

Prevalence of post-race exertional heat illness in Thoroughbred racehorses and climate conditions at racecourses in Japan

Motoi NOMURA^{1*}, Tomoki SHIOSE², Yuhiro ISHIKAWA³, Fumiaki MIZOBE⁴, Satoshi SAKAI⁴ and Kanichi KUSANO³

¹The Horse Racing School, Japan Racing Association, Chiba 270-1431, Japan

²Equine Research Institute, Japan Racing Association, Fukushima 972-8325, Japan

³Racehorse Clinic, Ritto Training Center, Japan Racing Association, Shiga 520-3085, Japan

⁴Racehorse Clinic, Miho Training Center, Japan Racing Association, Ibaraki 300-0493, Japan

Despite growing recognition of post-race exertional heat illness (EHI) in the horse racing industry, reports on its prevalence are limited. The purpose of this study was to investigate the prevalence of post-race EHI and climate conditions at racecourses in Japan. The overall prevalence of EHI from 1999 to 2018 was 0.04% (387 cases for 975,247 starters) in races operated by the Japan Racing Association (JRA). The yearly prevalence has been increasing, exceeding 0.07% in the last four years of the studied period. The overall prevalence in summer (May–September) was 0.086% (352 cases for 409,908 starters). The monthly prevalence varied among the 10 JRA racecourses, which are distributed from latitude 34 to 43°N, ranging from no cases to 0.459%. During summer, prevalence of post-race EHI was high when the mean monthly ambient temperature was high at a racecourse. To evaluate climate conditions, we investigated the wet-bulb globe temperature (WBGT, °C) from 9 AM to 5 PM on sunny race days in July and August of 2017 and 2018 at three racecourses with a high prevalence of EHI among the 10 racecourses. The durations of time during which WBGT was between 28 and 33°C at these three courses were 95, 94, and 65% of the minutes measured, respectively. This result indicated that most races on the sunny summer days were held when WBGT was between 28 and 33°C at the three racecourses. These findings could be useful in developing the appropriate countermeasures to be taken during hot weather at each of the studied racecourses.

Key words: exertional heat illness, heat stroke, racehorse, Thoroughbred, wet-bulb globe temperature

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Exercise-induced heat stroke is also referred to as exertional heat illness (EHI) and includes heat illnesses sometimes developed by Thoroughbred racehorses following a race [2, 3]. Despite growing recognition of the impact of post-race EHI and concern about the welfare of horses in the horse racing industry, there have only been a few reports on

the prevalence of this illness in the racing environment, such as that by MacDonald *et al.* in which the prevalence and risk factors of EHI in South Africa were reported [12]. Post-race EHI occurs as a result of a remarkable elevation of the core body temperature due to thermogenesis in the body when horses are raced in hot and humid environments [3]. Such environments often lead to inefficiency in the mechanism of evaporative heat loss through sweating [7–9, 13]. Post-race EHI initiates various physiological changes that may progress to lethal consequences unless affected horses are provided with proper care and treatment [9].

Recently, post-race EHI has been the subject of growing concern, both in the Japanese racing industry and globally. It is predicted that temperatures in Japan will increase faster

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*Corresponding author. e-mail: Motoi_Nomura@jra.go.jp

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than the global average [15]. Some authorities responsible for horseracing, equestrian competitions, and polo events have begun to take countermeasures against hot weather from the perspective of equine welfare, according to policies based on climate conditions. However, these policies can vary by region, even within the same country [1, 6, 17–19]. In Japan, countermeasures to protect racehorses against hot weather have included the installation of misting systems and cooling areas and a reduction in walking around parade rings. These countermeasures have been taken based on the experience and opinions of those concerned. However, there are no practical manuals or standard policies for effective countermeasures. Therefore, it is important to develop effective guidelines and policies in the Japanese racing industry to protect racehorses against hot weather. Additionally, it is important to determine the prevalence of post-race EHI and evaluate climate conditions by region to provide baseline data. For this purpose, we investigated 1) fluctuation in the prevalence of post-race EHI in Japan during a 20-year period and 2) the relationship between monthly prevalence of post-race EHI and climate conditions at individual racecourses.

Materials and Methods

Racing and racecourses in the Japan Racing Association

Thoroughbred horse races operated by the Japan Racing Association (JRA) were held at 10 specific racecourses according to an annual schedule. The total number of racing days throughout the year was 288, and 12 races were held each day from 9 AM to 5 PM. Ten JRA racecourses (A–J) are distributed from latitude 34 to 43° N, as shown in Fig. 1.

Official veterinarians of JRA are stationed across the racetrack (on the track, saddling enclosures, parade ring, etc.) to examine and treat all runners as necessary before, during, and after races. JRA has installed cooling facilities such as chilled water hoses and air-conditioned stalls to provide emergency care for horses affected by post-race EHI.

Prevalence of post-race EHI

Race and veterinary records of 975,247 starters from JRA races operated at racecourses from 1999 to 2018 were investigated. EHI was diagnosed based on commonly observed

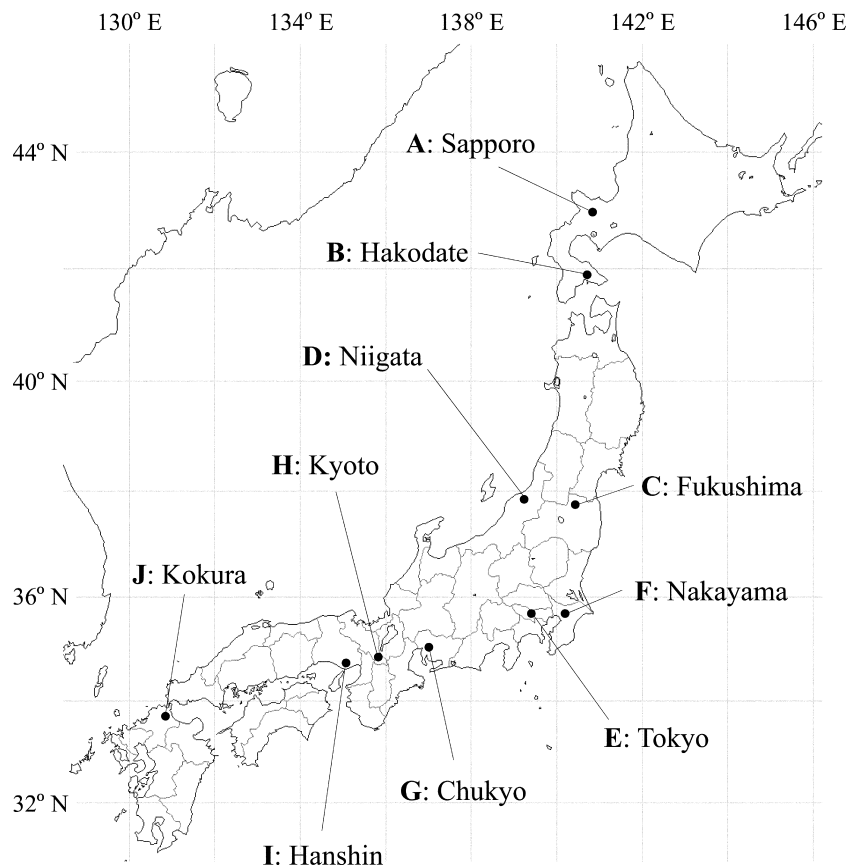


Fig. 1. Locations of the 10 racecourses of the Japan Racing Association (Created using a map downloaded from Craft MAP [<http://www.craftmap.box-i.net>]).

clinical signs such as profuse sweating; rapid breathing (>60–100 breaths/min) and elevated heart rate (>150 beats/min); unusual behavior, including head shaking, kicking out in a random fashion, and pawing the ground; and gait abnormalities [2, 3].

Based on the race and veterinary records obtained from a digital database (Japan Racing Information System, JARIS), we analyzed the overall prevalence of post-race EHI from 1999 to 2018 and the yearly prevalence; then this analysis was performed limited to the summer season (May–September) at all 10 JRA racecourses. We evaluated the prevalence throughout the summer and the monthly prevalence from May to September at all 10 JRA racecourses. However, the prevalence was not calculated if the total number of starters at the racecourse was less than 1,000.

Evaluating climate conditions

First, we assessed the mean monthly ambient temperature (1999–2018) at the local meteorological observatory closest to each racecourse from the website of the Japan Meteorological Agency. Then, to assess the climate conditions at the racecourse site, we used the ambient temperature (°C) and wet-bulb globe temperature (WBGT, °C), which is the most widely accepted index of heat stress in human and equine sports [4, 5, 16]. These measurements were recorded every 15 min from 9 AM to 5 PM on race day at three racecourses (racecourses C, G, and J), which showed a high prevalence of post-race EHI in a preliminary survey until 2016, during July and August of 2017 and 2018. A handheld heat index monitor (WBGT-213B, Kyoto Electronics Manufacturing, Kyoto, Japan) was used to measure WBGT and ambient temperature. It was set in a sunny place in the stable area of a racecourse at a height of approximately 120 cm above the ground [14]. We excluded data of days for which the relative sunshine duration was less than 40%, using weather data from the closest local meteorological observatory to each racecourse as shown on the Japan Meteorological Agency website. Mean and standard deviation of the mean, maximum, and minimum values during the measuring period of each day were determined for WBGT and ambient temperature at the three racecourses. Additionally, we calculated the ratio of minutes to the total measurement time for three WBGT ranges (below 28°C, between 28 and 33°C, and over 33°C) at the three racecourses.

Statistical analysis

Differences in the prevalence of EHI for 1999–2014 and 2015–2018 and for the summer season (May–September) and other seasons (January–April and October–December) were each analyzed using the chi-squared test. A *P* value <0.05 was considered statistically significant. Statistical

analyses were performed with EZR (1.00, Saitama Medical Center, Jichi Medical University, Saitama, Japan), which is a graphical user interface for R (version 2.13.0, the R Foundation for Statistical Computing, Vienna, Austria) [11].

Results

Prevalence of post-race EHI

There were 387 post-race EHI cases (once in 337 horses, twice in 16 horses, and three times in 6 horses) in the 20-year period between 1999 and 2018, based on the race records of 975,247 starters. The overall prevalence of EHI was 0.040%. The rate showed an upward trend, and the prevalence from 2015 to 2018 (0.080%) was significantly higher ($P<0.05$) than that from 1999 to 2014 (0.030%) (Fig. 2). Additionally, we investigated the prevalence of EHI cases in the summer season (May–September) from 1999 to 2018 for 10 racecourses. There were 352 post-race EHI cases, based on the veterinary records of 409,908 starters, and the prevalence was 0.086% during this limited period. The prevalence in summer was significantly higher ($P<0.05$) than in the other seasons (0.006%). The monthly prevalence of post-race EHI at racecourse G in July was exceedingly high at 0.495%, followed by racecourses C, H, and I in June or July, exceeding 0.15% (Table 1). Throughout the summer, the prevalence of post-race EHI at racecourses C and G–J reached 0.1%, while that at racecourses A and B was <0.05%.

Climate conditions at racecourses

Table 2 summarizes the mean monthly ambient temperature (1999–2018) at the closest local meteorological observatory to each racecourse. Overall, the further south the racecourses were located, the higher the temperatures were.

WBGT and ambient temperature values of six sunny race days from 11 race days which were measured in July of 2017 and 2018 at racecourse C were included in the analysis. Correspondingly, the values of nine sunny race days from 11 race days measured in July of 2017 and 2018 at racecourse G and 14 sunny race days from 16 race days measured in July and August of 2017 and 2018 at racecourse J were included in the analysis (Table 3). The mean of the maximum WBGT of each day (9 AM–5 PM) exceeded 30°C at the three racecourses, and the mean of the mean WBGT of each day reached 30°C at racecourses C and G. The duration for which when WBGT was between 28 and 33°C accounted for the highest proportion of the total measurement time at all three racecourses, and it exceeded 90% of the minutes measured at racecourses C and G (Table 4). The duration for which WBGT was >33°C was only 2.5% of the measured minutes at racecourse C.

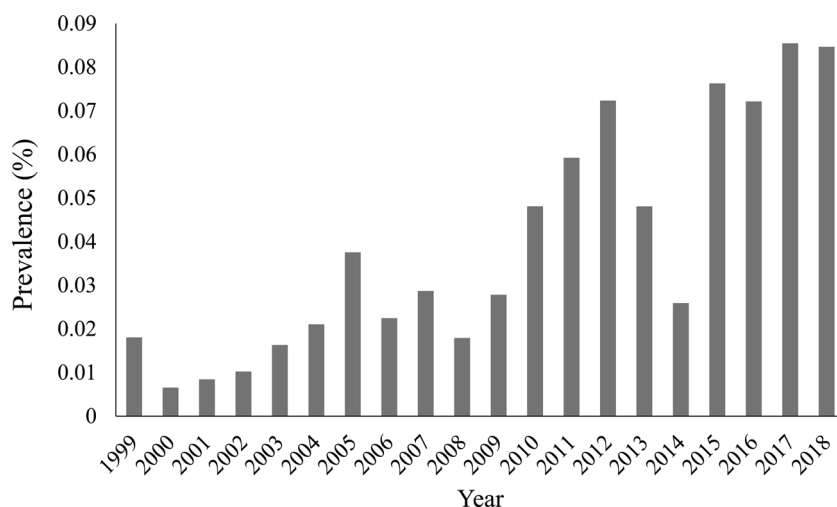


Fig. 2. Prevalence of post-race exertional heat illness over 20 years in Japan.

Table 1. Prevalence of post-race exertional heat illness (EHI) at each racecourse in Japan during the summer (May to September) from 1999 to 2018

Racecourse		May	Jun	Jul	Aug	Sep	May–Sep
A	Cases	-	0	3	7	0	10
	Starters	-	<1,000	2,891	21,190	16,929	41,598
	Prevalence (%)	-	N.C.	0.104	0.033	0	0.024
B	Cases	-	6	12	1	0	19
	Starters	-	13,885	22,810	5,163	<1,000	42,025
	Prevalence (%)	-	0.043	0.053	0.019	N.C.	0.045
C	Cases	0	11	25	0	0	36
	Starters	1,267	9,578	15,943	<1,000	<1,000	27,246
	Prevalence (%)	0	0.115	0.157	N.C.	N.C.	0.132
D	Cases	6	2	3	28	9	48
	Starters	21,565	<1,000	13,755	29,463	10,344	75,767
	Prevalence (%)	0.028	N.C.	0.022	0.095	0.087	0.063
E	Cases	16	13	1	-	-	30
	Starters	31,182	20,249	<1,000	-	-	52,088
	Prevalence (%)	0.051	0.064	N.C.	-	-	0.058
F	Cases	-	0	1	-	17	18
	Starters	-	<1,000	<1,000	-	21,448	22,792
	Prevalence (%)	-	N.C.	N.C.	-	0.079	0.079
G	Cases	2	9	45	-	1	57
	Starters	7,632	9,163	9,087	-	1,213	27,095
	Prevalence (%)	0.026	0.098	0.495	-	0.082	0.210
H	Cases	19	3	5	-	-	27
	Starters	23,361	1,647	2,092	-	-	27,100
	Prevalence (%)	0.081	0.182	0.239	-	-	0.100
I	Cases	0	23	3	-	26	52
	Starters	4,075	14,960	6,655	-	21,157	46,847
	Prevalence (%)	0	0.154	0.045	-	0.123	0.111
J	Cases	-	-	17	34	4	55
	Starters	-	-	12,325	28,117	6,908	47,350
	Prevalence (%)	-	-	0.138	0.121	0.058	0.116

-: Not started, N.C.: Not calculated (total number of runners in a month was less than 1,000).

Table 2. Mean monthly ambient temperature (°C; 1999–2018) at the local meteorological observatory closest to each racecourse (A–J) from the Japan Meteorological Agency website

Racecourse	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
A	-3.3	-2.9	1.1	7.3	13.0	17.3	21.1	22.7	18.8	12.0	5.2	-1.1
B	-2.4	-1.9	1.8	7.5	12.4	16.5	20.5	22.4	18.9	12.5	6.1	-0.2
C	1.7	2.4	5.9	11.8	17.3	21.0	24.6	25.6	21.7	15.7	9.5	4.2
D	2.8	3.0	6.1	11.6	17.0	21.1	25.1	26.8	22.9	16.8	10.7	5.4
E	4.4	5.4	8.9	14.0	18.7	22.0	26.1	27.0	23.3	17.6	11.8	6.7
F	4.7	5.5	8.9	13.9	18.4	21.6	25.6	26.7	23.3	17.7	12.2	7.1
G	5.0	5.9	9.3	14.7	19.5	23.1	27.2	28.4	24.8	18.9	13.0	7.4
H	4.6	5.4	8.8	14.5	19.6	23.4	27.5	28.5	24.5	18.5	12.5	7.0
I	6.0	6.6	9.8	15.1	19.9	23.4	27.3	28.7	25.5	19.9	14.1	8.6
J	6.0	6.9	10.1	14.9	19.4	22.9	27.0	27.9	24.3	19.0	13.4	8.2

Table 3. The mean and standard deviation of the mean, maximum, and minimum values during the measuring period of each day (9 AM–5 PM) for the wet-bulb globe temperature (WBGT, °C) and ambient temperature (°C) at three racecourses on the sunny race days in July and August of 2017 and 2018

	Racecourse C		Racecourse G		Racecourse J	
	WBGT	Ambient temperature	WBGT	Ambient temperature	WBGT	Ambient temperature
Mean value for the day	30.4 ± 0.8	33.8 ± 0.6	30.0 ± 0.7	31.4 ± 1.9	28.4 ± 1.4	31.2 ± 1.7
Maximum value for the day	32.9 ± 0.8	35.8 ± 0.9	31.9 ± 0.6	33.0 ± 2.0	30.8 ± 1.3	33.0 ± 1.9
Minimum value for the day	28.7 ± 1.0	30.0 ± 0.7	27.8 ± 1.0	29.1 ± 1.9	26.3 ± 1.6	29.1 ± 1.6

Table 4. The distribution of ratio (%) of minutes to the total measurement time for three wet-bulb globe temperature (WBGT) ranges (<28, 28–33, and >33°C) at three racecourses on the sunny race days (9 AM–5 PM) in July and August of 2017 and 2018

	Racecourse C	Racecourse G	Racecourse J
Duration for WBGT <28°C	2.9	6.0	34.9
Duration for WBGT of 28–33°C	94.6	94.0	65.1
Duration for WBGT >33°C	2.5	0.0	0.0

Discussion

In this study, we investigated fluctuations in the prevalence of post-race EHI. The prevalence of EHI per year has shown an upward trend since 1999, the start of the period surveyed, and exceeded 0.07% each year from 2015 to 2018. The prevalence from 2015 to 2018 was significantly higher than from 1999 to 2014. The average temperature in Japan, affected by global warming, has risen by 1.19°C in the past 100 years [10, 15]. The number of days with a maximum temperature >35°C has also increased in recent years [10, 15]. Such climate changes may have affected the racing environment in Japan. Furthermore, it has been recognized that because EHI may result in lethal consequences, it is important that racing veterinarians and stable staff diagnose the condition and provide proper care in a timely manner. It is possible that the number of horses diagnosed with EHI

may have increased as a result of increased awareness of this condition.

This study revealed that the monthly prevalence of post-race EHI varied among 10 racecourses, ranging from no cases in some months to 0.459% in the summer (May–September; Table 2). Throughout the summer, the prevalence of post-race EHI at racecourses C and G–J reached 0.1%, while that at racecourses A and B was <0.05%. JRA has 10 racecourses, which are distributed from latitude 34 to 43°N, and the difference in mean monthly ambient temperature between racecourses A and B and racecourses G–J was estimated to be approximately 6°C in the summer (Fig. 1; Table 2). Thus, the prevalence of post-race EHI might vary considerably even during the same season, depending on the climate condition, including the ambient temperature at each racecourse. However, this study does not elucidate why the prevalence of post-race EHI at racecourses G was

exceedingly high in July, and nor did it elucidate why it was higher at racecourse C and G throughout the summer than that at racecourses D and H, respectively, where ambient temperatures were almost similar (Tables 1 and 2).

In this study, WBGT were analyzed in July and August of 2017 and 2018 on sunny race days (9 AM–5 PM) at the three racecourses (racecourses C, G, and J) with a high prevalence of post-race EHI. The mean of the maximum WBGT for each day exceeded 30°C at the three racecourses, and the duration for which WBGT was between 28 and 33°C accounted for the highest proportion of the total measurement time at all three racecourses (Tables 3 and 4). According to the hot weather policies of some authorities, when WBGT is >33°C or the ambient temperature is >35°C, conditions are considered to have a very high risk of causing heat stress in horses, and when WBGT is 28 to 33°C, conditions are considered to have a moderate to high risk of causing heat stress in horses [1, 6, 17–19]. If the policies mentioned above were to be applied to the results of this study, most of the races held at racecourses C, G, and J on the sunny summer days would be held in an environment with a moderate to high risk of post-race EHI. This was reflected by the high prevalence of post-race EHI cases at these three racecourses during the summer. This may suggest that monitoring of the WBGT and ambient temperature at the racecourse is a useful tool to determine the risk of post-race EHI. However, although these data were limited to the days for which the relative sunshine duration was over 40%, climate conditions are influenced by how many sunny days there are in a month. Further studies are needed to determine how to evaluate climate conditions and to discuss other risk factors for post-race EHI.

Although there have only been a few reports on the prevalence of post-race EHI in the racing environment, we have reported fluctuation in the prevalence of post-race EHI during a 20-year period and the relationship between monthly prevalence of post-race EHI and climate conditions at racecourses in Japan. The overall prevalence of EHI was 0.04% (387 cases), and the prevalence per year has been increasing, exceeding 0.07% each year for the last four years. Limited to the summer (May–September), the overall prevalence was 0.086% (352 cases), and the monthly prevalence varied among 10 JRA racecourses that were distributed from latitude 34 to 43°N, ranging from no cases to 0.459%. During summer, the prevalence of post-race EHI was high when the mean monthly ambient temperatures at a racecourses was high. When climate conditions at the three racecourses with high prevalence were evaluated, most of the races were found to have been held when WBGT was between 28 and 33°C and would have presented a moderate to high risk of post-race EHI. These findings may be useful

in developing appropriate countermeasures to be taken during hot weather at each of the studied racecourses.

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