BRIEF REPORT

Detection and Management of Hypothermia at a Large Outdoor Endurance Event in the United Kingdom

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Objective.—Optimum detection of hypothermia in athletes during outdoor exposure events remains controversial. The aims of this study were firstly to assess whether temperature readings affected competitor discharge from the treatment station and secondly to assess agreement between oral and tympanic thermometer measurements.

Methods.—All competitors treated for symptomatic hypothermia at an outdoor endurance event in the United Kingdom during January 2009 were included. Temperature readings were taken using oral (Digitemp digital oral thermometer) and tympanic (Braun ThermoScan IRT 4520 ExacTemp) thermometers, with a temperature $<35^{\circ}\text{C}$ classifying hypothermia.

Results.—From 4700 competitors, 64 (1.4%) were treated for symptomatic hypothermia. Of these, 92% were male, the mean age was 26 years, and the mean treatment time was 25 minutes. There was no severe/life-threatening hypothermia, and no competitors required transport to a hospital for hypothermia. At discharge, 19% of competitors were still classed as hypothermic in the oral group and 28% in the tympanic group, despite competitors only being discharged when no longer symptomatic. Oral readings at discharge were significantly lower than tympanic readings (33.8°C [95% CI, 33.2°C to 34.5°C] vs 35.0°C [95% CI, 34.6°C to 35.3°C], respectively, $P = .003$).

Conclusions.—The use of thermometers had a limited role in discharging competitors at this event, who were apparently safely discharged when no longer symptomatic. Treating clinicians and the thermometers did not always agree on whether a patient was hypothermic or not. Oral and tympanic thermometers had poor agreement. Routine thermometer readings at future events may be unnecessary, although screening competitors of concern will remain useful.

Key words: hypothermia, thermometry, tympanic thermometry, endurance

Introduction

Optimum detection of hypothermia in athletes and in pre-hospital settings remains a controversial area. Tympanic, oral, and rectal measurements have been used, all with advantages and disadvantages.^{1–4} In cold-water swimmers and at extremes of environment, tympanic thermometers have been found to be unreliable.^{1,2,5}

Tough Guy is an outdoor endurance challenge course set over 150 acres of land in the United Kingdom containing numerous large obstacles that incorporate climbing, cool-water swimming, and rafting. The course is biannual, running in winter and summer. First established in 1987, it is

believed to be the largest public entry course of its type in the world, attracting international entries. Competitors in winter are subjected to immersion and swimming in cool water at multiple time points, with a variety of possible weather conditions including wind, rain, and snow.

Detection of cold-related illness at this event is through a combination of clinical assessment and thermometers (both oral and tympanic). However, whether these thermometers are useful at this event is unknown. Such temperature measurements have proved of limited use in open-water swimming events, which are similar in nature given cool-water and exposure.¹ To improve the service provided at this event, an audit of the use of thermometers was planned.

The aims of this study were firstly to assess whether temperature readings affected competitor discharge from

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the treatment station and secondly to assess agreement between oral and tympanic temperature measurements.

Materials and methods

This article is a descriptive study of an audit of current care practices (ie, a quality assessment analysis). Thus after consultation with the St. John Ambulance Clinical Governance Board, specific ethical committee approval was not required. Permission for data collection and analysis was subsequently granted from the St. John County Audit Board.

PARTICIPANTS

Competitors who were treated for what was considered on initial clinical assessment to possibly be symptomatic hypothermia were included. This assessment was made prior to temperature readings being obtained. These competitors were defined and identified as clinically hypothermic by the presence of physical impairment (fine or gross motor), mental impairment (simple or complex mental impairment without loss of consciousness), or a loss of shivering.⁶ During winter events, many competitors are treated for minor cold exposure illness (cold sensation with shivering) requiring rest only, in whom further medical assessment, temperature measurements, or documentation beyond basic first aid are not required; these competitors were not included. Competitors were excluded if they were suffering from a concurrent traumatic injury. Those with absent responses, life-threatening hypotension or bradycardia, and/ or ventricular fibrillation or cardiac arrest were considered to be clinically severely hypothermic and were not entered into the analysis. Such competitors would receive core body temperature readings and be transported immediately to a hospital.

THERMOMETERS AND MEASUREMENTS

Hypothermia was defined as a thermometer-read temperature of $<35^{\circ}\text{C}$.^{1,6–8} Competitors included had temperature measurements with both tympanic and oral thermometers upon arrival, after 15 to 20 minutes of care (the “check” reading), and upon discharge.

The tympanic infrared thermometer used was the Braun Thermoscan IRT 4520 ExacTemp (Braun GmbH, Kronberg, Germany). The detectable temperature range of this device is 34°C to 42.2°C , with an accuracy of $\pm 0.2^{\circ}\text{C}$ if between 35.5°C and 42.0°C or $\pm 0.3^{\circ}\text{C}$ outside this range and an operating ambient temperature range of 10°C to 40°C . The oral thermometer used was the Digitemp Digital oral thermometer (British Roto-

therm, UK). Its detectable temperature range was 32.0°C to 42.9°C with an accuracy of $\pm 0.1^{\circ}\text{C}$ and an operating ambient temperature range of 10°C to 40°C . Both devices were calibrated according to the manufacturers’ instructions.

Standardized methods were used to obtain temperatures by all those recording temperatures. For tympanic measurements, the thermometers were held in the operator’s dominant hand, placed in the subject’s ear on the same side, and aimed at the subject’s contralateral temple, with gentle traction on the pinna.¹ For oral measurements, the thermometer was placed in the deep sublingual pocket until a digital readout was obtained.

The outside air temperature was recorded at 2.8°C , and the treatment station was heated artificially to attempt to maintain a temperature of 21°C ; exact and constant indoor temperature control was not possible in these facilities.

DISCHARGE OF COMPETITORS

As this was an audit of current practice, all temperature readings were available to treating clinicians, who had options to discharge competitors back to event, home, or to transfer to a hospital. Competitors were only discharged back to event or home when they were no longer symptomatic.

STATISTICS

Differences between groups at each time point were compared with unpaired *t* tests and chi-square tests as appropriate. Data were analyzed using SPSS 16.0 (SPSS Inc, Chicago, IL, USA).

Results

From 4700 competitors, 172 (3.7%) were treated in the treatment station for any cause, of whom 64 (1.4%) reached the inclusion criteria. From these 64, 92% were male, ($n = 59$) and the mean age was 26 years (range, 16–60 years; 95% CI, 24–28 years).

OUTCOMES

There were no readmissions to the treatment station or any rest stations either during or after the event. No competitors required transport to a hospital for treatment of hypothermia. There were no severely hypothermic competitors. Two patients who were suffering with concurrent musculoskeletal trauma were excluded.

Figure 1. Number of competitors classed as hypothermic by thermometers (<35°C) at each time point.

DETECTING HYPOTHERMIA: CLINICIANS VS THERMOMETERS

Figure 1 shows that despite all competitors treated being initially symptomatic, neither type of thermometer defined all competitors as being hypothermic on arrival. In the oral thermometer group at this time point, 5% (3 of 64) of competitors had temperature readings above 35°C compared with 17% in the tympanic group (11 of 64, $P = .044$).

At the check reading, 14% (9 of 64) and 25% (16 of 24) of competitors were normothermic in oral and tympanic groups, respectively ($P = .119$). Finally at discharge, 81% (35 of 43) and 72% (31 of 43) of competitors were classed as normothermic by oral/tympanic thermometers, respectively ($P = .307$).

ORAL VS TYMPANIC READINGS

Readings were available in all competitors at arrival and check temperatures and in 43°C (67%) at discharge. Means of these readings are shown in Figure 2. At arrival, mean temperatures in both groups indicated hypothermia but were significantly lower in the oral group compared with the tympanic group (32.6°C [95% CI, 32.3–32.8] vs 34.4°C [95% CI, 34.2–34.5], $P < .001$). At the check reading, both means again indicated hypothermia, where oral thermometers were lower (32.8°C [95% CI, 32.5–33.1] vs 34.4°C [95% CI, 34.2–34.6], $P < .001$). At discharge, the mean temperature of tympanic readings was in the normothermic category (35.0°C [95% CI, 34.6–35.3]), although the mean of the oral readings remained significantly lower (33.8°C [95% CI, 33.2–34.5], $P = .003$).

Discussion

This observational audit of current clinical practice has shown that the use of thermometers had a limited role in

influencing discharge of hypothermic competitors at this event. Competitors were discharged when no longer symptomatic, despite some having hypothermic temperature readings that were available to discharging clinicians. As no competitors were readmitted to the treatment station (including after the end of the event), this “clinical” discharge policy was safe at this event, and routine thermometer readings at future events may be unnecessary. However, this study did not directly identify how treating clinicians used the temperature readings obtained and so such conclusions should be drawn cautiously. Screening temperatures for competitors in whom clinical concern of hypothermia exists will remain a useful policy. It should be noted that temperature readings in those with severe or life-threatening hypothermia remains necessary and mandatory.⁶

Thermometer readings have been found to be of limited use in outdoor swimmers and other cold-exposure situations, where infrared tympanic thermometers often overestimate hypothermia.^{1,2,5} This is likely due to cold ambient temperatures and cold water in the external auditory canal.^{1,5} These are conditions similar to those experienced by winter competitors of *Tough Guy*.

Poor correlation between oral and tympanic thermometer readings has been previously described, albeit in different settings.^{9,10} In this study, oral readings were lower at all time points than tympanic readings, although lower tympanic readings may have been expected due to the presence of cold water in the external auditory canal. Tympanic thermometers are also strongly influenced by external conditions, and their use in a warmed treatment station may have affected readings. Furthermore, the oral thermometers available had a lower minimal temperature than the tympanic thermometers, which may have reduced their mean reading. However, as both thermometers were capable of detecting hypothermia when defined as a temperature of <35°C, the discharge readings should have agreed; the tympanic group was normother-

Figure 2. Mean temperatures at each time point detected by oral and tympanic thermometers.

mic and the oral group hypothermic. Upon arrival, when all competitors were considered symptomatic of hypothermia, oral thermometers identified a significantly higher proportion of hypothermia than did tympanic thermometers. Thus, tympanic thermometers may be unreliable in this field setting,⁵ although ideally comparison with rectal temperatures would be needed to validate this.^{4,5}

Treating clinicians and thermometers did not always agree on whether a patient was hypothermic or not. All patients initially treated had symptoms consistent with hypothermia, but both thermometers failed to identify a proportion of hypothermic patients. At discharge, all patients were felt to be clinically normothermic, but both thermometers identified some patients as still having temperatures <35°C.

LIMITATIONS

This was an observational study of current practice and not an interventional study. Thus, whether temperature readings truly influenced management (including discharge policy) was not formally tested. Furthermore, whether strictly following the findings from thermometers would have affected treatment and outcome was not possible to assess here; a control arm would be needed to assess both these issues. This should be addressed as a randomized controlled study comparing treatment modalities, treatment time, and discharge of symptomatic competitors monitored clinically compared with a group whose management and discharge is guided by thermometer readings.

Using clinical definitions of hypothermia prior to thermometer definitions may have led to an overidentification of truly hypothermic competitors. In such cases, the possibly of alternative diagnoses triggering presentation may be important, although this was not explored further as part of this audit.

The main technical limitation of the thermometers used at this event was the minimal temperature detection. This may have caused lower mean readings in the oral thermometer group, as other studies have previously found the reverse. Because this was an audit of current practice and equipment, further investigation of new equipment was outside of this predefined remit. In future clinical practice and studies, more robust thermometers with lower minimal temperatures should be used.

It is possible and likely that some competitors may have been even colder than detected, and so these thermometers may have in fact underestimated temperature readings further. Ideally, rectal temperatures would be determined in these competitors against which other thermometers and clinical findings could be compared.³⁻⁵ This is, however, impractical in the *Tough Guy*

environment due to issues of privacy, exposure, and discomfort. More reliable readings may still be no more useful than discharging the no longer symptomatic competitor, although this hypothesis would benefit from direct testing.

The recorded incidence of treated hypothermia is probably an underestimate of the total incidence at this event, as some competitors with mild hypothermia may not have required and/or requested treatment, either continuing the race or self-treating. True incidences could further be explored by screening competitors at the finishing line.

Complete measurements on all treated competitors at the time of discharge were not achieved, which was in part due to the high patient turnover in a space-limited environment. Although no competitors were retreated in the onsite treatment station, it is possible that further medical advice away from the event was sought by competitors, although this is information beyond the scope of this study.

Finally, this is a unique event with unique competitors and conditions. The findings and results from this study are thus of a limited generalizability. Medical providers at similar events should audit the use and effectiveness of thermometers in their own environments before abandoning routine temperature readings for clinically symptomatic hypothermic competitors (excluding severely hypothermic competitors).

Conclusions

The use of thermometers had a limited role in discharging competitors at this event, who were apparently safely discharged when no longer symptomatic. Treating clinicians and the thermometers did not always agree on whether a patient was hypothermic or not. Oral and tympanic thermometers had poor agreement. Routine thermometer readings at future events may be unnecessary, although screening competitors where significant hypothermia is suspected will always be required.

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