Prehospital Emergency Care

ISSN: 1090-3127 (Print) 1545-0066 (Online) Journal homepage: http://www.tandfonline.com/loi/ipec20

Consensus Statement- Prehospital Care of Exertional Heat Stroke

Luke N. Belval, Douglas J. Casa, William M. Adams, George T. Chiampas, Jolie C. Holschen, Yuri Hosokawa, John Jardine, Shawn F. Kane, Michele Labotz, Renée S. Lemieux, Kyle B. McClaine, Nathaniel S. Nye, Francis G. O'Connor, Bryan Prine, Neha P. Raukar, Michael S. Smith & Rebecca L. Stearns

To cite this article: Luke N. Belval, Douglas J. Casa, William M. Adams, George T. Chiampas, Jolie C. Holschen, Yuri Hosokawa, John Jardine, Shawn F. Kane, Michele Labotz, Renée S. Lemieux, Kyle B. McClaine, Nathaniel S. Nye, Francis G. O'Connor, Bryan Prine, Neha P. Raukar, Michael S. Smith & Rebecca L. Stearns (2018): Consensus Statement- Prehospital Care of Exertional Heat Stroke, Prehospital Emergency Care

To link to this article: https://doi.org/10.1080/10903127.2017.1392666

Published online: 16 Jan 2018.

Consensus Statement- Prehospital Care of Exertional Heat Stroke

Luke N. Belval, MS, ATC, Douglas J. Casa, PhD, ATC, William M. Adams, PhD, ATC, George T. Chiampas, DO, Jolie C. Holschen, MD, Yuri Hosokawa, PhD, ATC, John Jardine, MD, Shawn F. Kane, MD, Michele Labotz, MD, Renée S. Lemieux, BS, Kyle B. McClaine, MD, Nathaniel S. Nye, MD, Francis G. O'Connor, MD, MPH, Bryan Prine, MD, Neha P. Raukar, MD, Michael S. Smith, MD, PharmD, Rebecca L. Stearns, PhD, ATC

Abstract

Exertional heat stroke (EHS) is one of the most common causes of sudden death in athletes. It also represents a unique medical challenge to the prehospital healthcare provider due to the time sensitive nature of treatment. In cases of EHS, when cooling is delayed, there is a significant increase in organ damage, morbidity, and mortality after 30 minutes, faster than the average EMS transport and ED evaluation window. The purpose of this document is to present a paradigm for prehospital healthcare systems to minimize the risk of morbidity and mortality for EHS patients. With proper planning, EHS can be managed successfully by the prehospital healthcare provider. **Keywords:** heat stroke; heat stress disorders; hyperthermia; sports; exercise

PREHOSPITAL EMERGENCY CARE 2018; Early Online:1–6

Received June 15, 2017 from Department of Kinesiology, Korey Stringer Institute, University of Connecticut, Storrs, Connecticut (LNB, DJC, YH, JJ, RLS); Department of Kinesiology, University of North Carolina at Greensboro, Greensboro, North Carolina (WMA); Departments of Emergency Medicine and Orthopedic Surgery, Feinberg School of Medicine, Northwestern University, Chicago, Illinois (GTC); Loyola University Chicago, Chicago, Illinois (JCH); Special Warfare Medical Group (Airborne), Ft Bragg, North Carolina (SFK); InterMed, South Portland, Maine (ML); Department of Emergency Services, The William W. Backus Hospital, Hartford Healthcare, Norwich, Connecticut (KBM); 559th Medical Group, United States Air Force (NSN); Uniformed Services University of the Health Sciences, Bethesda, Maryland (RSL, FGO); University of Florida, Gainesville, Florida (BP, MSS); Brown University, Providence, Rhode Island (NPR). Revision received October 3, 2017; accepted for publication October 9, 2017.

Douglas Casa has served as an expert witness.

Study Group Authorship and Acknowledgments: All members of the group contributed to the writing and editing of the manuscript.

Casa has received grant funding to study exertional heat stroke. Grant sources include Mission, Welkins, General Electric, CamelBak, NFL, Kestrel, Gatorade, Danone, University of North Carolina, NATA, US Air Force and US Army.

Address correspondence to Luke Belval, MS, ATC Korey Stringer Institute, Department of Kinesiology, University of Connecticut, 2095 Hillside Rd, U-1110, Storrs, CT 06269, USA. E-mail: Luke.belval@uconn.edu

Color versions of one or more of the figures in the article can be found online at www.tandfonline.com/ipec.

doi: 10.1080/10903127.2017.1392666

Introduction

Exertional heat stroke (EHS) is an emergent hyperthermic condition that occurs in individuals performing physical activity, typically in warm environments (1, 2), but can also occur with exertion or impaired heat dissipation in cool environments (3). This is contrasted by classic heat stroke, which occurs more commonly in those lacking normal thermoregulation, such as the elderly and infants during heat waves. EHS is characterized by severe hyperthermia (>40.5°C) and end organ dysfunction, which typically manifests as central nervous system (CNS) dysfunction (4). Optimal outcomes from EHS requires rapid reversal of hyperthermia through whole body cooling (5, 6). Evidence has shown that immediate and aggressive cooling after collapse ensures survivals with limited sequelae (6–10), highlighting the need for appropriate prehospital care.

Cold water immersion (CWI) is considered to be the gold standard treatment for EHS (11), but unfortunately, there are many situations in which CWI is not available. In the current practices of Emergency Medicine, Prehospital Medicine, and Sports Medicine, there is wide variability in practices for EHS despite published evidence for optimal EHS care. Efforts are required to standardize treatment by these providers and coordinate efforts toward providing optimal EHS care in the prehospital setting.

On March 1, 2016 the Korey Stringer Institute convened a meeting with experts in the fields of emergency and sports medicine to identify best practices for the care of EHS in the prehospital setting. Meeting participants provided input on topic areas related to exertional heat stroke care to achieve a consensus on best practices for the prehospital healthcare provider. The purpose of this paper is to introduce a paradigm for the emergency and sports medicine professional to develop prehospital protocols that increase the likelihood of survival and reduce morbidity from EHS. As shown in Figure 1, the steps for survival from EHS require a rapid response by the prehospital provider.

Rapid Recognition

The first step to optimize treatment for EHS is the early recognition of the condition. Recognition of EHS in an individual who has collapsed during or following

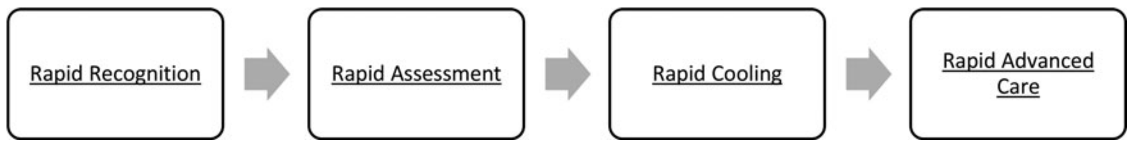

FIGURE 1. Basic paradigm for the care of EHS.

exercise often relies on first responders and lay persons. Emergency medical services dispatchers' input may be critical in guiding initial triage and treatment of a potential EHS patient. Recognizing the signs, symptoms and situations associated with EHS can greatly aid in identifying the EHS patient. Providing education to EMS dispatchers will improve recognition of this condition and allow for earlier implementation of treatment, thereby improving outcomes.

EHS typically occurs in warm environments in individuals performing strenuous exercise. However, it should be noted that even in cooler conditions, intense exercise by itself may result in an individual succumbing to EHS (12). The EHS patient will initially present with CNS disturbances (e.g. confusion, irritability or other irrational behavior) and may culminate in a collapse or loss of consciousness (4).

It should be noted that in some patients a lucid interval occurs, with CNS function rapidly declining afterwards (4). In addition, it is a common misconception that all EHS patients will have stopped sweating, have hot skin, or be unconscious, when in fact none of these symptoms are required for a diagnosis of EHS. In fact, many case reports have observed that the EHS patient may not only be awake, but have cool, clammy skin or likely still be sweating profusely. A basic algorithm for the recognition of EHS is presented in Figure 2.

RAPID ASSESSMENT

The two pathognomonic characteristics of EHS are hyperthermia and CNS dysfunction. The EHS patient can present in a variety of mental states, ranging from mildly disoriented or combative to comatose, which typically resolve rapidly with treatment and return to normothermia (13). The differential diagnoses for a collapsed athlete with altered mental status are broad (e.g., traumatic brain injury, hyponatremia, exertional sickling, cardiac arrhythmia), so an accurate measurement of internal body temperature is necessary to appropriately make a diagnosis of EHS (14, 15). The best field expedient for body temperature measurement in exercising individuals is a rectal temperature (T_{REC}). Previous research has shown that aural, oral, tympanic, axillary, and temporal measurements have been shown to be invalid during and immediately following intense exercise in the heat (16–20). Furthermore, surface temperature readings are likely to provide a false sense of reassurance that the patient is not severely hyperthermic, when in fact the patient may be suffering from EHS.

With suspected EHS, a prehospital healthcare provider should immediately perform a T_{REC} assessment, at an insertion depth of 15 cm (21). The typical temperature threshold associated with EHS is 40.5°C. In practice, however, based on the typical time for emergency medical services to arrive on-scene, it is important not to attempt to rule out EHS if the T_{REC} is slightly below the threshold (22). The identification of a suspected EHS with confirmation via T_{REC} should immediately trigger the next step of the process: immediate and rapid cooling. If a T_{REC} is not available or difficult to obtain (e.g., due to a combative patient), cooling should not be delayed in cases of suspected EHS.

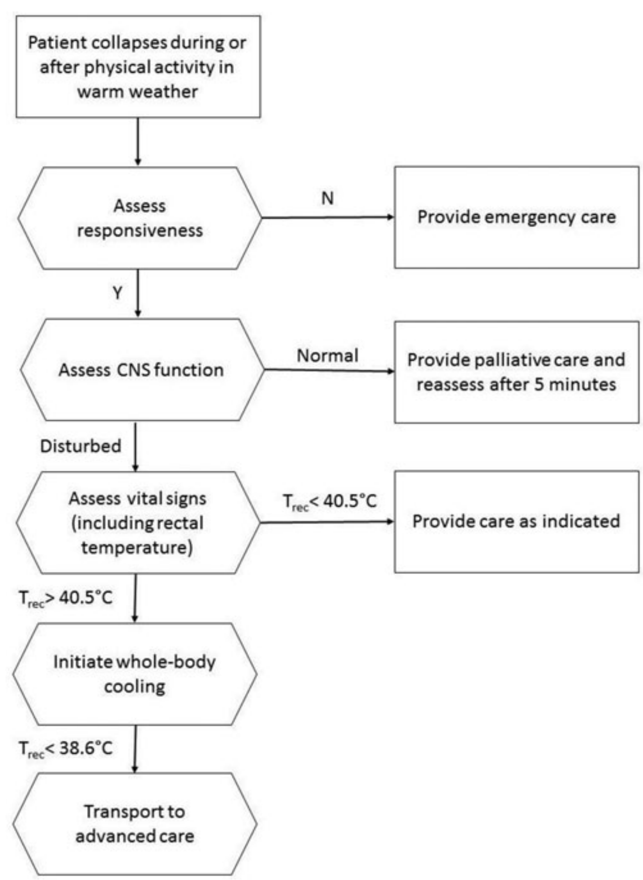

FIGURE 2. Algorithm for the treatment of EHS. T_{REC}: *Rectal Temperature*; CNS: *Central Nervous System*.

RAPID COOLING

Best practices require rapid cooling of the patient to a temperature less than the threshold for critical cell damage (~104.5°F) in less than 30 minutes from the time of collapse (8). In most situations, this leaves the prehospital healthcare provider with little time to deliver appropriate treatment. The current best practice for cooling an EHS patient is whole-body CWI from the neck down (11). Concerns for adverse side effects from CWI have been shown to be unfounded in hyperthermic individuals (23). If the dispatcher or first responder suspects EHS, the individual should be cooled with any available on-site measures until more advanced care arrives. If EHS is confirmed by responders, more aggressive cooling must begin immediately.

In situations where EHS is known or expected to occur, such as running races or football practices, advanced planning is essential to ensure adequate staffing, and access to the necessary supplies for CWI in order to allow for on-site cooling. Regardless of the nature and locale of an EHS patient, the goal for treatment is to minimize the amount of time the individual is hyperthermic (8, 10, 24). This reasoning underlies the principle of "cool first, transport second". Given the significant increase in organ damage, morbidity and mortality that occurs after 30 minutes of hyperthermia, rapid cooling onsite should be built into local existing protocols wherever feasible. This can only be accomplished with the understanding and cooperation of event planners, on site medical teams, and preplanning with the local EMS system. Transportation of an EHS patient should occur only if it is impossible to cool adequately onsite or after adequate cooling has been verified by a body temperature assessment.

There are two key principles for external cooling of an EHS patient: 1) provide a modality of adequate cooling capacity, and 2) apply this modality to a sufficient body surface area. These two components combined determine the effectiveness of a cooling modality. Due to its superior cooling capacity, modalities involving CWI applied to most of the body surface area typically yield the fastest cooling rates. The recommended minimum rate of cooling for treating an EHS patient is at least 0.15°C per minute (25). Cooling rates for some common methods are shown in Figure 3. Cooling should be terminated when the body temperature reaches 38.6°C to minimize the risk of severe hypothermia (4, 26). Mild hypothermic overshoot is common and benign, but patients should be passively rewarmed to 37.0°C.

CWI has been shown to have the highest documented cooling rates for the reversal of hyperthermia. In ideal conditions, Proulx et al. was able to achieve a cooling rate of 0.35°C per minute in hyperthermic healthy subjects (27). Meanwhile, Demartini et al. reported a cooling rate of 0.22°C per minute in a dataset of 274 EHS cases (6). An example of a CWI setup is shown in Figure 4.

There are some alternative modalities which have also shown acceptable cooling rates that may be more applicable for patient transport or when other resources are limited (25). For example, tarp-assisted cooling (Figure 5) has demonstrated cooling rates of

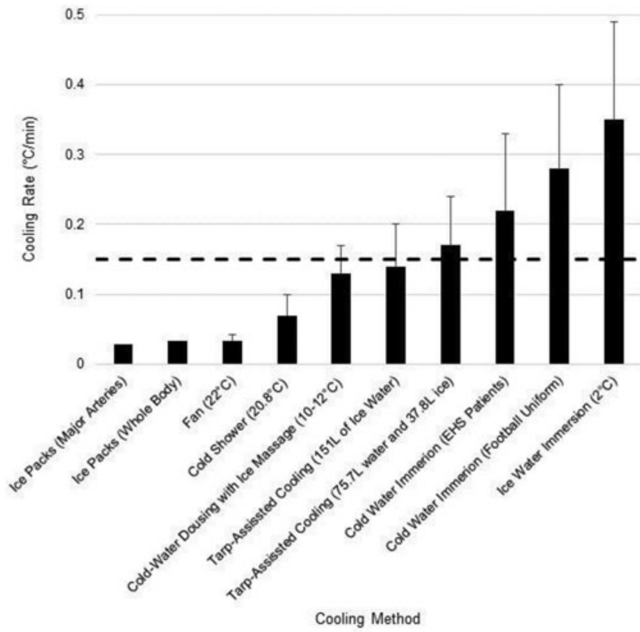

FIGURE 3. Cooling rates for common cooling methods (6, 27–29, 42–46). Dotted line represents minimum recommended cooling rate for an EHS patient.

FIGURE 4. Cold-water immersion setup for EHS patient treatment.

FIGURE 5. Tarp-assisted cooling.

0.14–0.17°C per minute (28, 29). Similarly, clinicians have reported success utilizing patient "body bags" filled with water and ice for cooling. Overall, the choice of cooling modality should be dictated by the maximal cooling rate that can be achieved given the resources at hand.

For events with medical personnel on-site (e.g., a certified athletic trainer or physician), the appropriate standard is to cool the EHS patient on site, which avoids delays in treatment (30). On-site cooling minimizes the amount of time that an individual is hyperthermic and has been shown to improve clinical outcomes (6–8, 10). Once an EHS patient has been cooled on-site, they can then be safely transported to a hospital for continued medical care. In situations where EHS is more likely to occur (e.g., large scale sporting events held in warm-weather), on-site medical staff should be prepared to immediately cool an EHS patient.

When transporting an EHS patient who was not able to be cooled on-site, the most aggressive cooling method available should be applied during transport until the recommended treatment endpoints are reached. For example, continuously applying cold-wet towels over the patient's body is an example of a cooling modality that can be applied in an ambulance and requires minimal supplies. During heat waves or other situations where increases in EHS are anticipated, prehospital providers should be prepared to initiate pre-established cooling options using their available resources. It should be noted that cold saline infusion by itself has not been shown to reach acceptable cooling rates (31). However, when cold saline infusion is used in combination with other cooling modalities patient outcomes may be improved (5, 31).

In order to minimize the risks of severe hypothermia from CWI, T_{REC} needs to be monitored throughout the cooling process. Cooling should be stopped when the body temperature reaches 38.6°C (32). In cases where hypothermia persists, normal rewarming procedures may be followed while monitoring body temperature.

In some situations, non-critical but distracting conditions may arise while cooling an EHS patient. Diarrhea, emesis, and combativeness can be seen and should be managed without disturbing the essential priority of rapid cooling. Only in rare cases an arrhythmia, seizure, or other serious condition will occur during an EHS episode. In these situations, the more emergent condition should be addressed first, with the goal of rapid re-initiation of cooling treatment for EHS as soon as the more concerning medical issue is stabilized.

In some instances where advanced resources and personnel are available onsite, and the EHS patient is appropriately treated, a physician can discharge the patient without being transported to a medical facility (5). However, for most cases of EHS the final step in care is the rapid initiation of supportive care and evaluation for other end organ dysfunction at an appropriate Emergency Department (ED).

RAPID ADVANCED CARE

In the case of an EHS being transported to the hospital, EMS dispatch and/or on-site medical officials should notify the hospital medical team in advance to allow staff to prepare for treatment to begin immediately upon patient arrival. The diagnosis of EHS in an ED may be difficult, as the EHS patient may present with a temperature less than 40.5°C either due to active or passive cooling that has already occurred (30). Furthermore, if it is not possible to adequately cool the patient in the prehospital setting, the hospital or medical center needs to be prepared to cool the patient to 38.6°C.

Most hospital EDs are not equipped with various mechanisms or modalities for cooling, making rapid cooling difficult to achieve once the patient arrives. CWI remains a viable option to successfully cool an EHS patient in the hospital, even if initial cooling was delayed (33). The hospital should consider having appropriate treatment areas ready for EHS cooling during heat waves or large-scale sporting events (e.g., road races). In many cases the decontamination room provides adequate drainage to employ CWI or dousing.

The ED and hospital should be prepared for common sequelae of EHS, such as rhabdomyolysis, disseminated intravascular coagulation, and liver failure, especially in cases where cooling was delayed (34). In addition, EHS may present very similar to a malignant hyperthermia-like syndrome (35). Beyond this, further care for EHS patients in-hospital after cooling are described elsewhere (36).

CONCLUSION

Rapid recognition, assessment, cooling, and advanced planning are the key components that need to be provided in order to minimize the risk of morbidity and mortality for EHS patients. EHS, like many other emergent medical conditions, such as acute ST elevation myocardial infarction, acute ischemic stroke, and trauma, requires timely intervention during the initial "golden hour" to achieve the best outcome for the patient (37–39). The importance of these concepts to the survival of EHS has led some states to develop prehospital EHS related statutes and legal support (40). The advancing evidence-based standard of care for EHS requires that medical systems need to plan, develop, practice and evaluate their capabilities for prehospital treatment and to implement protocols supporting immediate and aggressive cooling on site and during transport (41). We provide an updated paradigm for emergency medical services to initiate treatment in cases of EHS.

References

1. Bouchama A, Knochel JP. Heat stroke. NE J Med. 2002; 346(25):1978–88. doi:10.1056/NEJMra011089. PMID:12075060.
2. Casa DJ, Armstrong LE, Kenny GP, O'Connor FG, Huggins RA. Exertional heat stroke: new concepts regarding cause and care. Curr Sports Med Rep. 2012;11(3):115–23. doi:10.1249/JSR.0b013e31825615cc. PMID:22580488.
3. Roberts WO. Exertional heat stroke during a cool weather marathon: a case study. Med Sci Sports Exerc. 2006;38(7):1197–203. doi:10.1249/01.mss.0000227302.80783.0f.
4. Casa DJ, Demartini JK, Bergeron MF, Csillan D, Eichner ER, Lopez RM, et al. National Athletic Trainers' Association position statement: Exertional heat illnesses. J Athl Train. 2015;50(9):986–1000. doi:10.4085/1062-6050-50.9.07. PMID: 26381473.
5. Gaudio FG, Grissom CK. Cooling methods in heat stroke. J Emerg Med. 2016;50(4):607–16. doi:10.1016/j.jemermed.2015.09.014. PMID:26525947.
6. Demartini JK, Casa DJ, Stearns R, Belval L, Crago A, Davis R, Jardine J. Effectiveness of cold water immersion in the treatment of exertional heat stroke at the Falmouth Road Race. Med Sci Sports Exerc. 2015;47(2):240–5. doi:10.1249/MSS.0000000000000409.
7. Sloan BK, Kraft EM, Clark D, Schmeissing SW, Byrne BC, Rusyniak DE. On-site treatment of exertional heat stroke. Am J Sports Med. 2015;43(4):823–9. doi:10.1177/0363546514566194. PMID:25632055.
8. Heled Y, Rav-Acha M, Shani Y, Epstein Y. The "golden hour" for heatstroke treatment. Milit Med. 2004;169(3):184–6. doi:10.7205/milmed.169.3.184. PMID:15080235.
9. Costrini A. Emergency treatment of exertional heatstroke and comparison of whole body cooling techniques. Med Sci Sports Exerc. 1990;22(1):15–8. doi:10.1249/00005768-199002000-00004.
10. Zeller L, Novack V, Barski L, Jotkowitz A, Almog Y. Exertional heatstroke: clinical characteristics, diagnostic and therapeutic considerations. Eur J Intern Med. 2011;22(3):296–9. doi:10.1016/j.ejim.2010.12.013. PMID:21570651.
11. Casa DJ, McDermott BP, Lee EC, Yeargin SW, Armstrong LE, Maresh CM. Cold water immersion: the gold standard for exertional heatstroke treatment. Exerc Sport Sci Rev. 2007;35(3): 141–9. doi:10.1097/jes.0b013e3180a02bec. PMID:17620933.
12. Roberts WO. A 12-yr profile of medical injury and illness for the twin cities marathon. Med Sci Sports Exerc. 2000;32(9):1549–55. doi:10.1097/00005768-200009000-00004.
13. Casa DJ, Belval LN, Lopez RM. How should a clinician deal with a combative exertional heat stroke victim? In: Lopez RM, editor, Quick questions in heat-related illness and hydration. Vol 30. Thorofare, NJ: Slack; 2015:29–32. doi:10.1519/ssc.0b013e318177208f.
14. Asplund CA, O'Connor FG, Noakes TD. Exercise-associated collapse: an evidence-based review and primer for clinicians. Brit J Sports Med. 2011;45(14):1157–62. doi:10.1136/bjsports-2011-090378. PMID:21948122.
15. Casa DJ, Hosokawa Y, Belval LN, Adams WM, Stearns RL. Preventing death from exertional heat stroke—The long road from evidence to policy. Kinesiol Rev. 2017;6(1):99–109. doi:10.1123/kr.2016-0043.
16. Ronneberg K, Roberts WO, McBean AD, Center BA. Temporal artery temperature measurements do not detect hyperthermic marathon runners. Med Sci Sports Exerc. 2008;40(8):1373–75. doi:10.1249/MSS.0b013e31816d65bb.
17. Ganio MS, Brown CM, Casa DJ, Becker SM, Yeargin SW, McDermott BP, Boots LM, Boyd PW, Armstrong LE, Maresh CM. Validity and reliability of devices that assess body temperature during indoor exercise in the heat. Journal of Athletic Training. 2009;44(2):124–135. doi:10.4085/1062-6050-44.2.124. PMID:19295956.
18. Casa DJ, Becker SM, Ganio MS, Brown CM, Yeargin SW, Roti MW, et al. Validity of devices that assess body temperature during outdoor exercise in the heat. J Athl Train. 2007;42(3): 124–135. doi:10.4085/1062-6050-44.2.124. PMID:18059987
19. Huggins R, Glaviano N, Negishi N, Casa DJ, Hertel J. Comparison of rectal and aural core body temperature thermometry in hyperthermic, exercising individuals: a meta-analysis. J Athl Train. 2012;47(3):329–38. doi:10.4085/1062-6050-47.3.09. PMID:22892415.
20. Mazerolle SM, Ganio MS, Casa DJ, Vingren J, Klau JF. Is oral temperature an accurate measurement of deep body temperature? A systematic review. J Athl Train. 2011;46(5):566–73. doi:10.4085/1062-6050-46.5.566. PMID:22488144.
21. Miller KC, Hughes LE, Long BC, Adams WM, Casa DJ. Validity of core temperature measurements at 3 rectal depths during rest, exercise, cold-water immersion, and recovery. Journal of Athletic Training. 2017;52(4):332–8. doi:10.4085/1062-6050-52.2.10.
22. Adams WM, Hosokawa Y, Casa DJ. The timing of exertional heat stroke survival starts prior to collapse. Curr Sports Med Rep. 2015;14(4):273–4. doi:10.1249/JSR.0000000000000166. PMID:26166048.
23. Casa DJ, Kenny GP, Taylor NAS. Immersion treatment for exertional hyperthermia: cold or temperate water? Med Sci Sports Exerc. 2010;42(7):1246–52. doi:10.1249/MSS.0b013e3181e26cbb.
24. Hubbard RW, Bowers WD, Matthew WT, Curtis FC, Criss RE, Sheldon GM, Ratteree JW. Rat model of acute heatstroke mortality. J Appl Physiol: Resp, Environ Exer Physiol. 1977;42(6):809–16. PMID:881380.
25. McDermott BP, Casa DJ, Ganio MS, Lopez RM, Yeargin SW, Armstrong LE, Maresh CM. Acute whole-body cooling for exercise-induced hyperthermia: a systematic review. J Athl Train. 2009;44(1):84–93. doi:10.4085/1062-6050-44.1.84. PMID:19180223.
26. Gagnon D, Lemire BB, Casa DJ, Kenny GP. Cold-water immersion and the treatment of hyperthermia: using 38.6 C as a safe

rectal temperature cooling limit. J Athl Train. 2010;45(5):439–44. doi:10.4085/1062-6050-45.5.439. PMID:20831387.

27. Proulx CI, Ducharme MB, Kenny GP. Effect of water temperature on cooling efficiency during hyperthermia in humans. Journal of Applied Physiology. 2003; 94(4):1317–1323. doi:10.1152/japplphysiol.00541.2002. PMID: 12626467.
28. Luhring KE, Butts CL, Smith CR, Bonacci JA, Ylanan RC, Ganio MS, McDermott BP. Cooling effectiveness of a modified cold-water immersion method after exercise-induced hyperthermia. J Athl Train. 2016;51(11):946–51. doi:10.4085/1062-6050-51.12.07. PMID:27874299.
29. Hosokawa Y, Adams WM, Belval LN, Vandermark LW, Casa DJ. Tarp-assisted cooling as a method of whole-body cooling in hyperthermic individuals. Ann Emerg Med. 2017;69(3):347–52. doi:10.1016/j.annemergmed.2016.08.428. PMID:27865532.
30. Pryor RR, Casa DJ, Holschen JC, O'Connor FG, Vandermark LW. Exertional heat stroke: strategies for prevention and treatment from the sports field to the emergency department. Clin Ped Emerg Med. 2013;14(4):267–78. doi:10.1016/j.cpem.2013.10.005.
31. Sinclair WH, Rudzki SJ, Leicht AS, Fogarty AL, Winter SK, Patterson MJ. Efficacy of field treatments to reduce body core temperature in hyperthermic subjects. Med Sci Sports Exerc. 2009;41(11):1984–90. doi:10.1249/MSS.0b013e3181a7ae82.
32. Makranz C, Heled Y, Moran DS. Hypothermia following exertional heat stroke treatment. Eur J Appl Physiol. 2011;111(9): 2359–62. doi:10.1007/s00421-011-1863-x. PMID:21327793.
33. Flouris AD, Friesen BJ, Carlson MJ, Casa DJ, Kenny GP. Effectiveness of cold water immersion for treating exertional heat stress when immediate response is not possible. Scan J Med Sci Sports. 2015;25(Suppl 1):229–39. doi:10.1111/sms.12317.
34. Leon LR, Bouchama A. Heat stroke. Compr Physiol. 2015;5(2):611–47. doi:10.1002/cphy.c140017. PMID: 25880507.
35. Hosokawa Y, Casa DJ, Rosenberg H, Capacchione JF, Sagui E, Riazi S, et al. Round table on malignant hyperthermia in physically active populations: meeting proceedings. J Athl Train. 2017;52(4):377–83. doi:10.4085/1062-6050-52.2.06. PMID:28430550.
36. Smith MS, Prine BR, Smith K. Current concepts in the management of exertional heat stroke in athletes. Curr Orthopaed Practice. 2015;26(3):287–90. doi:10.1097/BCO.0000000000000223.
37. Jauch EC, Saver JL, Adams HP, Bruno A. Guidelines for the early management of patients with acute ischemic stroke: a guideline for healthcare professionals from the American Heart Association/American Stroke Association. Stroke. 2013;44(3):870–947. doi:10.1161/STR.0b013e318284056a.
38. O'Gara PT, Kushner FG, Ascheim DD, Casey DE. 2013 ACCF/AHA guideline for the management of ST-elevation myocardial infarction: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines. Circulation. 2013;127(4):e362–425. doi:10.1161/CIR.0b013e3182742cf6.
39. Kotwal RS, Howard JT, Orman JA, Tarpey BW, Bailey JA, Champion HR, Mabry RL, Holcomb JB, Gross KR. The effect of a golden hour policy on the morbidity and mortality of combat casualties. JAMA Surg. 2016;151(1):15–24. doi:10.1001/jamasurg.2015.3104. PMID:26422778.
40. Pagnotta KD, Casa DJ, Cates J, Mazerolle SM. Arkansas' creation and implementation of health and safety legislation utilizing Ambrose's requirements for change. Curr Sports Med Rep. 2013;12(5):285–9. doi:10.1249/jsr.0b013e3182a4b858. PMID:24030300.
41. Raukar N, Lemieux RS, Casa DJ, RK K. Identification and treatment of exertional heat stroke in the prehospital setting. J Emerg Med Svc. 2009;42(5):211–6. doi:10.1080/10903129908958939.
42. Kielblock AJ, Van Rensburg JP, Franz RM. Body cooling as a method-for reducing hyperthermia. S Afric Med J. 1986;69(3):378–80. PMID:3961622.
43. Mitchell JB, Schiller ER, Miller JR, Dugas JP. The influence of different external cooling methods on thermoregulatory responses before and after intense intermittent exercise in the heat. J Strength Condition Res. 2001;15(2):247–54. PMID:11710412.
44. Butts CL, McDermott BP, Buening BJ, Bonacci JA, Ganio MS, Adams JD, Tucker MA, Kavouras SA. Physiologic and perceptual responses to cold-shower cooling after exercise-induced hyperthermia. J Athl Train. 2016;51(3):252–7. doi:10.4085/1062-6050-51.4.01. PMID:26942657.
45. McDermott BP, Casa DJ, O'Connor FG, Adams WB, Armstrong LE, Brennan AH, Lopez RM, Stearns RL, Troyanos C, Yeargin SW. Cold-water dousing with ice massage to treat exertional heat stroke: a case series. Aviat Space Environ Med. 2009;80(8):720–2. doi:10.3357/asem.2498.2009. PMID:19653575.
46. Miller KC, Swartz EE, Long BC. Cold-water immersion for hyperthermic humans wearing American football uniforms. J Athl Train. 2015;50(8):792–9. doi:10.4085/1062-6050-50.6.01. PMID:26090706.