal and stable physical conditions, and all vital signs were within the normal ranges. With an initial systolic blood pressure of 122.5 (116.0–130.0) mmHg, HR of 72 (67–77) bpm, and SpO_2 of 98% (98–98) in room air, all participants had very similar physical data (Table 1).

Parameter	Median (IQR)
Age (years)	26.0 (24.0–29.5)
Height (cm)	172.3 (168.6–175.5)
Body weight (kg)	67.7 (63.6–71.7)
Body mass index (kg/m^2)	22.9 (22.5–24.0)
Total body water contents (L)	43.1 (40.8–44.5)
Muscle mass (kg)	56.2 (53.1–58.8)
Body fat percentage (%)	14.2 (11.8–16.9)
Initial systolic blood pressure (mmHg)	122.5 (116.0–130.0)
Initial diastolic blood pressure (mmHg)	82.0 (76.0–86.0)
Initial heart rate (bpm)	72 (67–77)
Initial SpO_2 (%)	98 (98–98)

Table 1: Characteristics of human participants (n=28, male).

Characteristics of participants (n=28, male) in an experiment to determine the effects of wearing a surgical mask while undergoing increased exercise intensity. Data are presented as medians (interquartile ranges).

Changes in core body temperature, axillary temperature, heart rate, and SpO_2

With increased exercise intensity, the deep body temperature, axillary temperature, and HR increased significantly in all participants. However, the SpO_2 decreased significantly. Core temperature, axillary temperature, HR, and SpO_2 were 37.2℃ (37.1–37.4℃) and 38.5℃ (38.3–38.9℃) ($p<0.001$), 36.8℃ (36.6–36.9℃) and 38.0℃ (37.8–38.2℃) ($p<0.001$), 72 (67–77) beats per minute (bpm) and 182 (177–192) bpm ($p<0.001$), and 98% (98–98%) and 94% (93–94%) ($p<.001$) before and after the experiment, respectively (Table 2).

Parameter	Pre	Post	p-value
Core body temperature (℃)	37.2 (37.1–37.4)	38.5 (38.3–38.9)	p<0.001
Axillary temperature (℃)	36.8 (36.6–36.9)	38.0 (37.8–38.2)	p<0.001
Heart rate (bpm)	72 (67–77)	182 (177–192)	p<0.001
SpO_2(%)	98 (98–98)	94 (93–94)	p<0.001

Table 2: Changes in core body temperature, axillary temperature, heart rate, and SpO_2

Changes in core body temperature, axillary temperature, HR, and SpO_2 in healthy men during exercise with increased intensity while wearing a surgical mask. After exercise, the core temperature, axillary temperature, and HR of all participants increased significantly, whereas the SpO_2 significantly decreased. Data are presented as medians (interquartile ranges).

Liver fatty acid-binding protein measurement

The L-FABP levels were measured before and after the experiment. The results ≥ 12.5 ng/mL were assessed as positive, and those <12.5 ng/mL were assessed as negative. The L-FABP test results were positive in 18 participants and negative in 10, resulting in a positivity rate of 64.3% (Figure 2). However, comparing the characteristics of the participants in the positive and negative groups, the weight of those in the positive group was 68.2 (63.5–73.0) kg and 67.2 (62.5–71.6) kg before and after the experiment, whereas that of participants in the negative group was 66.6 (63.6–71.2) kg and 65.6 (63.0–69.9) kg before and after the experiment (p=0.708). Furthermore, the muscle mass, body water content, BMI, and body fat percentage of participants in the positive group were 55.8 (51.6–57.8) kg and 57.5 (52.6–58.9) kg, 43.4 (40.0–45.0) L and 44.6 (40.8–45.6) L, 23.3 (22.5–24.0) kg/m^2 and 22.9 (21.9–23.7) kg/m^2, and 15.3% (11.4–18.4%) and 10.8% (8.6–15.4%) before and after the experiment, respectively. However, in patients in the negative group, the muscle mass, body water content, BMI, and body fat percentage were 54.9 (52.9–56.4) kg and 55.2 (53.8–57.3) kg (p=0.792), 42.7 (41.1–43.7) L and 42.9 (41.7–44.4) L (p=0.768), 22.8 (22.5–23.5) kg/m^2 and 22.6 (22.1–23.1) kg/m^2 (p=0.396), and 13.1% (12.2–15.6%) and 10.3% (9.3–12.3%) (p=0.015) before and after the experiment, respectively (Table 3). Therefore, there were no significant differences in body weight, muscle mass, water content, or BMI; however, there was a significant difference in body fat percentage.

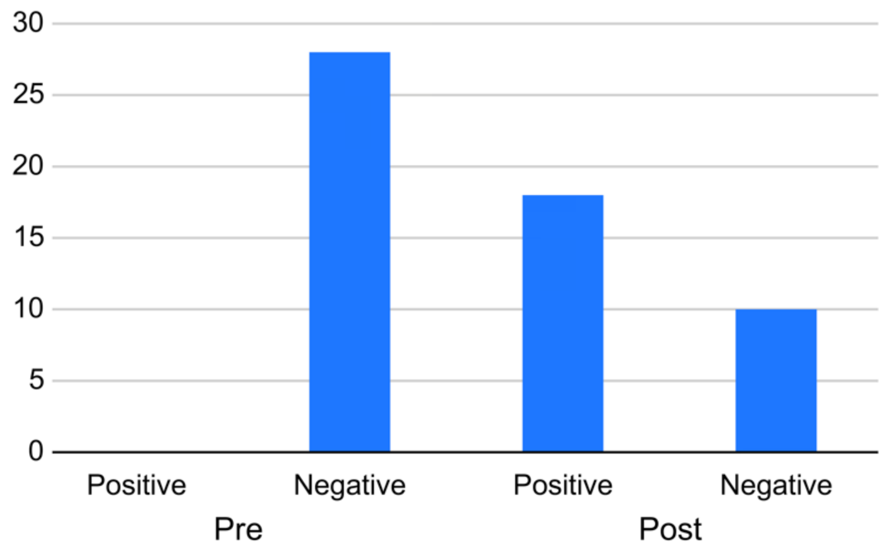

Figure 2: Results of measuring L-FABP levels in the urine of healthy men before and after the experiment showed that 18 of the 28 participants had positive reactions.

Parameter	Pre		Post	p-value
Body weight (kg)	Positive	68.2 (63.5–73.0)	67.2 (62.5–71.6)	0.708
	Negative	66.6 (63.6–71.2)	65.6 (63.0–69.9)	
Muscle mass (kg)	Positive	55.8 (51.6–57.8)	57.5 (52.6–58.9)	0.792
	Negative	54.9 (52.9–56.4)	55.2 (53.8–57.3)	
Total body water contents (L)	Positive	43.4 (40.0–45.0)	44.6 (40.8–45.6)	0.768
	Negative	42.7 (41.1–43.7)	42.9 (41.7–44.4)	
Body mass index (kg/m^2)	Positive	23.3 (22.5–24.0)	22.9 (21.9–23.7)	0.396
	Negative	22.8 (22.5–23.5)	22.6 (22.1–23.1)	
Body fat percentage (%)	Positive	15.3 (11.4–18.4)	10.8 (8.6–15.4)	0.015
	Negative	13.1 (12.2–15.6)	10.3 (9.3–12.3)	

Table 3: Characteristics of L-FABP-positive and L-FABP-negative participants.

There were no significant differences in muscle mass, body water content, or BMI between L-FABP-positive and L-FABP-negative participants; however, there was a significant difference in body fat percentage. Data are presented as medians (interquartile ranges).

Salivary amylase

The results of measuring the salivary amylase levels in each participant significantly increased from 5.7 (3.0–8.5) klu/L before the experiment to 37.0 (22.5–51.0) klu/L after the experiment ($p<0.001$).

Body composition

The weight, muscle mass, body water content, BMI, and body fat percentage of each participant were measured before and after the experiment. The body weight result was 67.7 (63.6–71.7) kg before the experiment and 66.7 (62.7–70.4) kg after the experiment ($p=0.408$), and no significant difference was observed. However, a decrease in body weight was observed after the experiment compared with that before the experiment, and the rate of weight loss was 1.5%. Furthermore, muscle mass, body water content, BMI, and body fat percentage were 55.4 (52.6–57.4) kg and 56.2 (53.1–58.8) kg ($p=0.329$), 43.1 (40.8–44.5) L and 43.7 (41.3–45.6) L ($p=0.306$), 22.9 (22.5–24.0) kg/m^2 and 22.6 (22.0–23.7) kg/m^2 ($p=0.251$), and 14.2% (11.8–16.9%) and 10.7% (8.7–14.5%) ($p=0.007$) before and after the experiment, respectively. There were no significant differences in muscle mass, body water content, or BMI; however, there was a significant difference in body fat percentage (Table 4).

Parameter	Pre	Post	p-value
Body weight (kg)	67.7 (63.6–71.7)	66.7 (62.7–70.4)	0.408
Muscle mass (kg)	55.4 (52.6–57.4)	56.2 (53.1–58.8)	0.329
Total body water contents (L)	43.1 (40.8–44.5)	43.7 (41.3–45.6)	0.306
Body mass index (kg/m^2)	22.9 (22.5–24.0)	22.6 (22.0–23.7)	0.251
Body fat percentage (%)	14.2 (11.8–16.9)	10.7 (8.7–14.5)	0.007

Table 4: Body composition change.

Changes in body composition before and after an experiment, in which the strength of healthy men increased while wearing a surgical mask. There were no significant differences in body weight, muscle mass, body water content, or BMI; however, there was a significant difference in body fat percentage. Data are presented as medians (interquartile ranges).

Discussion

In this study, we evaluated the effects of wearing a mask, a critical requirement for EMTs during emergency operations in hot and humid environments, on the risk of heatstroke. Currently, no research specifically addresses the risk of heatstroke for EMTs who must wear masks during emergencies. To our knowledge, this is the first study to examine the risk of heatstroke in EMTs operating in hot and humid conditions while wearing surgical masks.

We assessed the impact of resting for 20 min and exercising in an environment with a WBGT of 28°C-considered an “alert (active rest)” zone-on the body, using 11 physiological parameters: L-FABP, salivary amylase, core body temperature, axillary temperature, HR, SpO_2, BMI, body water content, muscle mass, body fat percentage, and body weight. Notably, 18 out of 28 participants tested positive for L-FABP. Salivary amylase levels increased significantly after the experiment compared to baseline. Additionally, significant increases were observed over time in core body temperature, HR, and axillary temperature, while THE SpO_2 levels significantly decreased. Although no significant differences were found in the BMI, body water content, muscle mass, or body weight, body fat percentage showed a significant change. These findings indicate that the 11 parameters used in this study are effective in evaluating the risk of heatstroke and highlight physical characteristics that may increase susceptibility to hot and humid environments.

Salivary amylase response

Before the experiment, the median salivary amylase level was 5.7 (range: 3.0–8.5) klu/L. After the experiment, there was a significant increase across all participants, with a median value of 37.0 (range: 22.5–51.0) klu/L. Salivary amylase has recently gained attention as a marker of sympathetic nervous system activation and is considered a direct response to physiological stress [13]. When the sympathetic nervous system is activated due to stress, salivary amylase secretion increases, providing a non-invasive measure of stress in the body. Silva, et al. [14] reported that heat exposure amplifies the stress response to exercise, with higher alpha-amylase levels observed in hot environments.

In this study, the significant increase in salivary amylase may be attributed to the participants’ exposure to high physical and thermal stress. The adherence of the mask to the skin due to perspiration, along with restricted breathing, likely compounded the psychological stress experienced by the participants. Moreover, Purssell, et al. [15] highlighted potential limitations in using salivary amylase to assess stress, as factors such as diet can influence the amount of saliva produced, which could in turn affect amylase levels. However, in our study, participants’ diet and water intake were controlled, minimizing the likelihood of such confounding effects.

Changes in heart rate, transcutaneous oxygen saturation, deep body temperature, and body composition

Core body temperature and HR significantly increased following the experiment, while the SpO_2 levels decreased. Although no significant differences were observed in body weight, muscle mass, body water content, or BMI, there was a significant change in body fat percentage. During the summer, the autonomic nervous system is placed under considerable strain in hot environments as it works to regulate body temperature. Wearing a mask to prevent infection may exacerbate this strain by trapping humid, warm air, making it difficult for the brain to cool and potentially leading to increased body temperature. The inhalation of humid air inside the mask, coupled with excessive physical activity and stress, may impair the autonomic nervous system's ability to regulate temperature, contributing to elevated body temperatures.

The increase in core and axillary temperatures is likely a normal thermoregulatory response to the physiological stress caused by excessive external stimuli. In hot environments, venous return decreases due to skin vasodilation and increased skin blood flow, alongside dehydration caused by sweating. As a compensatory mechanism, the HR increases to maintain circulation [16]. In this study, the participants' HR rose from a baseline of 72 (range: 67–77) bpm to 182 (range: 177–192) bpm after the experiment, reflecting a marked increase over time. Additionally, when the exercise load was intensified, sympathetic nervous system stimulation contributed to tachycardia.

Wearing a mask during physical exertion may increase the concentration of inhaled carbon dioxide (CO_2) due to the enlarged dead space in the mask. Shaw, et al. [17] found that wearing surgical masks can significantly impact cardiopulmonary function during strenuous exercise. The exercise load in this study is comparable to the physical demands of performing CPR in emergency settings. The observed decrease in SpO_2 may have been caused by the combined effects of mask-wearing, altered breathing patterns, and reduced ventilation volume, leading to restricted oxygen supply and CO_2 accumulation.

The reduction in SpO_2 is primarily attributed to mask-wearing during physical exertion. Moreover, a 1–2% loss in body weight is considered a mild case of dehydration, and dehydration levels of ≥ 2% should be avoided [18]. In this study, participants exhibited a 1.5% reduction in body weight, indicating the presence of mild dehydration.

Liver fatty acid-binding protein measurement

L-FABP levels were measured before and after the experiment. Notably, 18 out of 28 participants had positive L-FABP levels (≥ 12.5 ng/mL), yielding a positive rate of 64.3%. L-FABP is primarily expressed in the proximal tubules under normal physiological conditions, where fatty acids serve as the main energy source for metabolism [19]. In cases of acute kidney injury, L-FABP migrates from the cytoplasm to the lumen of proximal tubular cells, leading to elevated urinary L-FABP levels. Heat-related illnesses, such as dehydration, are also believed to increase the L-FABP levels due to ischemia and oxidative stress, which impair blood flow around the renal tubules [20-21]. The kidneys play a crucial role in regulating body temperature and maintaining hydration; however, exposure to high temperatures can overwhelm their capacity, leading to dehydration and further difficulties in regulating body temperature. Exercise-induced heat stroke has been associated with an increased risk of acute renal failure [20].

Kawakami, et al. [22] studied the effects of 30 min of aerobic exercise on renal blood flow and kidney function in middle-aged men and found that continuous moderate-intensity exercise maintained renal function by preserving blood flow. However, in the present study, 64.3% of participants showed positive L-FABP levels. The participants in previous studies were typically allowed to hydrate freely, resulting in only mild dehydration. In contrast, the dehydration in this study, likely exacerbated by dietary restrictions and perspiration in a controlled hot environment, mimics conditions that might occur during emergency response scenarios. This dehydration likely led to reduced blood flow and renal tubular dysfunction, explaining the increased L-FABP levels.

A comparison of the positive and negative groups in this study revealed a significant difference in body fat percentage. The body fat percentage in the positive group was 15.3% (11.4–18.4) and 10.8% (8.6–15.4) before and after the experiment, while the negative group had body fat percentages of 13.1% (12.2–15.6) and 10.3% (9.3–12.3) before and after the experiment, respectively (p=0.015). The standard body fat percentage for men is between 10–19%, with anything above that considered obese. In this study, both the positive and negative groups had median body fat percentages within the normal range. However, a closer examination showed that four of the 18 participants in the positive group (22.2%) had body fat percentages ≥ 20%, whereas none in the negative group had such levels. Dervis, et al. [23] reported a significant increase in core body temperature in individuals with higher body fat percentages compared to those with lower percentages. Although all participants in this study fell within the standard range, it is known that individuals with obesity are at a higher risk of heatstroke due to less efficient heat dissipation, as heat tends to accumulate in the fat layer. This may explain the higher rate of L-FABP positivity in participants exposed to excessive physical strain in hot and humid environments.

This study simulated various emergency scenarios in hot environments, with particular emphasis on the high intensity of activities performed by emergency responders, especially during CPR in cases of cardiac arrest. In Japan, firefighters often work in collaboration with EMS, particularly in severe cases, where they also experience a high physical burden. Firefighting and rescue activities are known to impose substantial physical strain. Rossi [24] highlighted that the concentration of fire fighters declines due to heat stress during firefighting activities, as body temperature rapidly increases and perspiration increases significantly.

The novelty of this study lies in its comparison of physiological parameters in firefighters wearing surgical masks, simulating real-life emergency scenarios. By analyzing multiple indicators, the effects of hot environments on the body were elucidated, particularly concerning the risk of exertional heat stroke in prehospital emergency care. The findings underscore the importance of precautions for heat stroke during extended emergency activities, such as prolonged rescue efforts and cases of cardiopulmonary arrest. Although this study was conducted under hot and humid conditions, its implications extend to high-intensity activities in various seasonal contexts.

Limitations

This study has limitations. this experiment was conducted exclusively with young male firefighters, which limits the generalizability of the results to female or middle-aged firefighters. Notably, the global incidence of heatstroke is higher in men, suggesting that the data gathered here align with existing trends. Thus, the study offers practical information that reflects the current situation and can be useful to EMTs active in prehospital care. However, it is important to recognize that middle-aged and older adults are also at risk of heatstroke, necessitating further research on these populations. In future studies, careful monitoring of exercise intensity in diverse age groups will be critical for understanding their vulnerability to heat-related illness under similar conditions.

Conclusion

Emergency activities involving the wearing of surgical masks in hot environments may be a factor affecting the risk of exertional heatstroke. Therefore, it is important to use accurate monitoring and measurement markers to reduce the risk of exertional heatstroke. By understanding the risk factors for heatstroke; evaluating the environment, labor management, and physical condition management; and implementing effective measures to reduce the risk of heatstroke, we aim to promote measures for preventing heatstroke.

Ethics approval statement

This study was conducted according to the Code of Ethics of the World Medical Association (Declaration of Helsinki). It was reviewed by the Ethics Committee of the Japan College of Physical Education (approval number 024-H003).

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