QUESTION

Should immersion in cold-water compared with another cooling technique (or combination of techniques) appropriate for first aid be used for adults and children (all ages) with heat stroke or exertional hyperthermia?	
POPULATION:	Adults and children (all ages) with heat stroke or exertional hyperthermia
INTERVENTION:	Immersion in cold-water
COMPARISON:	Another cooling technique (or combination of techniques) appropriate for first aid. For case series, there will be no comparator or control group
MAIN OUTCOMES:	Resolution of hyperthermia to 38.9°C (102.2°F); Rate of body temperature reduction; Mortality (short - term and long - term); Adverse effects (e.g. overcooling, hypothermia, injury); Hospital length of stay; Clinically important organ dysfunction;
SETTING:	
PERSPECTIVE:	First aid / prehospital emergency management of heat related illnesses
BACKGROUND:	Heat stroke (HS) is a heat related illness defined as a core temperature above 40ºC (104ºF). It is associated with central nervous system abnormality (e.g. irritability, confusion, abnormal behavior, syncope, seizure, and coma) and is a life-threatening condition with a significant morbidity and mortality. There is a strong association between the rate of body cooling and a reduced mortality. If the core body temperature is rapidly reduced to less than 40ºC (104ºF) within 30 minutes, the mortality rate approaches zero and most heat stroke casualties recover without sequelae. An evidence-based approach to the first aid management of both exertional and nonexertional (classic) HS will decrease morbidity and save lives.
CONFLICT OF INTERESTS:	None

ASSESSMENT

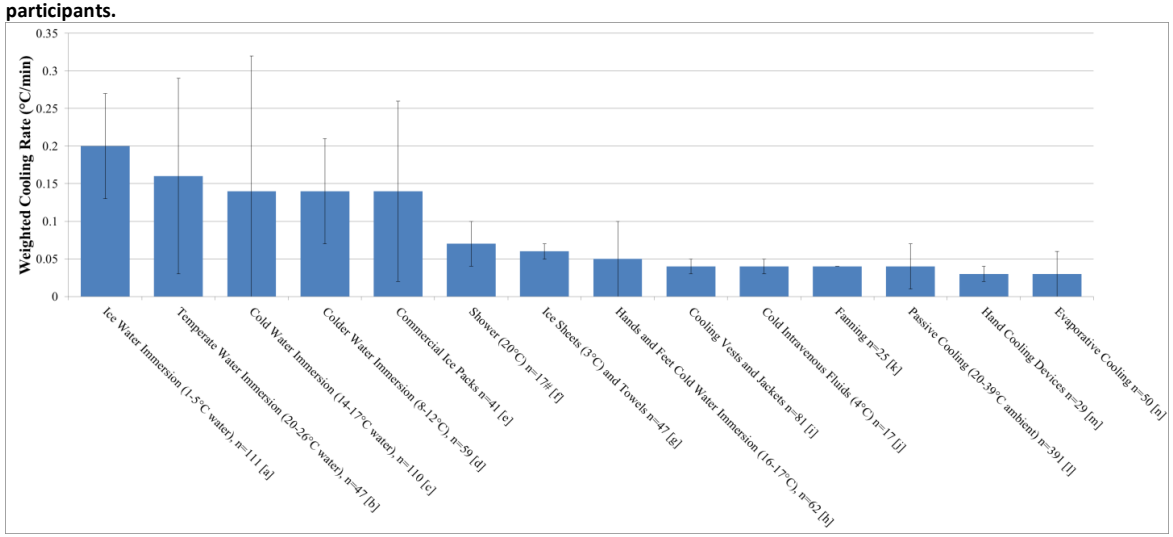
Problem

Is the problem a priority?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ No ○ Probably no ○ Probably yes ● Yes ○ Varies ○ Don't know	HS is an important clinical problem and is associated with permanent organ dysfunction and death. Extreme heat events, defined as an extended period of time (several days or more) with unusually hot weather conditions that potentially can harm human health (EPA, 2016) are a leading cause of weather-related deaths and the annual number of events and associated deaths is rising. Global climate change is projected to further increase the frequency, intensity and duration of heat-waves and attributable deaths (EPA, 2016; WHO, 2019; WHO, 2009). In the United States, between 2006 and 2010, exposure to excessive natural heat, and heat-related illnesses were cited as either the underlying cause or a contributing cause of death for 3,332 people (Berko 2014 1). In Australia, extreme heat events kill more Australians than any other natural disasters (Steffen, 2014). In July 2018, Japan experienced a national extreme heat event with temperatures reaching 41.1°C (106°F) resulting in 80 deaths (65 deaths in a single week) and over 35,000 admissions to hospital (France-Presse, 2018). In 2003, an extreme heat event in France resulted in an estimated mortality in excess of over 14,000 persons (60% higher than expected) with short and long-term mortalities of 58% and 71% respectively (Argaud 2007 2177). It is believed that if the core body temperature is rapidly reduced to less than 40°C (104°F) within 30 minutes, the mortality rate approaches zero and most heat stroke casualties recover without chronic sequelae (Belval 2018 392). The optimal evidence-based strategy for heat stroke cooling in the first aid setting is uncertain.	This topic was given a high priority rank by the ILCOR First Aid Task Force. Much of the world is exposed to extreme heat and heat waves or extreme heat events are likely to become more common. Major sporting events are being hosted in locations with hot climates and a meteorological history of extreme heat events. Guidelines for the prehospital care of exertional heatstroke have been published but are derived from experience and consensus rather than from an evidence -based systematic review (Belval 2018 392).

Desirable Effects

How substantial are the desirable anticipated effects?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Trivial ○ Small ● Moderate ○ Large ○ Varies ○ Don't know	The systematic review results suggest that water immersion techniques are superior to other methods of cooling for the critical outcome of cooling rate (low to very low certainty evidence). **Figure 1: Weighted mean cooling rates (°C/min) by cooling method. Standard deviations based on the mean cooling rate of study participants.**  a Armstrong 1996 355, Clements 2002 146, Flouris 2014 2551, Friesen 2014 1727, Gagnon 2010 157, Luhring 2016 946, Proulx 2006 434 b Caldwell 2018 512, Friesen 2014 1727, Lee 2012 655, Proulx 2006 434, Taylor 2008 1962 c Caldwell 2018 512, Clements 2002 146, DeMartini 2011 2065, Peiffer 2009 987, Peiffer 2010 461, Proulx 2003 1317, Taylor 2008 1962, Walker 2014 1159, Weiner 1980 507 d Clapp 2001 160, Halson 2008 331, Hosokawa 2017 347, Lee 2012 655, Nye 2017 294, Proulx 2006 434 e Kielblock 1986 378, Lissoway 2015 173, Sinclair 2009 1984 f Butts 2016 252 g Butts 2017 e1951, DeMartini 2011 2065, Nye 2017 294 h Barwood 2009 385, Carter 2007 109, Clapp 2001 160, DeMartini 2011 2065, Selkirk 2004 521, Zhang 2014 17 i Barwood 2009 385, Brade 2010 164, Lopez 2008 55, Maroni 2008 441, Smith 2018 413 j Morrison 2018 493, Sinclair 2009 1984 k Barwood 2009 385, DeMartini 2011 2065 l Adams 2016 936, Armstrong 1996 355, Barwood 2009 385, Brade 2010 164, Butts 2016 252, Butts 2017 e1951, Carter 2007 109, Clapp 2001 160, Clements 2002 146, DeMartini 2011 2065, Flouris 2014 2551, Gagnon 2010 157, Halson 2008 331, Hosokawa 2016 347, Kielblock 1986 378, Lissoway 2015 173, Lopez 2008 55, Luhring 2016 946, Maroni 2018 441, Peiffer 2009 987, Peiffer 2010 461, Pointon 2012 2483, Reynolds 2015 97, Sefton 2016 936, Selkirk 2004 521, Smith 2018 413, Taylor 2008 1962, Walker 2014 1159, Weiner 1980 507, Zhang 2009 283, Zhang 2014 17 m Adams 2016 936, Maroni 2018 441, Zhang 2009 283 n DeMartini 2011 2065, Sefton 2016 936, Sinclair 2009 1984, Kielblock 1986 378	There were limited included studies (with comparators) addressing the critical outcome of mortality. There were no included studies (with comparators) addressing the important outcome of hospital length of stay. The majority of included studies used a model of exertional hyperthermia achieving a maximum temperature of 39-40°C (102.2°-104°F) i.e. induced hyperthermia in healthy participants who did not have heat stroke. There were only 2 cohort studies and no RCTs of cooling interventions involving persons with heat stroke. These studies provide the only direct evidence of effectiveness of water immersion cooling for individuals with heat stroke. The impact on the population on a global scale could be large. There were no studies including children.

Undesirable Effects

How substantial are the undesirable anticipated effects?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ Large ○ Moderate ● Small ○ Trivial ○ Varies ○ Don't know	There were no included studies with comparators that reported on harms. Cohort studies of running events did not demonstrate any significant harms from water immersion techniques (Demartini 2015 240). The majority of included studies reported clinically relevant ice / cold water immersion times without significant hypothermia (or "after-drop") or any cold injuries being reported.	Excessive cooling may lead to hypothermia. This risk needs to be balanced against any potential benefits. Most included studies were undertaken on healthy athletes with exertional hyperthermia. The ability to tolerate cold water immersion is a potential undesirable effect. Monitoring of core temperatures (predominantly rectal) during cooling will offer some protection from potential over cooling and hypothermia

Certainty of evidence

What is the overall certainty of the evidence of effects?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
● Very low ○ Low ○ Moderate ○ High ○ No included studies	The certainty of the evidence for the critical outcome of 'rate of temperature reduction' is low. The majority of included studies involved healthy volunteer athletes with induced hyperthermia without heat stroke. The quality of the evidence from these studies was downgraded for indirectness and risk of bias. Studies involving individuals with exertional heatstroke were downgraded for study design and risk of bias.	Because there were only 2 cohort studies and no randomized controlled trials of cooling interventions involving individuals with heat stroke, results of studies evaluating cooling for exertional hyperthermia were extrapolated for treatment recommendations for exertional heat stroke. The task force considered the need for rapid cooling to be an urgent priority for exertional heat stroke and therefore were comfortable with this extrapolation. Although downgraded for study design and risk of bias, the two cohort studies provide direct evidence of effectiveness for individuals with heat stroke at sporting events. There were limited interventional case series on classic (nonexertional) heat stroke. There were few studies that combine active with passive methods of cooling and there may be additive effects with combination cooling therapies.

Values

Is there important uncertainty about or variability in how much people value the main outcomes?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Important uncertainty or variability ○ Possibly important uncertainty or variability ● Probably no important uncertainty or variability ○ No important uncertainty or variability	We have not identified any heat stroke / exertional hyperthermia studies that specifically addressed how those individuals treated valued the different outcomes. We are confident that health care providers and first aid providers as well as organizers of large sporting venues located in areas with anticipated high ambient temperatures will value these outcomes.	There were insufficient studies on the important outcomes of adverse events associated with different cooling techniques and important organ dysfunction.

Balance of effects

Does the balance between desirable and undesirable effects favor the intervention or the comparison?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Favors the comparison ○ Probably favors the comparison ○ Does not favor either the intervention or the comparison ● Probably favors the intervention ○ Favors the intervention ○ Varies ○ Don't know	Overall, when compared to passive cooling, the balance between desirable and undesirable effects favors most types of active cooling interventions. Water immersion is associated with the fastest cooling rates, with ice water immersion (1-5°C) being the fastest. Other methods of cooling, including use of chemical ice packs and hand and foot cold water immersion compared with passive cooling, probably favor the intervention, although studies using these interventions are limited and subject to imprecision from small sample sizes. For devices including cooling vests, use of ice sheets or towels, and hand cooling devices, the balance of effects does not favor either the intervention or the comparison. For reflective blankets, the balance of effects favors the comparison.	Passive cooling (20-39°C, e.g. removing to shade, moving to a cooler environment) was shown to have a mean weighted cooling rate of only 0.05°C/min. Several Task Force members reported that use of whole-body water immersion techniques was uncommon in their geographical region and that other (less effective) techniques were more commonly implemented. This may be due to the lack of approved recommendations for heat stroke cooling.

		The Task Force valued active cooling methods despite the lack of availability of core temperature measurement in many first aid settings.

Resources required

How large are the resource requirements (costs)?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Large costs ○ Moderate costs ○ Negligible costs and savings ○ Moderate savings ○ Large savings ● Varies ○ Don't know	We did not identify any heat stroke / exertional hyperthermia studies that specifically addressed the costs of specific interventions. The development of plans for the treatment of individuals with heat stroke (exertional or nonexertional (classic) is likely to have potentially substantial savings for health systems, especially during extreme heat events (heat waves). There is evidence of a significant economic burden associated with heat related illnesses (Schmeltz 2016 894). Case reports indicate that whole-body water immersion techniques can be facilitated with improvised and cheap materials (Luhring 2016 946; Hospkawa 2017 347).	Water is cheap but not always readily available. Natural bodies of water (e.g., pond, lake, river, sea, ocean) in temperate zones may be used if cooler than 26°C (78.8 °F) and if safe to use. Natural body water temperatures in tropical zones may not be appropriate based on the time of year. Tropical sea temperatures, for example, can peak in the ranges of 26-28C between February and August. Task Force members report cost of suitable vessels to establish whole-body water immersion ranges from $100-$500 USD. Improvised methods can be established for less than $50 USD. Commercial cold packs cost between $1-$3 USD depending on quantity. Multiple ice packs need to be used per person thereby increasing costs. Cooling vests range in price from $150-$350 USD. There are minimal costs associated with passive cooling – however there are costs associated with cooling utilizing air-conditioning.

Certainty of evidence of required resources

What is the certainty of the evidence of resource requirements (costs)?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Very low ○ Low ○ Moderate ○ High ● No included studies	We have not identified any heat stroke / exertional hyperthermia studies addressing the resource requirements (costs).	Task Force members have provided estimated pricing information for a range of available cooling techniques in a number of countries, as well as the estimated costs of the various methods used in the active cooling processes as described in the published studies. The estimated costs were low to moderate.

Cost effectiveness

Does the cost-effectiveness of the intervention favor the intervention or the comparison?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Favors the comparison ○ Probably favors the comparison ○ Does not favor either the intervention or the comparison ● Probably favors the intervention ○ Favors the intervention ○ Varies ○ No included studies	We have not identified any heat stroke / exertional hyperthermia studies addressing the cost effectiveness of active cooling. We did identify a report on the economic burden of hospitalizations for heat-related illnesses (Schmeltz 2016 894). This study outlined the significant burden on health systems and health inequities including gender, race, and socio-economic status.	Where a large number of individuals have heat stroke, cooling with whole-body water immersion techniques are likely to be very cost effective from a health system perspective. There were no included RCTs or cohort studies on classic (nonexertional) heat stroke.

Equity

What would be the impact on health equity?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Reduced ○ Probably reduced ○ Probably no impact ○ Probably increased ○ Increased ● Varies ○ Don't know	There may be important differences in availability of various cooling options between developed and developing regions due to costs of the various techniques or the availability of resources (e.g. water).	Individuals of lower socio-economic status are more susceptible to heat stroke and are possibly less likely to have access to the most effective treatments.

Acceptability

Is the intervention acceptable to key stakeholders?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ No ○ Probably no ● Probably yes ○ Yes ○ Varies ○ Don't know	Most key stakeholders are likely to find the faster cooling rates achieved using whole-body water immersion techniques as acceptable. A study of athletic trainers suggests that there may be barriers to implementation (e.g. core temperature measurement, not currently using whole-body water immersion techniques, concerns about safety, perceived success of other techniques) (Mazerolle 2010 170). There may be important cultural considerations for recommending whole-body water immersion techniques.	Core temperature measurement is not used routinely in many first aid settings. Task Force members reported that water immersion techniques were not commonly used in prehospital and in-hospital settings. Task Force members identified differences in practices for exertional heat stroke and nonexertional (classic) heat stroke. The Task Force felt that the provision of up-to-date clinical advice will change the acceptability of whole-body water immersion and the use of proper core temperature measurement

Feasibility

Is the intervention feasible to implement?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ No ○ Probably no ○ Probably yes ○ Yes ● Varies ○ Don't know	Feasibility may vary depending on the providers, setting, patient factors, resources and preparation. It should be feasible to have the capability of implementing whole-body water immersion in emergency medical systems, organized sports events and during predicted extremes of heat (heat waves). However, this may not be feasible in settings such as remote recreational or occupational events (e.g. military operations, remote firefighting, remote sporting events, unanticipated extreme weather events, limited space or economic reasons). Included cohort studies and case series demonstrate that it is feasible to implement cooling via water immersion at planned and organized events (e.g. running festivals, marathons) (Sloan 2015 823; Demartini 2015 240). Improvised whole-body water immersion techniques have been described for situations where equipment for whole-body water immersion is not feasible (Luhring 2016 946; Hospkawa 2017 347).	Core temperature measurement is unavailable in many first aid settings. Several Task Force members identified measurement of core temperatures as a major barrier to the implementation of whole-body water immersion techniques. Although the Task Force recognizes this potential barrier it would recommend the use of core temperature measurement as the standard technique for heat related illness monitoring and the associated cooling techniques. Natural bodies of water (e.g. oceans, rivers and dams) might be the only available water and immersion in these should be considered if cooler than the ambient temperature and safe to do so.

SUMMARY OF JUDGEMENTS

	JUDGEMENT						
PROBLEM	No	Probably no	Probably yes	**Yes**		Varies	Don't know
DESIRABLE EFFECTS	Trivial	Small	**Moderate**	Large		Varies	Don't know
UNDESIRABLE EFFECTS	Large	Moderate	**Small**	Trivial		Varies	Don't know
CERTAINTY OF EVIDENCE	**Very low**	Low	Moderate	High			No included studies
VALUES	Important uncertainty or variability	Possibly important uncertainty or variability	**Probably no important uncertainty or variability**	No important uncertainty or variability			
BALANCE OF EFFECTS	Favors the comparison	Probably favors the comparison	Does not favor either the intervention or the comparison	Probably favors the intervention	**Favors the intervention**	**Varies**	Don't know
RESOURCES REQUIRED	Large costs	**Moderate costs**	Negligible costs and savings	Moderate savings	Large savings	**Varies**	Don't know
CERTAINTY OF EVIDENCE OF REQUIRED RESOURCES	Very low	Low	Moderate	High			**No included studies**
COST EFFECTIVENESS	Favors the comparison	Probably favors the comparison	Does not favor either the intervention or the comparison	**Probably favors the intervention**	Favors the intervention	Varies	No included studies
EQUITY	Reduced	Probably reduced	Probably no impact	Probably increased	Increased	**Varies**	Don't know
ACCEPTABILITY	No	Probably no	**Probably yes**	Yes		Varies	Don't know
FEASIBILITY	No	Probably no	Probably yes	Yes		**Varies**	Don't know

TYPE OF RECOMMENDATION

Strong recommendation against the intervention	Conditional recommendation against the intervention	Conditional recommendation for either the intervention or the comparison	Conditional recommendation for the intervention	Strong recommendation for the intervention
○	○	○	○	

CONCLUSION

For adults with exertional hyperthermia

- We recommend immediate active cooling using whole body (neck down) water immersion techniques (1-26°C; 33.8-78.8°F) until a core body temperature of less than 39°C (102.2°F) is reached in favour of any other active cooling technique (weak recommendation, very low certainty evidence).
- We recommend that where water immersion is not available, any other active cooling technique be initiated (weak recommendation, very low certainty of evidence).
- We recommend immediate cooling using any active or passive technique available to care providers that provides the most rapid rate of cooling (weak recommendation, very low certainty of evidence)

For adults with nonexertional (classic) heat stroke, we cannot make a recommendation for or against any specific cooling technique compared with an alternative cooling technique (no recommendation, very low certainty evidence)

For children with exertional or nonexertional heat stroke, we cannot make a recommendation for or against any specific cooling technique compared with an alternative cooling technique (no recommendation, very low certainty evidence).

Technical remarks

1. The most rapid cooling was achieved using whole-body (from the neck down) water immersion techniques between 1-26°C (33.8-78.8°F). While there was heterogeneity in cooling rates between different water temperatures, colder water temperatures were associated with faster cooling rates.
2. Cooling rates achieved with water immersion techniques were faster than other active cooling modalities such as commercial ice packs, cold showers, evaporative cooling, ice sheets and towels, fanning, evaporative cooling, cooling vests and jackets. However, because confidence intervals cross for most of the mean weighted cooling rates for techniques studied, we are unable to provide a rank order list. Graphically displayed trends in mean weighted cooling rates for cooling techniques are available in Figure 1 (see above).
3. The evidence summary consistently reports core body temperature as measured by rectal. The absence of core rectal temperature measurement availability should not preclude initiation of whole-body cold-water immersion if available.

Justification

Overall justification

For exertional hyperthermia, despite very low certainty of evidence, the Task Force recommends whole-body water immersion techniques (from the neck down) compared with other active cooling techniques, as water immersion (across a range of temperatures) was associated with the fastest rates of cooling and will therefore minimize the raised body heat exposure time and result in an improved overall outcome. If whole-body water immersion is not available, other active cooling methods should be commenced to reduce the core temperature as rapidly as possible. We recommend immediate cooling using any active or passive technique available to care providers that provides the most rapid rate of cooling

For exertional heat stroke, despite very low certainty of evidence, the Task Force also recommends that the same immediate active, or if unavailable, passive cooling techniques for exertional hyperthermia be applied to the management of exertional heat stroke (weak recommendation, very low certainty of evidence).

As there were no included studies on nonexertional (classic) heat stroke or heat stroke in children, the Task Force is unable to recommend for or against any specific cooling technique compared with an alternative cooling technique.

Detailed justification

Desirable Effects

- The Task Force recommends using the coldest water available within the wide range of water temperatures used in the experimental studies (between 1°C and 26°C; 33.8-78.8°F),
- Task Force members identified the need for core temperature monitoring in individuals being cooled with whole-body water immersion techniques. Whilst whole-body water immersion techniques are associated with the fastest cooling rates, the Task Force acknowledges that other methods of active cooling have been successfully used despite slower cooling rates. Accordingly, if whole-body water immersion techniques are not available or not feasible, we suggest that other active cooling techniques such as evaporative cooling, ice sheets and towels, commercial ice packs, fanning, or cold shower, should be used as available.
- There was limited evidence favoring cooling vests when compared with other techniques. The Task Force discussed the potential role that cooling vests might play in prevention of exertional heat stroke for at risk individuals. These devices are currently not commonly used in first aid settings.
- The Task Force suggests that reflective blankets are not an effective active cooling method. The confidence interval of the mean difference from a single study includes the possibility of increasing core temperature by their use

Undesirable Effects

- Whilst concerns were expressed about the possibility of hypothermia resulting from over- cooling, the Task Force noted that clinically significant hypothermia was not reported in any of the experimental studies of exertional hyperthermia or in any of the cohort studies of exertional heat stroke.

Balance of effects

- If core temperature measurement is unavailable, the Task Force identified the following strategies to mitigate risks of potential harm when whole-body water immersion is initiated without core temperature measurement: 1) calling for advanced care early; 2) cooling until resolution of symptoms or for 15 minutes (consensus opinion). The Task Force acknowledges that whilst there is a risk of causing hypothermia without core temperature measurement the benefits will still outweigh any harm.

Cost effectiveness

- The immediate costs of implementing active cooling strategies are variable. Effective cooling strategies are likely to be very cost-effective, especially in instances of extreme heat events which have place health systems under great pressures. These considerations assisted the Task Force to make a strong recommendation for the use of cooling techniques with the fastest cooling rate.

Acceptability

- It is medically acknowledged that the time spent above the critical core temperature of 40°C is associated with increased morbidity and mortality. As a general “good practice” principle the Task Force recommends the immediate commencement of active cooling by the modality available that provides the most rapid rate of cooling.
- The Task Force considered that the treatment recommendation includes the need for core temperature measurement despite this not being a technique practiced by many first aid providers. Given the clinical consequences of delayed cooling for heat stroke, the Task Force considered that core temperature measurement should be available in first aid settings where there is a high risk of encountering heat stroke, such as sports events, particularly when high ambient or wet bulb temperatures are anticipated.
- The Task Force considered that even in the absence of core temperature measurement, the use of water immersion, if available, should be continued until there has been resolution of symptoms or until 15 minutes of immersion has elapsed as benefit is more plausible than harm.

Feasibility

- The Task Force also discussed that whole-body water immersion techniques were not common in many first aid settings within their jurisdictions including events where there was high risk of encountering exertional heat stroke. The Task Force also considered that it should be feasible to implement cooling with whole-body water immersion in emergency medical systems, organized sports events and during predicted extreme heat events.

- The Task Force acknowledge that whole-body water immersion may not be feasible in settings such as remote recreational or occupational events (e.g. military operations, remote firefighting, remote sporting events, unanticipated extreme weather events, limited space or for economic or cultural reasons). Costs associated with implementing cooling with whole-body water immersion were variable with low (< $50 USD), moderate ($100-$500 USD) and high cost (more than $5000 USD) options available.
- The Task Force also considered operational and logistical constraints (e.g. availability of water, temperature control, drainage, transport, etc.). The Task Force discussed that training of first aid providers in core temperature measurement is likely to be a possible barrier to implementation.

Subgroup considerations

It was not possible to undertake planned sub-group analyses for:

- Exertional heat stroke compared with nonexertional (classic) heat stroke
- Exertional heat stroke compared with exertional hyperthermia
- Age and gender
- Etiology of heat stroke
- Care and outcomes by different levels of care providers

Implementation considerations

The Task Force identified potential barriers to implementation of treatment recommendations.

Whole-body water immersion techniques are not currently used in many jurisdictions. There may be reluctance to change techniques of cooling given the perceived success of other cooling techniques.

The Task Force is cognizant that previous research has shown that aural, oral, tympanic, axillary, surface and temporal measurements are inaccurate during and immediately following intense exercise in the heat, and accordingly cannot recommend them as alternatives to measurement of core temperature.

Core temperatures are not commonly measured by first aid providers and this could be considered a barrier to the implementation of whole-body water immersion techniques.

The level of training required by first aiders to implement whole-body water immersion techniques should be determined by undertaking a risk assessment. In situations where there is a high likelihood of encountering heat related illness, core temperature measurement will aid making a diagnosis, monitoring rates of cooling and preventing hypothermia.

In locations where extreme heat events are likely, planning will be required to effectively manage multiple patients.

Monitoring and evaluation

There would be benefit from registries of outcomes for individuals with heat related illness to better understand the short- and long-term outcomes.

Research priorities

Current knowledge gaps include but are not limited to:

- There are no prospective comparative studies of cooling techniques for individuals with exertional or classic (nonexertional) heat stroke. Recommendations in this review are based primarily on indirect evidence from exertional hyperthermia.
- There is an urgent requirement for studies to investigate the optimal duration of cooling by cold water immersion techniques when core temperature measurement is unavailable
- There are no comparative studies of combining active with passive cooling techniques on rate of cooling and on clinical outcomes, for example, use of ice packs with evaporative and passive cooling.
- There are no studies of the optimal method of cooling for heat related illness in children or based on body mass index
- Research is required into the ability of a first aid provider to recognize heat stroke without a core temperature measurement and the educational requirement to bridge this gap
- Research is required into the optimal approach of the management of extreme heat events involving multiple victims with heat related illness, including evaluation of the health economic impact and the impact of active cooling techniques.

References

Argaud L, Ferry T, Le Q, et al. Short- and long-term outcomes of heatstroke following the 2003 heat wave in Lyon, France. Arch Intern Med. 2007;167(20):2177–2183. doi:10.1001/archinte.167.20.ioi70147.

Belval, NL, Casa, DJ, Adams, WM, Chiampas, GT, Holschen, JC, Hosokawa, Y, Jardine, J, Kane, SF, Labotz, M, Lemieux, RS, McClaine, KB, Nye, NS, O'Connor, FG, Prine, B, Raukar, NP, Smith, MS & Stearns, LS. Consensus statement- prehospital care of exertional heat stroke. Prehosp Emerg Care. 2018;22(3):392-397. doi: 10.1080/10903127.2017.1392666.

Berko, J, Ingham, DD, Saha, S, Parker, JD. Deaths Attributed to Heat, Cold, and Other Weather Events in the United States, 2006–2010. National Health Statistics Reports, [online]. 2014;76:1-15. Available at : https://www.cdc.gov/nchs/data/nhsr/nhsr076.pdf [accessed 5 June 2019].

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):240-245.

France-Presse A. 'Unprecedented' Japan heatwave kills 65 people in a week. The Guardian. 2018. [online]. Available at : https://www.theguardian.com/world/2018/jul/24/unprecedented-japan-heatwave-kills-65-people-week [accessed 5 June 2019].

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):347-352. doi: 10.1016/2016.08.428.

Luhring KE, Butts CL, Smith CR, et al. Cooling effectiveness of a modified cold-water immersion method after exercise-induced hyperthermia. J Athl Train. 2016;51(11):946–951. doi:10.4085/1062-6050-51.12.07.

Mazerolle SM, Scruggs IC, Casa DJ, et al. Current knowledge, attitudes, and practices of certified athletic trainers regarding recognition and treatment of exertional heat stroke. J Athl Train. 2010;45(2):170–180. doi:10.4085/1062-6050-45.2.170.

Schmeltz MT, Petkova EP, Gamble JL. Economic burden of hospitalizations for heat-related illnesses in the United States, 2001-2010. Int J Environ Res Public Health. 2016;13(9)E894. doi:10.3390/ijerph13090894

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), 823–829.

Steffen W, Hughe , Perkins S. Hotter, longer, more often. 2014. [online] Available at : https://www.climatecouncil.org.au/uploads/9901f6614a2cac7b2b888f55b4dff9cc.pdf [accessed 5 June 2019].

United States Environmental Protection Society & Centre for Diseases Control and Protection. Climate change and extreme heat : What you can do to prepare. 2014 [online]Available at : https://www.epa.gov/sites/production/files/2016-10/documents/extreme-heat-guidebook.pdf [accessed 5 June 2019].

World Health Organisation. Improving public health responses to extreme weather/heat-waves – EuroHEAT. 2009. [online] Available at : http://www.euro.who.int/__data/assets/pdf_file/0010/95914/E92474.pdf?ua=1 [accessed 5 June 2019].

World Health Organisation. Exposure to extreme heat and cold. 2019. [online] Available at : https://www.who.int/sustainable-development/housing/health-risks/extreme-heat-cold/en/ [accessed 5 June 2019].