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Health challenges in outdoor sports competitions in Indonesia: A descriptive analysis

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ABSTRACT

Background: Weather plays a significant role in influencing health issues during outdoor sports competitions. However, limited studies have specifically examined the impact of weather on health problems in such settings. This study investigates the association between weather, measured by Wet Bulb Globe Temperature (WBGT), and health issues during outdoor sports competitions.

Methods: This cross-sectional study was conducted in Indonesia from August 2023 to July 2024. Data were collected from four running races, four land vehicle races (three motorcycle and one car race), and two soccer competitions. Weather conditions were monitored using WBGT, and health problems were recorded among participants requiring medical assistance. Statistical analysis assessed the relationship between weather conditions and health issues, with significance at $p<0.05$.

Results: According to WBGT, motorcycle and car races were held under high-risk weather conditions, soccer was under moderate risk, and running was under low risk. A total of 209 health-related incidents were reported, including 104 injuries and 105 illnesses. There were 151 health issues in running competitions, 17 in soccer, and 41 in motorcycle and car racing events. The types of injuries and illnesses varied by sport. Motorcycle racing was associated with a 15.5-fold increase in health problems ($p<0.001$), while competition under moderate-to-high-risk weather conditions increased the risk of health issues by 7.7 times ($p<0.001$).

Conclusion: Weather conditions are strongly associated with health problems in outdoor sports competitions. Moderate-to-high-risk weather significantly increases the risk of health issues.

Keywords: heat-related health issues, outdoor competition, sports type, sports injury .
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INTRODUCTION

Global warming, driven by rising ambient temperatures, has intensified environmental heat exposure and increased the risk of adverse health outcomes worldwide. These effects are particularly pronounced during outdoor physical activities, where athletes are exposed to substantial thermal stress. Sports competitions and other outdoor activities significantly elevate the risk of exertional heat illness (EHI), which includes a spectrum of conditions ranging from dehydration, hyperthermia, heat rash, sunburn, heat cramps, and heat syncope to heat exhaustion and, in severe cases, heat stroke.[1-4]

Recent international research highlights the increasing importance of environmental heat stress in sports epidemiology. The Wet Bulb Globe Temperature (WBGT) is the preferred measure for assessing heat stress in the athletic and occupational environment. WBGT incorporates key factors such as ambient temperature, humidity, solar radiation and wind speed that more effectively represent the total thermal load on athletes than simpler measures, such as air temperature alone.[5] Epidemiological studies show a close correlation between increased WBGT and increased incidence of heat illness, with a steep increase in risk above about 27°C.[6] This pattern persisted during major events such as the Tokyo 2020 Olympic and Paralympic Games, where cases spiked during periods of high WBGT, particularly in outdoor endurance events.[7]

Recent field studies have emphasized the need for accurate venue-specific WBGT readings. Environmental heat stress can differ greatly between playing surfaces and locations and careful assessment is important to avoid misclassification. Such evidence points to the essential role of real-time, context-aware heat tracking in shaping safety protocols for outdoor sports.[8]

At the regional scale, data from Southeast Asia including Indonesia stay sparse. Most prior work has zeroed in on discrete issues like musculoskeletal injuries at individual events, with scant attention to environmental heat factors.

Take, for instance, an international tennis tournament in Indonesia, where injuries struck at a rate of 30.[8] per 1,000 player-hours and high air temperatures emerged as a key influence.[9] However, these analyses failed to consider the common heat stress indices such as WBGT, limiting their ability to fully account for environmental hazards.

Researchers have proposed several approaches to reduce heat risk, such as acclimatization and acclimation. Acclimatization is the process of developing tolerance by repeated exposure to the natural environment that resembles the location of the event, and acclimation provides similar effects in controlled, simulated environments. However, practical problems such as time constraints or limited resources often prevent the use of these methods.[10,11]

Indonesia, a tropical nation in Southeast Asia, faces relentless heat up to 38°C alongside relative humidity routinely over 90%.[12] Such conditions heighten vulnerability to heat-induced health problems in outdoor sports. Yet systematic tracking of health outcomes against WBGT remains rare, both in this region and worldwide, particularly for varied outdoor disciplines in the tropics.[13]

Current research tends to be limited to individual sports, laboratory or cooler conditions, and overlooks the relationship of WBGT with a wide range of health issues in real-world tropical outdoor events. Moreover, there is a lack of strong epidemiological relationships between WBGT data with heat illnesses and broader health disruptions during competitions in Southeast Asia. These gaps hamper the development of tailored, evidence-based safety measures for hot and humid venues. Hence, this study investigated the relationship of WBGT with health incidents in Indonesian outdoor sports events. The findings should help to fill this gap with tropical field data and to assist the development of actionable measures to mitigate heat-related issues

METHODS

Design

This cross-sectional study was conducted during ten outdoor sports competitions held in multiple regions of Indonesia between August 2023 and July 2024. This study employed a descriptive observational design to investigate health-related challenges occurring during outdoor sports competitions in Indonesia.

Study setting and data collection

Observations were made at key urban and regional sites in Indonesia, namely Jakarta, Semarang, Mandalika International Street Circuit, and East Nusa Tenggara. These sites have a tropical climate with consistently high ambient temperature, high humidity, and high solar radiation, which are critical factors in assessing environmental heat stress in outdoor sports.

The study covered three outdoor sports disciplines: motorsports (motorcycle and car racing), soccer, and road running events. The competitions were conducted in open settings without climate control, exposing the participants to natural weather conditions. Prospective health data collection was conducted by trained medical teams deployed by organizers at each event. Records captured incidents at fixed medical stations and mobile units along racetracks, soccer fields, and running routes.

All athletes or participants needing care underwent evaluation and documentation via standardized forms. Information collected included participant demographics (where available), type of sport, nature of health issue (injury or illness), body part affected and clinical diagnosis. Environmental metrics were collected simultaneously using portable WBGT monitors placed at representative locations adjacent to competition areas. Data were collected at regular time intervals during the duration of the events in order to capture variations in heat stress. WBGT measurements were classified into pre-determined risk levels (low to extreme) for subsequent analysis.

Sampling technique and participant recruitment

The present study was conducted with consecutive sampling according to a total population surveillance method. All participants who required medical attention during the included outdoor sports competitions were eligible for inclusion. Rather than recruiting participants in advance, data were collected passively through on-site medical services. Therefore, the study sample consisted of all athletes, officials, or event participants who presented to medical teams with any health-related complaint during the competition period.

Participants were identified at the point of care by event medical personnel stationed at fixed medical posts and mobile units. Recruitment or random sampling was not applied as the aim of the study was to include the entire range of real-life health problems that occurred during competitions. All cases fulfilling the inclusion criteria during the study period were consecutively recorded to minimize selection bias.

Eligibility criteria

Participants were included if they participated in a selected outdoor sports event and presented to the event medical team with an injury or illness requiring assessment or treatment. Individuals with incomplete records or those who did not receive formal medical evaluation were excluded from the analysis.

Rationale for participant selection

This approach allowed us to comprehensively and unbiasedly capture health issues that occurred in real-world competition settings, using a total population surveillance and consecutive sampling design. It is consistent with established procedures in the epidemiology of sports injury and illness, which use medical encounter-based surveillance to quantify the burden and nature of health events that occur during sports competitions. The inclusion of all medical-attended cases increases the ecological validity of the findings, and allows meaningful comparisons of health issues across sport types and environmental heat stress conditions. While this approach may underestimate minor conditions not reported to medical teams, it provides standardized clinical confirmation of the cases recorded.

Sports types

The sports competitions included three motorcycle racing (Moto GP of Indonesia 2023, Yamaha Sunday Race/YSR 2024, and Asia Road Racing Championship/ARRC

Table 1. Competition events

Type of events	Motorcycle racing			Car racing	Soccer competition		Running race			
Name of events	Moto GP of Indonesia	Yamaha Sunday Race	Asia Road Racing	Porsche Sprint Challenge Indonesia	Elite Pro Academy League	TC Eltari Memorial Cup XXXII	Run with Me	Jakarta Marathon	PLN Electric Run	Semarang 10K
Time events	October 2023	July 2024	July 2024	January 2024	September 2023	August 2023	December 2023	October 2023	December 2023	December 2023
Location	Mandalika, West Nusa Tenggara	Mandalika, West Nusa Tenggara	Mandalika, West Nusa Tenggara	Mandalika, West Nusa Tenggara	Solo, Central Java	Rote Ndao, East Nusa Tenggara	Jakarta	Jakarta	Serpong, Banten	Semarang, Central Java
WBGT,°C	28.3	28.2	28.4	28.6	26.7	27.5	25.8	25.3	25.6	25.4
Risk classification	High	High	High	High	Moderate	Moderate	Low	Low	Low	Low
Participants (n)	98	172	94	12	~270	~405	~3000	~10.000	~5.000	~2.100
Male	98	172	94	12	~270	~405	-	N/A	N/A	N/A
Female	-	-	-	-	-	-	~3000			
Health issue (n)										
Injury	7	20	12	1	5	4	6	17	20	12
Illness	-	1	-	-	1	7	20	38	20	18
Percentage*	7.1%	12.2%	12.8%	8.3%	~2.2%	~2.7%	~0.87%	~0.55%	~0.80%	~1.4%

n, number of participants; °C, degrees Celsius; *, based on the number of participants.

2024), one car racing (Porsche Sprint Challenge Indonesia 2024/PSCI), two soccer competitions (Elite Pro Academy (EPA) League 2023 and El Tari Memorial Cup (ETMC) XXXII/2023), and four running races (Jakarta Marathon2023, Run with Me 2023, PLN Electric Run 2023, and Semarang 10K 2023).

Motorsports race

MotoGP™ is the highest level of two-wheeled road motorcycle racing sanctioned by the Fédération Internationale de Motocyclisme (FIM). Indonesia was appointed as the host of MotoGP in October 2022 and has since held the event annually. The Yamaha Sunday Race is a national motorcycle racing event featuring domestic participants and multiple sessions. The Asia Road Racing Championship (ARRC) is a regional motorcycle racing championship held in Asia, open to riders from all countries, and endorsed by the FIM. The championship includes several sessions, including practice, qualifying, and the main race. The Porsche Sprint Challenge Indonesia is a national car racing event featuring the Porsche 911 GT3, organized by the Indonesian committee and held annually.

Soccer

Elite Pro Academy League is a national youth football competition for ages Under-16, Under-18, and Under-20. El Tari Memorial Cup XXXII is a Third division of Indonesian amateur football competition in the province of East Nusa Tenggara.

Running race

The Jakarta Marathon is an international running event held regularly in Jakarta, offering distances of 5 km, 10 km, half marathon, and full marathon. Run with Me (RwM) is a national running competition for women, covering a distance of 6 km. The PLN Electric Run is a national competition organized by the State Electricity Company in Jakarta, featuring 5 km, 10 km, and half marathon distances. Additionally, the Semarang 10K is a national running race covering a distance of 10 km, which allows runners from other countries to participate.

Environment monitoring by WBGT

Weather conditions were monitored using the WBGT during competition at a single location. WBGT can assess heat stress risk by accounting for temperature, humidity, wind speed, sun intensity, and other factors.3 WBGT results for heat stress were classified into: low risk (<25°C), moderate (25°C – 28°C), high risk (28°C – 30°C), very high risk (30°C – 32°C), extreme risk (>32°C).[9]

Health Issues Surveillance

The match physicians recorded all types of health issues and issues reported by participants who needed medical or health aid during the competition. Health issues were classified into two categories: injuries and illnesses. Injuries were further classified according to the affected body part and the possible type of injury.

The competition committee granted permission for data collection. This study was reviewed and approved by the Ethics Committee of Universitas Negeri Yogyakarta, Indonesia (No. T/35/UN34.9/KP.06.07/2023). All participants provided informed consent prior to inclusion in the study.

Statistical analysis

Statistical analysis was performed using SPSS version 22.0 (SPSS Inc., Chicago, IL, USA). A p-value set at < 0.05 was considered statistically significant. Numeric data are presented as frequencies and percentages. The associations between health issues, sport type, and heat stress risk based on WBGT were assessed using the Chi-square test.

RESULTS

Table 1 provides an overview of all competitions. Seven of ten events occurred during cooler months (December-January

Table 2. Injury and illness distribution according to the sports type

Variable	Run	Soccer	Motor Race	Total
	n (%)			
Sex				
Female	69(100)	-	-	69
Male	82(58.6)	17(12.1)	41(29.3)	140
Injury/Illness				
Injury	55(52.9)	9(8.6)	40(38.5)	104
Illness	96(91.5)	8(7.6)	1(0.9)	105
Injury type				
Sprain	19(65.6)	5(17.2)	5(17.2)	29
Skin lesion	12(50)	1(4.2)	11(45.8)	24
Contusion	2(14.3)	1(7.1)	11(78.6)	14
Plantar foot pain	13(100)	-	-	13
Strain	9(81.8)	2(18.2)	-	11
Concussion	-	-	7(100)	7
Fracture	-	-	3(100)	3
Abdominal trauma	-	-	1(100)	1
Compartment syndrome	-	-	1(100)	1
Dislocation	-	-	1(100)	1
Illness				
Heat cramp	62(88.6)	7(10)	1(1.4)	70
Heat exhaustion	15(100)	-	-	15
Heat stroke	7(100)	-	-	7
Respiratory/ENT System	6(100)	-	-	6
Gastrointestinal	3(75)	1(25)	-	4
Other	3(100)	-	-	3

n, number of participants; %, percentage.

Table 3. The association between health issues and sports type

Variable	Motor race	Soccer	Running race	p-value	p-value (OR)
No health issues	335	658	19,949	<0.001	<0.001 (15.5)*
Health issues	41	17	151		

*, soccer and running races were combined due to their different characteristics compared to motor racing. OR, odds ratio.

Table 4. The association between health issues and WBGT classification for heat stress

Variable-	Low risk	Moderate risk	High risk	*p*-value	*p*-value (OR)
No health issues	19.949	658	335	<0.001	<0.001 (15.5)*
Health issues	151	17	41		

*, moderate and high risk were combined due to their different characteristics compared to low risk. OR, odds ratio.

and June-August). According to WBGT classifications, four motorsport events were conducted under high heat stress risk, two soccer competitions under moderate risk, and four running races under low heat stress risk.

The overall number of participants across all events was approximately 21,151. About 376 motorcyclists and car riders participated in the motorcycle and car races. In soccer, there were 18 teams in the EPA League and 27 teams in the ETMC XXXII. Considering that each team had 15 players, the total number of soccer participants in these two events was approximately 675. Meanwhile, the number of participants in the running races is estimated to be around 20,100 runners from four events, as reported by the race committee. The total number of female and male participants remains uncertain.

In total, 209 health issues (around 1%) were found in the ten competition events. Most health issues (151 cases, 72.2% of total cases) were seen in running competitions, with the Jakarta Marathon having 55 cases (26.3%). However, the frequency of health issues in running competitions was only 0.76% of the participants. The frequency of health issues in motor racing and soccer was 10.9% and 2.5% respectively. Motor racing and soccer are the most common sport with injuries (12.8% prevalence) in Asia Road Racing Championship 2023 and running competitions probably have the most common health problem of injury.

Table 2 provides a detailed description of the health problems. Most injuries and illnesses were consistent with the type of sport the participants played. Sprains, strains, and plantar foot pain were more common in running events, while contusions and concussions were more frequently observed in motor racing. Heat-related illnesses, including heat cramps, heat exhaustion, and heat stroke, were exclusively reported in running races.

Table 3 presents the association between the incidence of health issues and the type of sport. Although the frequency of health issues in motorsports was lower, the percentage was higher than in running races due to the smaller number of participants. Health issues were significantly associated with the type of sport ($p < 0.001$). The association was confirmed when soccer and running races were combined due to their different characteristics compared to motor racing. Motorcyclists had a 15.5 times greater risk of experiencing health issues ($p < 0.001$).

Table 4 shows the association between the incidence of health issues and WBGT results. Sports competitions held in moderate-to-high-risk zones increase the

risk of health issues by 7.7 times compared to those conducted in low-risk zones ($p < 0.001$).

DISCUSSION

This study demonstrates a clear association between environmental heat stress, as measured by the WBGT, and the occurrence of health problems during outdoor sports competitions. Events conducted under moderate-to-high WBGT conditions were associated with a 7.7-fold higher likelihood of injuries and illnesses compared with low-risk conditions. Furthermore, the magnitude of this association varied by sport type, with motor racing showing the highest relative increase (15.5-fold), followed by other outdoor sports. These findings indicate that both environmental heat exposure and sport-specific characteristics contribute to the risk profile of health issues during competitions.

This is the first study to investigate the association between health issues and weather during outdoor sports events in Indonesia. Our findings extend previous evidence by demonstrating that WBGT, as a composite indicator of environmental heat stress, is significantly associated with the occurrence of both injuries and illnesses in real-world competition settings.

The impact of environmental conditions on injury risk is well documented, in particular temperature, humidity, wind speed and solar radiation. For example, a time-series study in Spain showed an increase in emergency visits for sports injuries with increasing ambient temperatures. In tropical countries such as Indonesia, where baseline environmental heat exposure is high, these risks may be even more pronounced. Our results support this hypothesis; we found a greater proportion of health issues in events conducted in moderate-to-high WBGT conditions versus low-risk environments.[14]

Our results are supportive of previous studies on the relationship between weather and musculoskeletal injuries. For example, studies in Indonesia found that WBGT was an important risk factor for injuries during an international tennis tournament and studies in China have shown relationships between ambient temperature and injury risk.[15,27,28] Nevertheless, the relationship between environmental conditions and the risk of injury seems to be dependent on the sport and injury mechanism.[16] In motor racing traumatic injuries may be more influenced by high-speed dynamics and mechanical factors, but environmental stress can still indirectly influence the risk of injury through fatigue or decreased concentration.29,30 Conflicting results from other sports such as baseball where no clear relationship between weather conditions and risk of injury has been reported demonstrate the need for sport-specific analyses.[17]

The study's findings regarding the association between environmental heat stress and health outcomes have further added to a growing international body of epidemiological evidence. Analysis of large-scale surveillance data from elite beach volleyball competitions found a significant association between increased risk of heat-related medical time-outs and high WBGT, temperature and humidity, highlighting the importance of environmental stress during competition.18,24 Similarly, data from the Tokyo 2020 Olympic and Paralympic Games found that over 50% of all heat-related illness cases occurred on days with high WBGT, especially in endurance sports such as athletics and triathlon.[7,25,26]

Increased WBGT (>30–32°C) has been associated with increased medical callouts and altered performance characteristics in tennis providing evidence of both physiological strain and clinical impact during competition.[19,21,22] These findings are similar to those in population-based epidemiologic studies outside of sport-specific settings. A large case-crossover study in Taiwan found a 41% increase in risk of heat-related illness per 1°C increase in WBGT, with a clear exposure-response relationship.6,23 Similarly, a nationwide study in Japan found a strong relationship between high WBGT levels and increased hospitalizations for heat-related illness with a sharp increase in risk at WBGT ≥28 °C.20

These international findings reinforce the present study's results, confirming that WBGT is a robust and clinically relevant indicator of heat-related health risk across different populations, sports, and environmental contexts. Importantly, while most existing studies have focused on single sports or elite-level competitions, the present study extends this evidence by demonstrating consistent associations across multiple sport types within a tropical Southeast Asian setting, where baseline heat exposure is persistently high.

The results have implications for athlete safety and management of sporting events in the tropics. The increased health risk associated with moderate to high WBGT values highlights the need for appropriate heat risk mitigation strategies for outdoor athletic events. Organisers of sporting events and medical staff may consider implementation of WBGT-based procedures such as schedule modifications (i. avoiding the warmest part of the day), heat acclimatization programs, hydration techniques, shaded recovery areas and real-time environmental monitoring. Additionally, sport-specific risk profiles (i.e. The increased relative risk in motorsports highlight the need for sport-specific interventions to mitigate risk based on nature and intensity of the sport. The incorporation of WBGT monitoring into routine medical planning may help in identification and prevention of heat-related illness and other weather related events.

A strength of this study was the use of data from several large national and international outdoor sporting events from a range of geographic regions in Indonesia which increased the generalisability of the findings to tropical settings. In addition, the use of real-world surveillance data increases the ecological validity of the results. However, a number of limitations should be noted. Firstly, the absence of detailed exposure data, such as individual participation duration and total athlete numbers, prevented the computation of standardized injury incidence rates (e.g., per 1,000 athlete-hours). Second, the disproportionate number of participants across sport types particularly the higher participation in running events may have influenced the relative distribution of health problems. Third, reliance on medically attended cases may underestimate minor conditions that were not reported to on-site medical teams.

CONCLUSION

Health problems during outdoor sports competitions are significantly associated with environmental heat stress as measured by WBGT. Events conducted under moderate-to-high WBGT conditions substantially increase the likelihood of injuries and illnesses, with variation observed across sport types. These findings underscore the importance of integrating environmental monitoring into sports safety protocols, particularly in tropical climates. Future studies incorporating exposure-based incidence measures and sport-specific analyses are warranted to further clarify these relationships.

ETHICAL CONSIDERATION

This study was reviewed and approved by the Ethics Committee of Universitas Negeri Yogyakarta, Indonesia (No. T/35/UN34.9/KP.06.07/2023). All participants provided informed consent prior to inclusion in the study.

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CONFLICT OF INTEREST

The authors declare the following potential conflicts of interest. This study was funded by Taisho, a company that produces analgesic creams and cooling products for injury management. However, this funding did not influence the study's design, data collection, analysis, interpretation, or publication decision.

AUTHOR CONTRIBUTIONS

MIZ, AA, and LA handled data collection, methodology development, and manuscript drafting. MS, RDR, and AAK oversaw study conceptualization, design, and critical revisions. LLF, TF, and R contributed to data interpretation and manuscript drafting. MRA, WBS, and NAP provided critical revisions and technical feedback. IRH assisted with data analysis and literature review. All authors contributed to drafting and approved the final manuscript.

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