Original Article

Evaluation of the physiological changes in prehospital health-care providers influenced by environmental factors in the summer of 2020 during the COVID-19 pandemic

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Aim: Wearing personal protective equipment (PPE) is essential to prevent infection transmission, but the risk of heatstroke increases with wearing PPE in a humid and hot environment. Therefore, we aimed to examine how environmental parameters change the body physiology in a hot environment during the coronavirus disease (COVID-19) pandemic.

Methods: This was a retrospective cohort study extracted from the MEDIC Japan heatstroke prevention database, which was recorded between 1 August and 7 September, 2020. Its database is a registry collection from seven healthy health-care providers. Subjects recorded their own vital signs (forehead and tympanic temperature, blood pressure, pulse rate, and oxygen saturation) and environmental factors (type of weather, wet-bulb globe temperature [WBGT], air temperature, humidity, and location) every hour during their working shift.

Results: From 323 records, a weak positive but statistically significant correlation was observed between WBGT and pulse rate (correlation coefficient [95% confidence interval], r = 0.34 [0.23, 0.45]) and between WBGT and core body temperature. Forehead temperature had a stronger correlation than tympanic temperature (forehead, r = 0.33 [0.21, 0.43]; tympanic, r = 0.17 [0.05, 0.28]), which also showed a larger effect (forehead, η^2 = 0.08; tympanic, η^2 = 0.05). The effect size of oxygen saturation measured outdoors was large (η^2 = 0.30). Forehead temperature increased abruptly at 28°C WBGT and at 33°C air temperature.

Conclusion: A hot environment significantly affected forehead temperature, and the daytime imposed a high risk of heatstroke. To avoid heatstroke, environmental parameters are important to note as outdoor environments had a large effect on vital sign changes depending on the time of day.

Key words: Humid, personal protective equipment, summer, temperature, wet-bulb globe temperature

INTRODUCTION

THE CORONAVIRUS DISEASE (COVID-19) outbreak led to a global pandemic.[1] Infection control is significantly important to decrease virus transmission risk. Antiviral drug development and vaccination have been promoted worldwide,[2] but new mutated virus variants have appeared, and complete containment of the COVID-19 pandemic remains difficult to predict. Therefore, basic good hygiene practices remains the major approach to protect against COVID-19.[1] The Ministry of Health, Labor and Welfare of Japan (MHLW) recommends: (i) ensuring adequate physical distance, (ii) wearing a mask, (iii) maintaining hand hygiene and avoiding the three Cs (closed spaces, crowded places, and close contact) to reduce the risk of transmission.[3] However, it is known that wearing a mask increases the facial temperature, and not wearing a mask is

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permitted during sports or in a hot and humid environment. This is because wearing a mask in a hot environment increases the risk of heatstroke.[3]

The number of people with heatstroke transported by ambulance was as high as 92,710 in 2019.[4] In the summer of 2020, wearing a mask was part of the "new normal," and precautions to be taken against heatstroke were announced.[3] In exercising individuals, wearing a mask increased the facial temperature by 1.76°C.[5] Oral temperature also increased with a face mask,[6] whereas aural temperature did not show a change (36.49 ± 0.42°C without mask and 36.53 ± 0.45°C with mask).[6] A guideline to prevent heatstroke during the COVID-19 epidemic was published.[7] Wet-bulb globe temperature (WBGT) is known as an ideal indicator to monitor the risk of heatstroke. In nonexercising individuals, tympanic temperature more accurately represents the core body temperature (BT) than forehead temperature does.[8] However, during this pandemic, forehead temperature was often used to screen individuals entering a building. Typically, a difference of 0.4°C is observed between the tympanic temperature and forehead temperature in individuals who do not have chills.[9]

To the best of our knowledge, there are no studies on changes in vital signs with environmental changes during the current pandemic. The purpose of the present study was to examine how vital signs change depending on the location (outdoor or indoor), presence of face shield (FS), and difference in tympanic and forehead temperature. We hypothesized that pulse rate and forehead and tympanic temperature would rise as WBGT increases and that the use of a FS would affect forehead temperature more than tympanic temperature.

METHOD

Participants

THIS WAS A retrospective cohort study carried out in collaboration with MEDIC Japan Inc. (Shibuya, Tokyo). The MEDIC Japan heatstroke prevention data were recorded in the Google Sheets application (Mountain View, CA, USA) between 1 August and 7 September, 2020, to monitor the medical condition during a work shift. Its database is a registry collection from seven medics (five male individuals and two female individuals). Due to invasive and ethical problems with undertaking this study under the extreme heat environment in Japan, only seven medics were available to record the data under the same condition during the study period. This resulted in a small sample size. Participants were chief medics who worked during the study period. MEDIC Japan provides health-care workers as medics at television commercial shooting sites. Medics are health-care professionals who provide COVID-19 medical screening and first aid and ensure infection control under the supervision of a medical control physician. All participating medics were certified as emergency life support technicians or nurses and young healthy pre-hospital health-care providers free from known pre-existing diseases. They wore medical scrubs and a surgical mask. A FS was worn depending on the field condition.

Data collection

During their work shift, the participants measured their own vital signs every hour from the commencement of work. The duration of the day shift and the waiting area were variable. Medics recorded weather, including WBGT (°C), air temperature (°C), and humidity (%), and vital signs, which included forehead temperature (°C), tympanic temperature (°C), blood pressure (mmHg), pulse (b.p.m.), and oxygen saturation (%).

To mandate continuous wearing of a mask under the extreme heat environment in Japan, or to mandate continuously not wearing a mask during the COVID-19 pandemic, are invasive and ethical issues. The wearing of masks was dependent on the field situation. Therefore, we could not investigate the effects of wearing a mask by comparing mask-wearing data with nonmask-wearing data in a retrospective study. As recommended by the MHLW, the medical director of MEDIC Japan Inc. also directed to remove masks outdoors when there is adequate physical distance (>2 m) between individuals.[3] To maintain good health conditions and prevent heatstroke, the following measures were taken: (i) removing masks outdoors only when there was enough physical distance from others, (ii) keeping adequately hydrated, (iii) taking a break without hesitation when not feeling well.

Instruments

Miharinbou Pro AD-5698 (A&D Company, Ltd., Toshima-Ku, Japan) was used to measure air temperature, humidity, and WBGT. The WBGT instrument was placed under shade as per the manufacturer's instructions, but the height at which the instrument should be placed was not specified. The Braun ThermoScan 7 with Age Precision (Braun, Kronberg im Taunus, Germany) thermometer was used to measure BT.

Outcome

Outcomes were forehead temperature (°C), tympanic temperature (°C), blood pressure (mmHg), pulse (b.p.m.), and oxygen saturation (%).

Statistical analysis

Continuous variables were reported as mean and standard deviation or median and interquartile range. Categorical variables were presented as counts and percentages. For comparison between the indoors and outdoors cohort, continuous data were compared using Student's *t*-test or Welch's *t*-test; categorical variables were compared using the χ^2-test or Fisher's exact test, whichever was appropriate. We undertook a significance test for comparison between the two groups wearing FS (with or without) and measurement locations (indoor or outdoor) by calculating the 95% confidence interval for the difference in means. Time of day and vital signs were plotted as mean and standard deviation, and the variation in vital signs was tested with repeated measured ANOVA. Eta-squared was calculated to estimate effect size. In order to confirm vital sign changes and the time of day depending on the location, we carried out a stratified analysis. Spline curves were used to confirm more specifically the transition between WBGT and BT and between air temperature and BT. The significance level was 0.05 (two-tailed) for all tests. We used RStudio (version 1.2.1335; RStudio, Boston, MA, USA) for describing figures and JMP Pro 15.0.0 (SAS Institute, Cary, NC, USA) for statistical analysis.

RESULTS

Background

THE MEAN PARTICIPANT age was 23.71 ± 1.28 years. A total of 323 measurements were taken, of which 73.7% were taken during daytime and 77.1% were taken on sunny days (Table 1). The mean air temperature, humidity, and WBGT were 28.2 ± 3.3°C, 65.9 ± 37.5%, and 24.4 ± 2.8°C, respectively (Table 1).

Vital sign changes with environmental factors and time of day

The correlation between WBGT and vital signs is shown in Figure 1. In general, a weak positive but statistically significant correlation was observed between WBGT and pulse rate (correlation coefficient [95% confidence interval], $r = 0.34$ [0.23, 0.45]) and between WBGT and BT. In terms of BT, forehead temperature had a stronger correlation than tympanic temperature (forehead, $r = 0.33$ [0.21, 0.43] versus tympanic, $r = 0.17$ [0.05, 0.28]; Fig. 1), which also showed a larger effect (forehead, $\eta^2 = 0.08$ versus tympanic, $\eta^2 = 0.05$; Fig. 2). A weak negative but statistically significant correlation was found between WBGT and oxygen saturation ($r = -0.21$ [−0.32, −0.09]; Fig. 1). Systolic and diastolic blood pressure (SBP and DBP, respectively) very weakly or weakly decreased with increasing WBGT and air temperature. Vital signs were maintained within the normal range throughout the day (Fig. 2). Both tympanic temperature and forehead temperature were higher during daytime than at morning or night-time.

Use of a FS

Of 323 measurements, 40 (2 outdoors and 38 indoors) were taken with a FS and 283 were taken without a FS (Table 1). The following vital signs showed a statistically significant difference between the presence and absence of a FS: SBP (118.5 ± 5.5 mmHg versus 113.5 ± 9.8 mmHg, $P = 0.02$), pulse rate (63.2 ± 6.1 b.p.m. versus 66.9 ± 8.2 b.p.m., $P < 0.001$), and tympanic BT (36.6 ± 0.2°C versus 36.6 ± 0.2 °C, $P = 0.40$; Table 2).

As shown in Figure 1, when a FS was not worn and only a surgical mask was worn, a statistically significant difference was observed in the correlation between WBGT and the following factors: tympanic temperature, forehead temperature, pulse rate, and SBP. The correlation coefficient between WBGT and tympanic temperature was 0.33 (−0.02, 0.61) with a FS and 0.17 (0.04, 0.29) without a FS. The correlation between WBGT and forehead temperature was weakly positive regardless of the presence of a FS ($r = 0.27$ [−0.09, 0.57] with a FS versus $r = 0.34$ [0.22, 0.45] without a FS). As WBGT increased, tympanic and forehead temperature increased in individuals wearing a surgical mask but not a FS. Pulse rate and WBGT showed a very weak positive correlation with a FS ($r = 0.03$ [−0.34, 0.39]) but a weak positive and statistically significant correlation without a FS ($r = 0.37$ [0.25, 0.48]). Blood pressure and WBGT showed a weak positive correlation with a FS (SBP: $r = 0.20$ [−0.25, 0.58]; DBP: $r = 0.31$ [−0.41, 0.65]) but a very weak negative correlation without a FS (SBP: $r = -0.17$ [−0.32, −0.02]; DBP: $r = -0.15$ [−0.30, 0.01]). Notably, SBP and WBGT showed a statistically significant correlation in individuals wearing a surgical mask but not a FS (Fig. 1).

Location

As shown in Table 1, 64 and 216 measurements were taken outdoors and indoors, respectively, and 47 measurements were taken outdoors on a sunny day. All five measurements that recorded WBGT of 31°C or greater were taken outdoors. The mean WBGT indoors and outdoors was 23.9 ± 2.4°C and 26.4 ± 2.9°C, respectively ($P < 0.001$). Forehead and tympanic temperatures were significantly higher outdoors (36.7 ± 0.3°C and 37.0 ± 0.3°C, respectively) than indoors (36.6 ± 0.2°C and 36.8 ± 0.3°C, respectively; $P < 0.001$;

Table 1. Environmental factors overall, by location, and in the presence or absence of a face shield among prehospital health-care providers wearing personal protective equipment

	Overall		Face shield					Location				
	Overall, $n = 323$	Missing, n (%)	Face shield$^+$ $n = 40$	Missing, n (%)	Face shield$^-$ $n = 283$	Missing, n (%)	p-value	Indoor, $n = 216$	Missing, n (%)	Outdoor, $n = 64$	Missing, n (%)	p-value
Time zone, n (%)[a]		0 (0.0)		0 (0.0)		0 (0.0)	0.008*		0 (0.0)		0 (0.0)	0.980
Morning (06:00–09:59)	40 (12.4)		11 (27.5)		29 (10.3)			26 (9.3)		8 (12.5)		
Daytime (10:00–18:59)	238 (73.7)		25 (62.5)		213 (75.3)			158 (56.4)		46 (71.9)		
Night-time (19:00–05:59)	45 (13.9)		4 (10.0)		41 (14.5)			32 (11.4)		10 (15.6)		
Weather, n (%)[a]		0 (0.0)		0 (100.0)		0 (0.0)	0.010*		0 (0.0)		0 (0.0)	<0.001*
Sunny	249 (77.1)		39 (97.5)		210 (74.2)			199 (71.1)		47 (16.8)		
Cloudy	19 (5.9)		1 (2.5)		18 (6.4)			14 (5.0)		5 (1.8)		
Rainy	2 (0.6)		0 (0.0)		2 (0.7)			2 (0.7)		0 (0.0)		
Unknown	53 (16.4)	0 (0.0)			53 (18.7)			1 (0.4)		12 (4.3)		
Environmental factors												
WBGT, mean (SD), °C[b]	24.4 (2.8)	56 (17.3)	24.2 (2.2)	4 (10.0)	24.5 (2.9)	52 (18.4)	0.540	23.9 (2.4)	16 (7.4)	26.4 (2.9)	5 (7.8)	<0.001*
Caution (21–25°C), n (%)[a]	156 (48.3)		27 (67.5)		129 (45.6)			138 (63.9)		14 (21.9)		<0.001*
Warning (25–28°C), n (%)[a]	79 (24.5)		6 (15.0)		73 (25.8)			47 (21.8)		28 (43.8)		
Severe warning (28–31°C), n (%)[a]	25 (7.7)		1 (2.5)		24 (8.5)			15 (6.0)		12 (18.8)		
Danger (≥31°C), n (%)[a]	7 (2.2)		2 (5.0)		5 (1.8)			0 (0.9)		5 (7.8)		
Temperature, mean (SD), °C[c]	28.2 (3.3)	56 (17.3)	27.9 (3.1)	4 (10.0)	28.2 (3.3)	52 (18.4)	0.610	27.8 (2.8)	16 (7.4)	29.9 (4.1)	5 (7.8)	<0.001*
Humidity, mean (SD), %[c]	65.9 (37.5)	56 (17.3)	63.8 (9.8)	4 (10.0)	66.2 (40.2)	52 (18.4)	0.450	65.6 (43.1)	16 (7.4)	65.8 (9.2)	5 (7.8)	0.940

Abbreviations: SD, standard deviation; WBGT, wet-bulb globe temperature.
[a] χ^2-test.
[b] Student's t-test.
[c] Welch's t-test.
*Statistically significant.

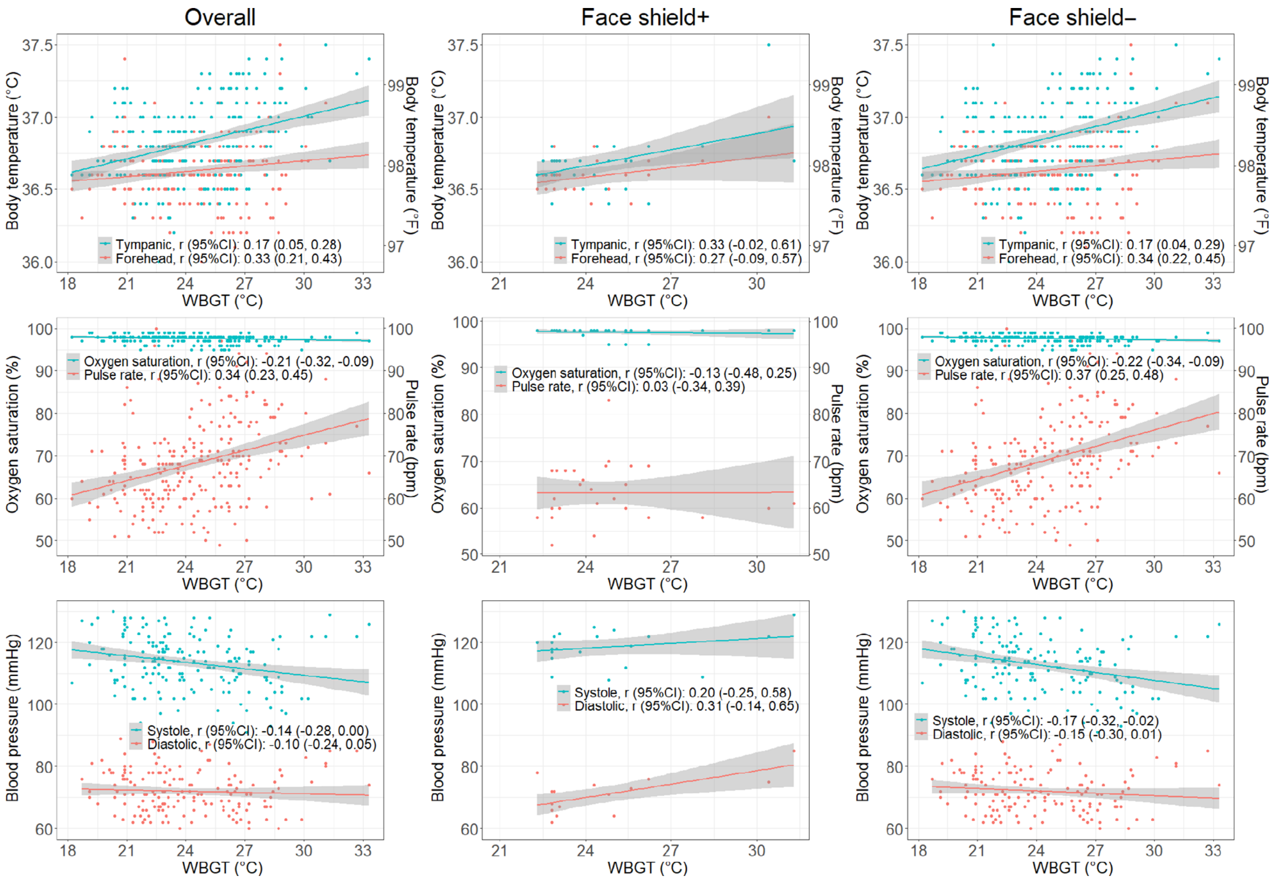

Fig. 1. Correlation of vital signs with wet-bulb globe temperature (WBGT) overall and in instances with and without a face shield among prehospital health-care providers wearing personal protective equipment. CI, confidence interval.

Table 2). Pulse rate was maintained within the normal range regardless of being outdoors or indoors, but it was higher outdoors than indoors (66.9 ± 8.2 b.p.m. versus 72.2 ± 13.1 b.p.m.; $P < 0.001$; Table 2).

Wearing a mask outdoors had a large effect on vital sign changes depending on the time of day (Fig. 2). Oxygen saturation had a medium effect size of 0.08 when measured indoors but a large effect size of 0.30 when measured outdoors. Similarly, SBP and DBP had a small effect size of 0.04 and a medium effect size of 0.08, respectively, when measured indoors and a large effect size of 0.45 and 0.51, respectively, when measured outdoors. Forehead temperature measured indoors had a medium effect size of 0.09, but forehead temperature measured outdoors had a large effect size of 0.28. However, tympanic temperature measured indoors and outdoors both showed a medium effect size of 0.09 and 0.11, respectively (Fig. 2).

Tympanic and forehead temperature changes depending on WBGT and air temperature

There was a difference of 0.2°C between mean tympanic and forehead temperature (36.8 ± 0.3°C and 36.6 ± 0.2°C, respectively; Table 2). Tympanic temperature was higher than forehead temperature at all times (r = 0.33 [0.21, –0.43] versus r = 0.17 [0.05, –0.28]; Fig. 1).

As shown in Figure 3, forehead temperature increased sharply at a WBGT of 28°C and at an air temperature of 33°C. Similarly, tympanic temperature also rapidly increased at a WBGT of 25°C. However, tympanic temperature increased constantly with increasing air temperature without showing an abrupt increase at a certain temperature. When air temperature reached 40°C, there was no difference observed between tympanic and forehead temperature (Fig. 3).

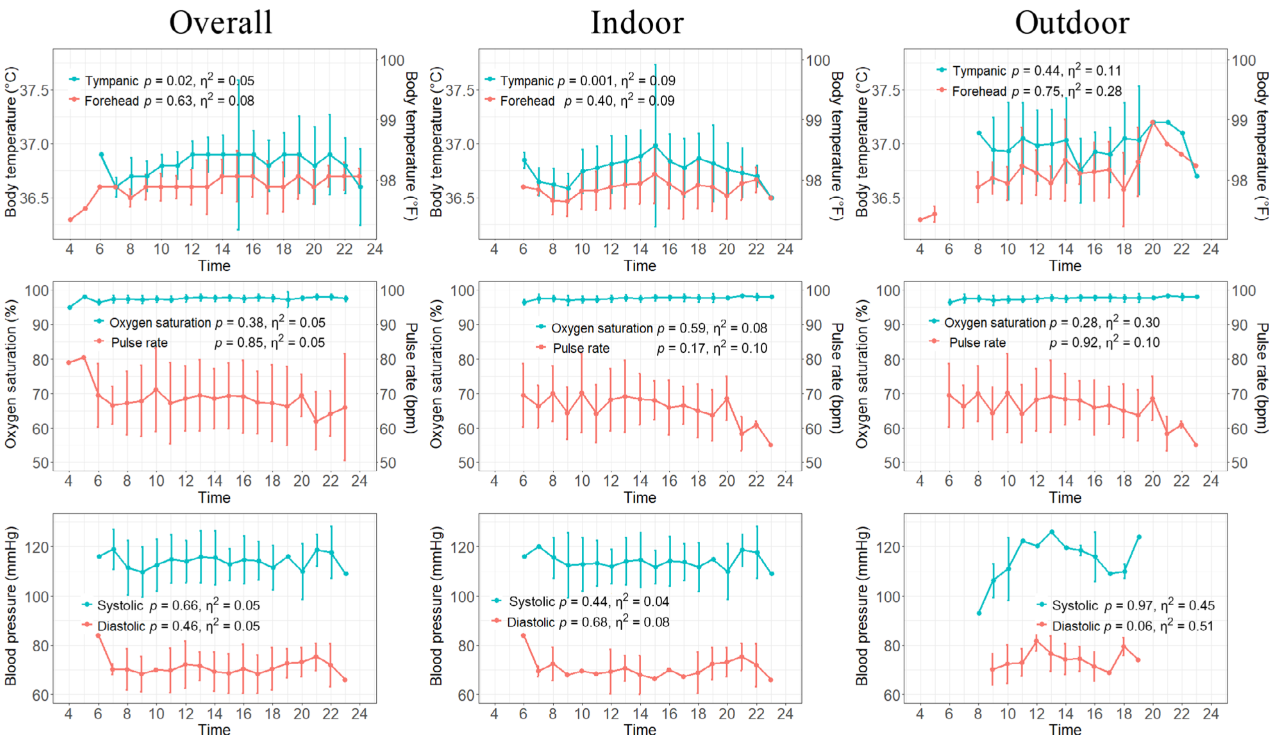

Fig. 2. Correlation of vital signs with time of day overall and by location among prehospital health-care providers wearing personal protective equipment.

DISCUSSION

SIMULTANEOUS PREVENTION OF both heatstroke and the spread of the novel coronavirus was challenging. The number of participants in our study was very low, but none of them complained of any COVID-19-related or heatstroke-related signs and symptoms during the study period. A total of 323 measurements of vital signs of seven healthy prehospital health-care providers and environmental factors were taken in the summer of 2020 during the COVID-19 pandemic. Wearing a FS did not show strong correlation with environmental change; however, pulse rate and BT had a statistically significant. We found that forehead temperature was greatly affected by environmental factors. The subjects experienced extreme discomfort, but we did not assess subjective experiences in this study.

Mask removal was allowed only when there was enough physical distance between individuals. Wearing a mask while exercising has been shown to increase facial temperature (by 1.76°C) as well as oxygenation saturation, respiratory rate, and pulse rate.[5] Wearing a surgical mask did not affect tympanic or oral temperatures, whereas wearing an N95 mask significantly increased tympanic and oral temperatures.[6] Similarly, skin temperature was not affected by wearing a surgical mask[10]; the mean skin temperature of the nose showed a steady change, and that of the forehead showed a small change over time.[10] This could explain why forehead temperature abruptly increased as air temperature increased, whereas tympanic temperature rose constantly. Forehead temperature rose rapidly when WBGT reached 28°C, and no difference between tympanic and forehead temperature was found at 33°C. In contrast, tympanic temperature rose constantly after WBGT reached 24°C. Forehead temperature was greatly influenced by facial temperature, which might have been affected by wearing of a mask.

During the summer of 2020, there were concerns about the increasing number of heatstroke cases due to a lack of exercise and heat adaptation because of the stay-at-home appeal. In Japan, a total of 64,869 people were transported by ambulance between June and September 2020, which was lower than the previous year by approximately 2,000.[4] According to the Japan Meteorological Agency, the seasonal mean temperature was 0.96°C higher than normal in the summer of 2020.[11] The nationwide highest temperature was 41.1°C in the summer of 2020.[12] According to a report by the Fire and Disaster Management Agency, in the summer of 2020, the highest proportion of heat illness cases occurred at home; the proportion of heatstroke cases occurring at

Table 2. Vital signs overall, by location, and in the presence or absence of a face shield among prehospital health-care providers wearing personal protective equipment

	Overall				Face shield										Location									
Vital signs	Overall, n = 323		Missing		Face shield+, n = 40		Missing		Face shield−, n = 283		Missing		Mean difference (95% CI)	*p*-value	Inside, n = 216		Missing		Outside, n = 64		Missing		Mean difference (95% CI)	*p*-value
	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)			n	(%)	n	(%)	n	(%)	n	(%)		
Systolic BP, mean (SD), mmHg[a]	114.0	(9.6)	134	(41.5)	118.5	(5.5)	19	(47.5)	113.5	(9.8)	115	(40.6)	−4.97 (−9.29, −0.69)	0.02*	113.5	(9.4)	67	(31.0)	116.2	(10.9)	31	(48.4)	−2.69 (−0.98, 6.35)	0.150
Diastolic BP, mean (SD), mmHg[a]	70.4	(8.2)	134	(41.5)	67.4	(8.3)	19	(47.5)	70.8	(8.1)	115	(40.6)	−3.40 (−0.32, 7.13)	0.07	69.5	(8.3)	67	(31.0)	73.9	(6.7)	31	(48.4)	-4.41 (1.37, 7.45)	0.005*
Pulse rate, mean (SD), b.p.m.[b]	68.4	(10.0)	63	(19.5)	63.2	(6.1)	11	(27.5)	69.0	(10.2)	52	(18.4)	5.76 (1.92, 9.60)	<.001*	66.9	(8.2)	23	(10.6)	72.2	(13.1)	4	(6.3)	5.29 (2.51, 8.07)	<.001*
Oxygen saturation, median, (IQR), %[c]	98.0	(1.0)	63	(19.5)	97.7	(0.9)	11	(27.5)	97.6	(1.1)	52	(18.4)	−0.07 (−0.48, 0.34)	0.73	97.5	(1.2)	23	(10.6)	97.6	(1.0)	4	(6.3)	-0.11 (−0.42, 0.20)	0.48
Forehead BT, mean (SD), °C[b]	36.6	(0.2)	52	(16.1)	36.6	(0.2)	8	(20.0)	36.6	(0.2)	44	(15.5)	0.20 (0.08, 0.32)	<.001*	36.6	(0.2)	16	(7.4)	36.7	(0.3)	1	(1.6)	0.16 (0.07, 0.26)	<.001*
Tympanic BT, mean (SD), °C[a]	36.8	(0.3)	59	(18.3)	36.6	(0.2)	9	(22.5)	36.6	(0.2)	50	(17.7)	0.03 (−0.05, 0.12)	0.40	36.8	(0.3)	15	(6.9)	37.0	(0.3)	8	(12.5)	0.13 (0.06, 0.19)	<.001*

Abbreviation: BP, blood pressure; BT, body temperature; CI, confidence interval; IQR, interquartile range; SD, standard deviation.
[a]Student's *t*-test.
[b]Welch's *t*-test.
[c]Mann–Whitney *U*-test.
*Statistically significant.

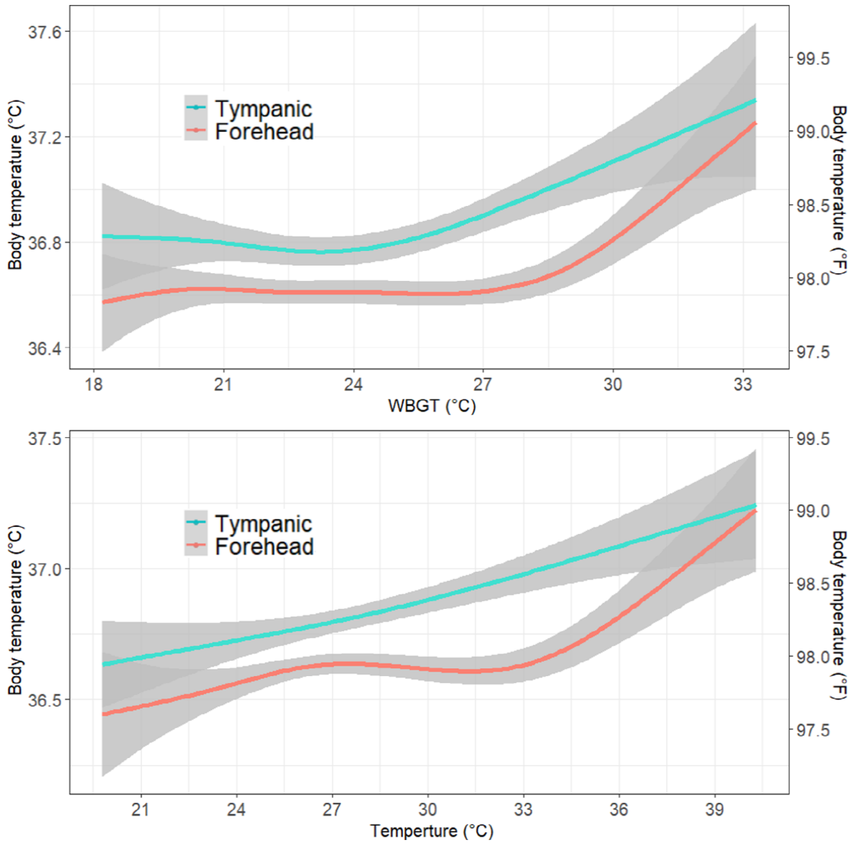

Fig. 3. Spline curve in the correlation between tympanic and forehead temperature with wet-bulb globe temperature (WBGT) and air temperature among prehospital health-care providers wearing personal protective equipment.

home was higher (43.4%) in 2020 than that (38.6%) in 2019.[4] However, the incidence of heatstroke in public places (indoors and outdoors) decreased from 8.7% and 9.4%, respectively, in 2019 to 6.7% and 9.4%, respectively, in 2020.[4] The number of heatstroke-related ambulance dispatches decreased in the summer of 2020.[13] School restrictions on outdoor activities and event cancellation could also explain this finding.[14]

The combination of infection control and heatstroke prevention is essential to consider from early summertime. In order to prevent heatstroke, recognizing the early signs and symptoms is of highest importance. Warnings should be given when air temperature changes. A rise in body temperature can signify the onset of heatstroke, so it is essential to identify this symptom. Clinical decisions should be based on overall presented signs and symptoms. As we observed, forehead temperature, blood pressure, and oxygen saturation were significantly affected by the external environment depending on the time of day. At mass gathering events held outside, for example, first aiders would suffer from heatstroke. If the events are held indoors with air conditioning, the heat is endurable. During mass gathering events in the summer of 2021, outdoor event staff on standby or health-care providers must take heatstroke prevention measures while wearing a mask to avoid COVID-19 infection. The phrase “cool first, transport second” has been used to manage exercise-induced heatstroke.[15] In these cases, only rectal temperature is known as the accurate parameter for measuring core BT in exercising individuals.[16–18] Apart from rectal temperature, an alternative accurate measure of BT in nonactive individuals is tympanic temperature.[8] We also found that tympanic temperature did not abruptly change with increasing air temperature and WBGT. Our subjects were mainly standing outdoors instead of walking around. Tympanic temperature shows the highest accuracy in measuring BT, whereas forehead temperature shows the lowest accuracy.[8] Thus, forehead temperature is not an accurate measure to assess BT during exercise.[19–21] Moreover, skin temperature tends to be lower when walking than when standing.[22] Measuring rectal temperature is not possible in the Japanese prehospital setting. For heatstroke prevention, we propose first measuring forehead temperature as a non-contact screening and then having prehospital care providers measure tympanic temperature to assess alternative core BT.

We evaluated the physiological response regarding the FS. Our results suggest that wearing a mask and FS would not pose a risk unless it is done indoors. Although the pulse rate increased without a FS and did not change with a FS, the sample size was very small, and only two measurements were taken outside. Pulse rate increases 8.35 b.p.m. as BT increases by 1°C.[23] This is due to increasing sinoatrial node activity from enhancing the sympathetic nervous system activity or increasing oxygen demand. Measurements with a FS showed that vital signs were barely influenced by environmental conditions, whereas changes observed in absence of a FS were natural physiological reactions. In terms of wearing a FS outdoors in a hot and humid environment, a FS is essential to protect virus transmission through eyes; therefore, it could be useful when treating patients at a close distance, but it should be removed when physical distance is ensured.

The present study had several limitations. To prevent heatstroke, we did not ask the participants to consistently wear a mask. We followed the MHLW recommendations; thus, the subjects removed the mask at their own discretion and when transmission risk was low. The frequency of mask removal and duration of not wearing a mask depended on the subjects and their surrounding environment. Second, there was a selection bias as all our subjects were aged in their 20s. Thus, we only had data on young healthy subjects who worked as health-care providers; therefore, the results might not apply to all age categories. Finally, sample size was limited due to the secondary use of the database; therefore, the detection power could have been insufficient. A *p*-value is a sample size-dependent value, so the size difference cannot be specified. Therefore, clinical decisions cannot be made using only *p*-values. Consequently, we showed effect size, which is not a sample size-dependent value and indicates real difference.

CONCLUSION

A HOT ENVIRONMENT significantly affects the forehead temperature, and the daytime imposes a high risk of heatstroke. The waiting area (indoor or outdoor) also affects BT. To avoid heatstroke, environmental parameters are important to note as a large effect was found on vital signs measured outdoors depending on the time of day. These findings are valuable to consider not only in upcoming mass gathering events during the current pandemic but also in events that requires healthcare even after the pandemic.

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DISCLOSURE

APPROVAL OF THE research: The study was approved by Kokushikan University Ethics Committee (#21004).

Informed consent: All participants provided written informed consent.

Registry and registration no. of the study/trial: N/A.

Animal studies: N/A.

Conflict of interest: All authors are employees of MEDIC Japan Inc. Author HT has medical advisory roles. The company had no role in design, practice or analysis of this study.

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