Determining a "Do Not Start" Temperature for a Marathon on the Basis of Adverse Outcomes

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ABSTRACT

ROBERTS, W. O. Determining a "Do Not Start" Temperature for a Marathon on the Basis of Adverse Outcomes. *Med. Sci. Sports Exerc.*, Vol. 42, No. 2, pp. 226–232, 2010. **Introduction**: Marathon races faced with unexpectedly hot conditions must make a decision to start or not to start. The current race cancellation parameters may not reflect the safety profile of an individual race, and a universal temperature may not work an individual race. **Methods**: A retrospective review of the number of starters, finishers, and finish line medical encounters was used to calculate the rate of "unsuccessful" marathon starters from race records, where unsuccessful is defined as medical encounters seen for any reason in the finish medical area plus marathon starters who did not finish. Unsuccessful marathon starters were plotted against the race start wet bulb globe temperature (WBGT), and the WBGT level at which a mass casualty incident (MCI) occurred was used to calculate a "do not start" WBGT. **Results**: A start WBGT of >21°C resulted in MCI or midrace cancellation in several races. Twin Cities Marathon data show a rapid increase in the rate of unsuccessful marathoner starters above a start WBGT of 13°C. The event experienced an area-wide MCI at a start WBGT of 22°C with an unsuccessful starter rate of 160 per 1000 finishers. **Conclusions**: Marathons in northern latitudes (>40°) held in "unexpectedly" hot conditions when the participants are not acclimatized and the start WBGT is >21°C often end in either race cancellation or an MCI. It would seem prudent not to start these races in similar conditions. The rate of unsuccessful marathon starters per 1000 marathon finishers plotted against start WBGT generates a curve that can be used to estimate a do not start level. The do not start WBGT for Twin Cities Marathon is 20.5°C on the basis of this model. **Key Words:** EXERTIONAL HEAT STROKE, HEAT STRESS, MASS CASUALTY INCIDENT, RACE CANCELLATION

Marathon races that cater to nonelite runners are occasionally faced with unexpectedly hot conditions on race day and must decide "to start" or "not to start" the race. Unexpectedly, hot conditions are within the historical range of weather conditions for the day and area, but at the upper end. The much warmer-than-average race conditions are not anticipated by the runners and are often associated with lack of acclimatization because the runners are prepared for the usual or average race day weather. The risks of starting a popular marathon in hot conditions are twofold: 1) medical problems and inability to finish among the marathon starters increases and 2) race-related emergencies overwhelm the community medical assets (emergency rooms and ambulances), increasing ambulance response times beyond acceptable limits and overpopulating the emergency facilities with runners who become ill in the heat creating a mass casualty incident (MCI). An MCI is simply defined as an event that produces more patients than available resources (ambulances, emergency room beds, emergency room staffing) can manage using routine procedures. An MCI puts the community members at risk for delayed care when the ambulances are deployed to transport marathon casualties and the emergency rooms are filled to capacity or beyond.

The current wet bulb globe temperature (WBGT) cancellation parameters for many marathon races are based on the 1996 American College of Sports Medicine (ACSM) "Heat and Cold Illnesses during Long Distance Running" Position Stand (Table 1) (3). The ACSM WBGT temperature cascade is based on heat tolerance of young military recruits, acclimated military personnel, and laboratory study subjects and is not based on the heat tolerance of unacclimatized, nonelite marathon runners in unexpectedly hot conditions (1,2,6,9). The ACSM table may not reflect the safety profile of a marathon race with unacclimatized participants. The updated 2007 "Exertional Heat Illness during Training and Competition" ACSM Position Stand allows even higher WBGT levels for continuous activity such as a marathon (cancel at >30°C for acclimated participants) but has not been adopted by many marathons at this time (4). The ACSM parameters do not seem to

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TABLE 1. Temperature cascades for activity modification on the basis of WBGT with modifications suggested for TCM contrasted to the 1996 ACSM heat recommendations.

EHS Risk (3,4)	1996 ACSM Road Race WBGT (3) (°C/°F)	2007 TCM WBGT Modification (°C/°F)
Generally safe; EHS can occur associated with individual factors	<10/50	(<13/55)
Generally safe; EHS can occur	10/50–18/65	<13/55
EHS risk begins to rise; high-risk individuals should be monitored or not compete	18/65–23/73	13/55–17/63
EHS risk for all competitors is increased	23/73–28/82	17/64–20/68
Cancel or postpone	>28/82	>20.5/69

EHS, exertional heat stroke.

apply to poorly acclimated, nonelite marathon starters who face "unexpected" heat stress with ambient temperature and relative humidity that are well above the seasonal average for race day.

Marathon race participant data from MCI at several individual marathons and longitudinal race data across several years at a single marathon show the effects of high heat stress on the race medical encounters, race dropouts, and the risk of a community-wide MCI. The purpose of this study was to demonstrate a method using longitudinal race data to determine start WBGT temperatures that are unsafe for nonelite marathon runners and have potential for causing an MCI in the host community.

METHODS

A retrospective review of the number of marathon starters, finishers, and finish line medical encounters from race records, personal communications, and newspaper accounts was used to calculate the number and rate of "unsuccessful" marathon starters. The total number of marathon entrants is usually greater than the actual number of marathon starters for any given race because injury or illness during training force some entrants not to participate and, when it is hotter than expected, some uninjured entrants decide not to start the race. In the mid 1990s, chip timing technology was introduced to mass participation marathon races, allowing the actual number of marathon starters to be accurately tallied for each race. Chip timing also produces an accurate count of official marathon finishers. The number of medical encounters in the finish area medical facility is also recorded for each race. This combination of race statistics allows a calculation of unsuccessful marathon starters and can be used as a surrogate marker to estimate race day stress. Unsuccessful is defined as either not finishing the race or seeking medical assistance of any kind in the finish medical area. Race day stress is estimated for this model by the rate equation: $\{[(\text{race starters} - \text{race finishers}) + \text{finish line race–related medical encounters}] / \text{race finishers}\} \times 1000$ = unsuccessful marathon starters per 1000 finishers. Plotting this rate of unsuccessful marathon starters for each race against the start WBGT generates a curve that reflects the effects of heat and humidity for the race participants as a group. If one or more MCI have occurred, the "do not start" (DNS) WBGT level can be determined by setting the DNS level below the start WBGT that resulted in the race MCI status.

Either an MCI status for the race or a midrace cancellation was considered the undesired outcome in this study assuming that the course, the race start time, and the general type of participant is relatively constant from year to year.

The common measures used for heat stress prediction —ambient temperature (T_d), relative humidity (RH), dew point, wet bulb temperature (T_w), and black globe temperature (T_b)—were collected on site and from the National Weather Service. The start WBGT, defined by the equation $\text{WBGT} = 0.7T_w + 0.2T_b + 0.1T_d$, was calculated from on-site measurements or from local weather station measurements using the algorithms from www.zunis.org.

The study was considered exempt by the University of Minnesota's Institutional Review Board (no. 0804E30202).

RESULTS

The race start time, cancellation time (if applicable), start WBGT, the number of entrants, starters, finishers, race dropouts, and medical encounters and the rate of unsuccessful starters are summarized in Table 2 for marathons held in "unexpectedly" hot conditions that resulted in either

TABLE 2. Hot races with MCI and midrace cancellation outcomes.

Year	Race	Start Time (CX Time)	Start WBGT at °C (°F)	ENT	ST	FIN	DNF	ME	ME + DNF/1000 FIN
2004	Boston—Boston Area, MA	1200 h	22.7 (73)	20,344	18,003	16,783	1220	1100	132
2006	Med City—Rochester, MN	0800 h (1230 h)	27 (80)	376	292	139	153	24+	Midrace cancellation
2006	Mad City—Madison, WI	0800 h (1315 h)	27.4 (81.3)	NA	1270	788	482	>100	Midrace cancellation
2007	Rotterdam—Rotterdam, Netherlands	1130 h (1430 h)	20.5 (69)	20,000	7800	4200	3600	NA	Midrace cancellation
2007	London—London, England	0945 h	18.1 (64.6)	46,500	36,396	35,688	708	NA	NA
2007	Twin Cities—Minneapolis-St Paul, MN	0800 h	22.1 (71.8)	11,500	8093	7226	867	291	160
2007	Chicago—Chicago, IL	0800 h (1135 h)	22.2 (72)	45,000	36,280	25,534	10,746	685	Midrace cancellation
2008	Preferred Care—Rochester, NY	0800 h (NA)	22.2 (72)	NA	618	567	51	129	301 midrace cancellation

CX, cancellation; DNF, did not finish race; ENT, entrants; FIN, finishers; ME, finish line medical encounters; NA, data not available; ST, starters.

midrace cancellation or an area-wide MCI incident. Additional details for each of the races are described below.

- The 2004 Boston Marathon generated more than 300 emergency medical calls and approximately 1100 finish area medical encounters. This race responded to the MCI by changing its traditional noon (1200 h) start time to an earlier 1000 h start to decrease the afternoon heat stress and related casualties in future races (7).
- The 2006 Med City Marathon (Rochester, MN) was canceled at 4.5 h into the race with four runners hospitalized and more than 20 (>20%) finishers requiring intravenous fluids (7).
- The 2006 Mad City Marathon (Madison, WI) was canceled at 5.25 h with >100 runners evaluated at the finish line medical station, approximately 75 intravenous fluid lines started (10% of finishers), and 8 runners transferred to the hospital (one male runner with a body temperature of 42.2°C who survived and one female runner who was hospitalized for several days with postrace seizures) (7).
- The 2007 Rotterdam Marathon was canceled at 3.5 h into the race. "Some 30 participants were taken to (the) hospital, many of them with symptoms of dehydration," and 17 were admitted for further treatment. Only 7800 of 20,000 entrants actually started the race.
- The 2007 London Marathon was held 1 wk after Rotterdam and was hot by London standards. The St John Ambulance treated 5032 people along the course and at the finish line. In contrast, the number treated in 2008 in cool rainy conditions was just more than 4000. In 2007, 73 runners needed hospital treatment, the average time was 17 min slower than usual, and there were 6 cases of exertional hyponatremia and one died of hyponatremia. There was a 1-h or more wait for ambulances at finish area, causing delays in hospital treatment.
- The 2007 Chicago Marathon was canceled at just over 3.5 h with 185 hospital transports and 66 runners admitted to the hospital (12 in intensive care and 1 sudden cardiac death). The start WBGT was 22.2°C, and the peak WBGT was 28.9°C. The race records show more than 25,000 finishers despite only 1363 finishers at the time of cancellation, demonstrating a large number of participants who did not heed the heat cancellation warnings and continued on to the finish line.
- The 2007 Twin Cities Marathon (TCM) had 10 finish line and 70–80 off-the-course ambulance transfers to hospital emergency rooms. Six local hospitals went onto divert status because of the volume of runner-related casualties (including two of the three area level-1 emergency facilities). There were nine runners with exertional heat stroke in the medical tent and at least two who were taken off the course to the hospital with rectal temperatures as high as 42.7°C. The 0800 h start WBGT was 22.2°C, and the WBGT rose to 27°C 3 h into the race. The rising WBGT was blunted by a 45-min cloud cover that temporarily reduced the heat stress.
- The 2008 Rochester NY Marathon was canceled midrace when the emergency rooms were deemed too busy to accept more patients. The 0800 h start WBGT was 22.2°C, and the 1200 h (noon) WBGT was 27.2°C.

The TCM data for start WBGT compared with unsuccessful marathon starters are plotted in Figure 1 for 12 annual races from 1997 to 2008. The TCM unsuccessful marathon starters (finish line medical encounters plus marathon starters who where unable to finish) per 1000 marathon finishers versus the race start WBGT plotted as a polynomial curve of best fit shows a strong correlation coefficient of 0.94 (r^2 = 0.89). When the start WBGT is >13°C (55°F), the number and rate of finish line medical encounters and on-course marathon dropouts begin to rise. This data set includes one race (2007) that surpassed metro-wide MCI criteria (six hospital emergency departments temporarily closed to new patients because of marathon-related patient volume and out-of-area ambulances were used to transport ill runners off the course) and two races (2005 and 1997) that were at MCI level in the finish area locale (two to three finish area hospital emergency departments temporarily closed to new admissions, but no out-of-district ambulances were required to transport ill runners). The remaining years were in the acceptable range for unsuccessful starters and form the baseline for data comparison. Also of concern, the number of runners with

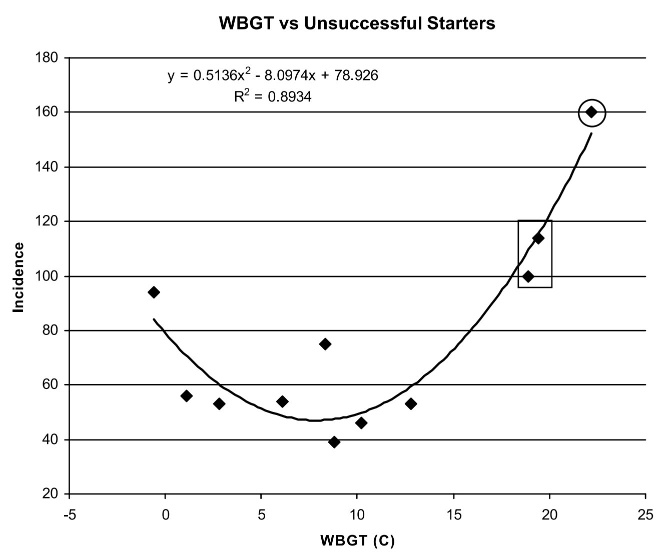

FIGURE 1—The 1997–2008 TCM unsuccessful runners per 1000 finishers plotted against start WBGT shows increasing risk with WBGT above 13°C (55.4°F). About 100–120 unsuccessful starters per 1000 finishers are borderline for MCI (*rectangle*) and 160 is area-wide (*true*) MCI (*circle*).

heat stroke in 2007 was at least 11, which is considerably higher than the 0–1 that occur in the cooler years (start WBGT, <13°C). The number of dropouts is estimated for the 1997 race because the true number of starters was unknown for the years before 1998 when chip timing was instituted.

The DNS level was placed just above the two races that were in near MCI status at 130 unsuccessful starters per 1000 finishers where the area medical capacity seems stressed, but adequate, and well below the 160 unsuccessful rate of 2007. The curve for unsuccessful starters per 1000 finishers crosses the 130 mark at 20.5°C (Fig. 2). On the basis of these data, the marathon should not start the nonelite racers at 20.5°C or above if the heat stress will become more severe as the race progresses through the day to protect both the runners and, more importantly, the community access to the emergency medical system. The recommended DNS level derived from Figure 2 is shown in Table 1.

DISCUSSION

The TCM medical plan is set up to care for the common marathon-related problems in the finish area and to offer first aid and comfort care along the course. The overarching theme is to care for the simple problems on site and initiate care for the more complex or life-threatening problems followed by transfer to one of the local hospital emergency departments. The secondary goal is to keep the emergency rooms open for the true race-related life-threatening problems and the community emergencies that occur during and unrelated to the race.

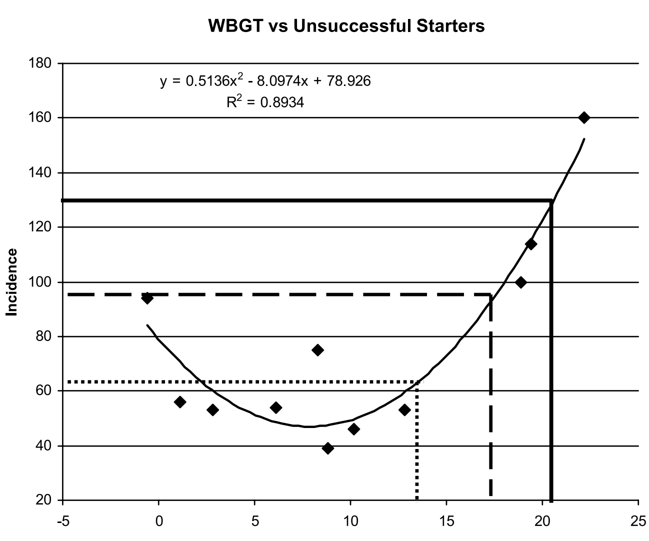

FIGURE 2—Risk levels on the basis of MCI risk: DNS WBGT is calculated using an incidence of 130 unsuccessful starters per 1000 finishers that intersects the curve at a WBGT of 20.5°C (69°F) on the temperature axis. The cancel level (*solid line*) at 20.5°C (69°F) is just above the finish area MCI races and below the area-wide MCI race. The high-risk level (*dashed line*) is placed just below the finish area MCI races, and the caution level (*dotted line*) is placed just above the races with acceptable unsuccessful runner rates. The definitions are found in Table 1.

It is a general observation of many marathon medical staff providers that the medical workload increases with increasing heat and humidity. Jones, comparing two Boston Marathon races in Boston, MA (USA), at ambient temperatures of 9°C and 20°C, found that nausea, vomiting, confusion, and blisters all increased substantially in the heat, whereas the most common problem of cramping was only minimally increased (B. Jones, personal communication). At Grandma's Marathon in Duluth, MN (USA), the odds ratio for requiring medical care increased to 1.8 if the average marathon dry bulb temperature was above 15.5°C (5). This is consistent with the experience at TCM where the number of medical encounters increases when the conditions warm above a start WBGT of 13°C.

The common measures used for heat stress prediction such as ambient temperature (T_d), relative humidity (RH), dew point, wet bulb temperature (T_w), and black globe temperature (T_b) are difficult to compare from site to site and year to year. WBGT is considered the criterion standard in heat stress management and is used for heat safety cascades that suggest when to curtail or cancel activity (1–4,6,9). For this race stress calculation model, WBGT was chosen for its ease in year-to-year comparison of TCM heat stress conditions and to compare with other races that have canceled midrace or experienced MCI status. The heat stress level, measured by start WBGT, at which an unacceptable portion of athletes can no longer successfully complete the marathon and maintain a safe medical environment for the community can be imputed on the basis of historical race data regarding the MCI status outcome at each race start WBGT (MCI occurred vs MCI did not occur). At or above the MCI heat stress level, the risk of another MCI increases.

During a 12-year span from 1983 to 1994, the "usual" weather conditions for TCM show an average start temperature of 5°C (41°F) with a range of −4°C to +16°C (24°F–61°F) and an average medical encounter rate of 23 per 1000 finishers (8). In the last decade, the advent of chip timing has allowed an accurate measure of the number of race dropouts. The sum of the race dropouts and the race finish line medical encounters gives an indirect measure of the heat stress encountered by the runners. These data can be plotted against the start WBGT to give a curve that reflects the effects of increasing heat stress on the measure of unsuccessful runners.

The risk of requiring medical attention and not finishing the race increases rapidly above 13°C (55.4°F) start WBGT at TCM as shown in Figure 1. The finish area MCI risk starts in the 100–120 unsuccessful marathon starters per 1000 finishers range and an area-wide MCI occurred at the 160 level. As the heat stress increases, the number of exertional heat stoke casualties rises and the number of runners who require care in the local emergency facilities also rises dramatically. For example, the number of exertional heat stroke casualties at TCM average 0–1 per race when the start WBGT is <13°C and rises to 11–12 per race when the start WBGT is 22°C.

This rise in both the number and the severity of race casualties stresses the community medical system beyond capacity and may block local community member access to the emergency facilities. This poses a danger to the runners and the community members-at-large as emergency response vehicles become unavailable for community response and emergency facilities are stretched beyond their functional capacity to adequately care for the overall patient load. On the basis of these data, the TCM should not start the nonelite racers at a WBGT of 20.5°C (69°F) or above if the heat stress will become more severe as the race progresses through the day to protect the runners and the community members.

Individual heat tolerance during exercise is variable, and race stress seems most dependent on the level of runner acclimatization and the heat and humidity on race day as reflected by the WBGT. Inadequate acclimatization negatively affects heat tolerance and increases dropout rates. The combination of an unexpectedly hot race day combined with lack or loss of acclimatization owing to cool weather in the weeks preceding a race produces an increase in the number of unsuccessful marathoners and an unacceptably high rate of exertional heat stroke. Fall and spring marathons such as TCM, Chicago, and Boston are usually preceded by several weeks of cool weather but, historically, can have hot conditions on race day. It is these unusually hot days that pose the greatest risk to participants who are training for and usually training in the average race day conditions. In contrast, destination marathons such as the Honolulu Marathon that are run each year in relatively hot and humid conditions do not seem to have the increase in casualties when run at similar temperature, possibly because the runners arrive with expectations for a slow pace.

The number of participants who "successfully complete" a marathon decreases as the heat stress increases. The race stress mathematical model presented in this study requires an easily calculated number that any race can use to estimate the effects of heat stress on the runners. The sum of finish line medical encounters and participants who are unable to complete the race, defined in this study as unsuccessful starters, becomes a surrogate measure of heat strain as exercise-associated collapse, exhaustion, and heat stroke rise with the heat load. The model assumes that the usual marathon-related problems that occur in cooler race conditions will continue to occur, and the increase in dropouts and medical encounters is due mainly to the heat and humidity.

The variables used to calculate unsuccessful marathoners at a given race may vary on the basis of the record-keeping system in place; however, the chosen variables must be consistent from year to year and reflect the medical activity both on the course and in the finish area for this model to have predictive value for race stress. Nonfinisher numbers are easily calculated from start and finish data, but some races may have a record-keeping system that can reliably reflect medical activity on the course and choose to use that as a race stress measure rather than dropouts. Likewise at the finish area, all medical encounters for any reason may be easily obtained, but another measure of medical activity such as nausea and vomiting may be used.

The TCM model uses all encounters including blisters and ankle sprains to make this calculation simple. However, the background baseline medical encounter and DNF numbers, such as the chances of spraining an ankle, are probably about the same at the start or on the course in both hot and cold conditions so sprains remain a part of the equation. The key is consistency from year to year in the measure chosen. The London Marathon has a course-wide (including the finish area medical tents) measure of encounters for any reason that rises with warmer conditions and may be a useful marker for that race. In the TCM medical management protocol, all medical problems that occur on the course are transferred to local hospital emergency rooms, where other marathons transfer all medical problems to the finish area medical tent. Using the formula developed for this analysis, runners who dropout and are transferred to the medical tent would be counted twice. As long as the race statistics are consistent from year to year at a given site, the process should still work because it is the amplification of unsuccessful starters that helps distinguish the effects of hot conditions.

There are probably several factors that interact to create an MCI scenario in a given community at the marathon distance. Those factors determining a DNS WBGT level for a given race include the WBGT, sun penetration at the start and during the race, acclimatization of the participants, number of starters (field size), racing ability of the participants (elite vs nonelite), on-site race medical support, and available community medical assets. With this in mind, each race may have a different DNS level. For example, a Florida race with acclimatized participants may be able to safely start a race at WBGT of 22°C (72°F), whereas a fall Minnesota race that is unexpectedly hot may be well above the DNS level and experience, as in 2007, excess casualties at this heat load.

In the past four years, several different races were started with WBGTs in the 18°C–28°C range, and all experienced high casualty rates that give insight into the safety profile for marathon participants (Table 2). These races overwhelmed the community emergency medical resources and were either canceled in midrace or experienced MCI status. It seems logical and unlikely, on the basis of the resulting midrace cancellation or MCI status of these races, that it would be deemed safe or prudent to start a future race at or above that WBGT. Races should determine the most likely safe temperature threshold and establish a DNS temperature level. This established safety threshold is partly to protect the runners but is mainly to protect the community from the collateral effects of an overwhelmed medical system.

There is probably no universal temperature level at which all races should be canceled to protect community access to medical care. It is clear from the TCM data that an acceptable casualty rate changes to unacceptable at a start temperature in the 18.8°C–22.2°C (66°F–72°F) range and that, at 22.2°C (72°F), the number of unsuccessful marathoners exceeds the current capacity of the metro area medical system. The TCM data suggest that the race should not be started if the WBGT is above 20.5°C (69°F). This seems to be true for Boston, MA; Chicago, IL; Madison, WI; Rochester, MN; and Rochester, NY, all near 40°N. The WBGT cutoff may be lower for the London and Rotterdam marathons, which are near 50°N. Some races at the same latitude may tolerate higher WBGT start levels. For example, smaller races in large communities such as the 2007 Milwaukee Marathon run on the same day in the same conditions as Chicago and TCMs had no appreciable affect on the medical system, elite-only races, races with fully acclimatized participants (normally hot humid areas with local participants), and hotter destination marathons where participants either arrive acclimatized to the conditions or slow their pace to accommodate the heat.

The current ACSM guidelines for road racing with starts allowed with WBGT up to 28°C–30°C may be too liberal for acceptable community emergency load when correlated with the recent hot weather experiences, especially when the runners are not acclimated to the heat (4). Each race should calculate the WBGT DNS level on the basis of its own race data. It seems that an unsuccessful starter per 1000 finishers rate of >120–130 will cause MCI status in metropolitan areas with larger races in the northern tier of states in the spring and fall.

Canceling the race before it starts has a safety advantage for the community because experience from midrace cancellations shows many participants continue to run on the course after cancellation, making it difficult to track and manage their medical problems and further taxing an already overloaded medical system. In hot conditions, the finish area medical facilities seem to handle the increase in encounters, partly because the finish areas tend to be staffed for high volume and partly because many of the potential finish line casualties drop out on the course and do not make it to the finish area.

The care and transportation of collapsed runners on the race course is often overwhelmed by the large volume of heat-stressed participants who cannot continue or are dangerously ill with heat stroke. Response times for sudden cardiac arrest, hyponatremic encephalopathy, and other collapsed runners lengthen and put these runners at risk for excess morbidity and mortality. More importantly, the community access to the emergency medical system may be compromised when races are conducted in hot and humid conditions (particularly above a WBGT of 21°C (70°F) in northern latitudes). Emergency medical systems can be overwhelmed with a surge of patients from the race, reducing the emergency call response times to unacceptable levels for the citizens of the community, as well as the race-related casualties. As emergency departments are overwhelmed, individual hospitals are forced to divert patients to more distant hospitals slowing the access and time to emergency care for all.

For those races that do not already conform to the accepted standard of near-dawn start times, there is the option of moving the start time to early morning to improve the race safety profile and decrease the chance of encountering afternoon heat stress conditions. High casualty rates may also be avoided by limiting race participation to only elite acclimated runners when it is unexpectedly hot. Other secondary intervention strategies such as putting water spray "misters" on the course have not been proven to be effective in road racing situations and may falsely elevate the expectations for safety among participants and race officials. Likewise, advising runners to slow down does not seem to be an effective strategy in the heat for TCM runners on the basis of the 2007 experience.

With respect to marathon starters, increasing heat stress accelerates both the finish line medical encounter rate and the on-course dropout rate and is also associated with an increase in the incidence of exertional hyponatremia and heat stroke. Hot conditions stress the community medical resources, and the effects of heat on combined dropout and medical encounter incidence suggest that the parameters for starting a road race may need to be reassessed. The era of the race continuing without consideration of both athlete and community safety should be a thing of the past, and races owe the community that supports their existence due consideration. At 40°N and above, races should consider not starting nonelite, nonacclimatized participants if the WBGT is above 20°C–21°C (68°F–70°F), in contrast to the 28°C–30°C (82°F–86°F) recommended in the 1996 and 2007 ACSM Heat Position Stands (3,4).

CONCLUSIONS

Marathons held in unexpectedly hot conditions that resulted in either cancellation or an area-wide MCI occur predictably in northern latitudes when the participants are not acclimatized and the start WBGT is >21°C. It would seem prudent to not start these races in similar conditions and the likely DNS level is near 20°C–21°C. Unsuccessful starters per 1000 finishers plotted against start WBGT generates a curve that can be used to estimate a DNS level. The calculated DNS WBGT for TCM is 20.5°C. Each race should calculate its unique DNS WBGT level.

No conflicts to report with companies or manufacturers that may benefit from this study.

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