

Welcome to 'On the Line', a podcast for today's wildland firefighter. Brought to you by the Black.

CP: I'm Charlie Palmer, joining me today on the podcast are University of Montana professors Brent Ruby and Chuck Dumke. Both call themselves Exercise Physiologists, so we're going to hear both those guys' words on the topic- "Heat related illness, or heat related injury".

CP: So HRI's are often the acronym thrown about, is there one that's more proper?

BR: I think Heat Related Injury or Heat Related Illness, either one, they're used interchangeably.

CP: So, to clear it up from a definitional standpoint, Chuck, what is a working definition?

CD: Heat Related Injuries or Heat Related Illnesses, which Brent said is synonymous, is kind of an umbrella term, to include everything from heat cramps, heat exhaustion, or heat stroke. And, you self-define muscle cramps as heat cramps, and they might be associated, you might be predisposed in the heat for muscle cramps. But the prevailing wisdom is that you go from one step to the next step, to the next; and that's not necessarily true. They are a continuum of severity, in which heat cramps are the least severe, heat exhaustion more severe, and heat stroke- is certainly very severe, in which case you can result in brain damage, and death. Of course, one can skip a step, and go straight into heat exhaustion. One doesn't necessarily start at the beginning, go to the next step, and then the next step. Indeed, one can even hopscotch over heat cramps and heat exhaustion, and develop acutely heat stroke.

CP: Okay, so why is the wildland firefighter at risk, Brent, for heat related illnesses or Injuries?

BR: When you think about the occupation that is wildland fire suppression, the first thing that comes to mind is the ambient condition. And the ambient conditions are often hot and dry. And therefore, create the potential for the body temperature to rise uncontrollably, if bad decisions are made. It's important to clarify the difference between exertional heat injury and simply injury. Further, the term exertional heat injury is really what we're talking about. And that is sort of a run-away core temperature that is created by a combination of a high work output, with the muscles working very hard, and the environment is not conducive to cooling the individual off. So, the wildland firefighter is inherently at a slightly higher risk, than another occupational worker in a climate controlled factory, because the ambient conditions can be so aggressive. And so, it is really important that wildland firefighters choose a work intensity that is both conducive to get the job done safely, that allows them to offload heat as it is produced by the muscles inside the body.

CP: Okay, and that must be difficult at times with the Personal Protective Equipment clothing, and a pack, maybe working direct line, where the fire is right there, and its 90-100 degrees outside from an air temperature standpoint. It's got to be a difficult set of circumstances.

BR: Yeah, most of the people will call some of those primary factors that lead to this increased risk. But most of them are really, secondary factors. So, the radiant heat from the sun, the radiant heat from the fire, the fact that you've got a 40 or 50-pound pack on, the

clothing barriers; those things that sort of trap heat in. But really, the primary driving heat producers are the muscles on the actual firefighter. Those engines are working at the intensity that the firefighter decides to hike, or dig line, or throw slash, or whatever. That's where the heat is being produced. And so, making good choices and using appropriate work to rest ratio provides the utmost in protection and allows you to offload heat as you're accumulating it.

CD: So, to just add to Brent's point of the metabolic heat that gets produced when you're working. Outside of the wildland firefighter world, just as an example, the ambient temperature- the environmental temperature that results in the greatest performance- say in a running, marathon; for an elite athlete is about 48 degrees Fahrenheit. So, that just speaks to the metabolic importance of being able to unload the metabolic heat into the environment. And again, with the safety protection- the PPE, the pack, excetera, makes a challenge in unloading the metabolic heat.

CP: You know, firefighters probably are not going to encounter a lot of 48 degree temperatures, as they're punching in hotline.

CD: No.

CP: So, that's a good segue into an avoidance of protective strategies. How can we try to minimize or mitigate some of those issues?

CD: Well, I stopped short of kind of clearly defining heat exhaustion earlier. And certainly, one of the important points will be to recognize what is going on. Part of the challenge is the recognition of the symptoms can be construed in a lot of different diagnosis, and some of those include stopping sweating. Meaning, you have centralized your blood volume, you start to feel cool and get chills even though your environment hasn't changed. Conversely, it could be profuse sweating, where you're just dumping out sweat. You know, feeling light headed, dizziness, fainting. You know, kind of feeling that sort of low blood pressure feeling as you're moving around; getting a sort of syncope or light-headedness. We mentioned muscle cramping, although not a required symptom, might be there. Sometimes an accelerated heart rate-sometime you can feel your wrist pulse and notice that, 'Wow I'm not working that hard right now, and it's really kind of fast!' [or] getting a headache.

CP: Okay, going to kick back to that question of: What can we do about it? How can we avoid these things, or what kind of preventative strategies can we put in place for fire-fighters to help themselves?

BR: Besides just saying sort of just, slow down working in an environment that you're not used to performing in, like the present situation in Arizona where it's quite hot. If you're pulling crews from the North West, some of the temperatures that are happening in Arizona in the fires right now, some of the people on these crews have never seen (some of them, never in their lives). And so, they are obviously not acclimatized to that environment. There's multiple things that those firefighters hold in their hands that they can bring to the fire that can increase their readiness. That is, early season strategies, or even pre-season strategies towards enhancing their own levels of aerobic fitness. The higher the level of aerobic fitness that a firefighter brings into the season, that's the sort of safety net you can hang your hat on. I mean, that is really an important thing to consider. So, if you go into the season with a very low level of aerobic fitness, as soon as you begin to hike in, you've exceeded your sustainable fitness level. So, you start to have this run-away core temperature response, and

you notice it because your sweat production is much higher, you're out of breath, and you're producing monstrous amounts of heat that you're not used to. So the most important thing in terms of avoidance is- come into the season ready. Now, that's often easier said than done for a northwest crew member. Saying, 'Oh come into the season acclimatized!' They're living in the northwest in Montana, or Washington, or Idaho, and now boom, they're in Arizona. They're not ready, there's nothing you can do to prepare them for that environment. But, when they arrive, they're not going to behave as [unclear, 00:07:51] as usual. So, you need to slow down. You need to pick a pace that is both appropriate for your fitness level, and appropriate for that environment. Which means... slow down.

CP: So, that means being more realistic about expectations about how much you're going to accomplish if you're one of those folks that's coming down [from the Pacific Northwest], and isn't acclimatized to that new environment.

BR: Absolutely!

CD: To reiterate that point, both Brent and I have done research at ultra-distance running races- Brent and I even went to Badwater, where they run through Death Valley. The air temperatures can be 125 to 130 degrees. I've gone to the Western States 100. Air temperatures are often in the 100s, and these athletes are running, and yet, they don't typically overheat. In part, because they simply, slow down. Certainly, they have other strategies which they employ -appropriate hydration, sometimes in the Badwater they will have big coolers of ice, and that certainly isn't an option for a wildland firefighter. But, the important point is that they reduce their metabolic heat, by slowing down. That speaks to Brent's point that- don't hit the fire line hard when you're coming from Montana, down to Arizona, and it's all of a sudden this new environment. You need time to sort of prepare for that sort of situation.

BR: It's also important to know that the fitness you bring, to the fire is critical but you cannot go to the fire and hope to say, 'Okay, within three days I'm going to be completely used to this environment! I'm going to use this fire to a) get fit, and b) get completely acclimatized to the southwest.' You will develop some acclimatization, in those first seven days in a fire, or longer and that will benefit you. But, that is completely secondary protection to the fitness that you have, and the good choices that you make regulating your intensity.

CD: I'd like to point out, being an exercise physiologist [and not talking about the mechanisms], why is fitness so important? And, one of the many things is, one, you can be working at a lower relative intensity. So basically, the work that you are being asked to do, is easier for you. Two, you actually go through what we call, 'Plasma Volume Expansion', which means you reserve more fluid in your body. You actually have more fluid, and therefore you have a greater heat dissipation tool at your readiness. It probably should also be mentioned that you are typically carrying less insulation, if you will. Right? You've optimized your body composition so that your heat dissipation is improved, by not having a layer of insulation. And indeed, that will benefit you out in the field as well.

CP: Well I know as a firefighter; this message was always preached as far as hydration goes. You'd hear it in the morning meetings, you'd see it in the [unclear, 00:10:38] action plan- what seems to be a hyper focus on hydration. 'Stay hydrated out there!' Thoughts on that?

BR: Yeah.

CP: But not to diminish the importance of hydration.

BR: Yeah, you don't want to diminish the importance of hydration of, I mean, it's obvious that any firefighter is gonna know that, "it's 12 hours on the line –hiking, digging, sweating... I should probably have some adequate water." That's true. But the terms- hydration, or 'hydrate or die', or whatever. Just, that sort of scare tactic that, if you get even the slightest bit dehydrated your day is screwed, I think that's overemphasized. Fitness, and adequate rest to work ratios are greatly underemphasized, and the two things I think need to be flip-flopped. Even the least experienced firefighter is going to understand the importance of regular drinking patterns during the day, and so it's not that hydration is not important, it's just of secondary importance compared to some of the other mechanistic things you bring to the table on day one, like your fitness levels and your appropriate work to rest ratios. But yeah, obviously, hydration is critical because it helps maintain that plasma volume, helps maintain normal cardiac function, helps maintain your normal heat dissipation. But the one thing you can't do is you can't drink yourself to safety. If you are making poor decisions, and you are over working and under resting, in terms of that work to rest ratio, even if you are perfectly hydrated, you can still have an issue of exertional heat exhaustion. Which can run away to heat stroke very quickly.

In a study we did in 2006, one of the firefighters in that study overworked himself. The measurement of work that we have with accelerometers in their work shirts, he produced the highest amount of work output that we've ever seen in an individual with this mechanism.

CP: He was one of those firefighters that was always on the move, probably. Just liked to keep working...

BR: Just really working hard. And, we knew how much fluid he was drinking. So in the couple of hours prior to him going down with heat exhaustion, his core temperature went just above 104 degrees Fahrenheit, and he collapsed, and had to be evacuated with a helicopter. It was a mess. But, his drinking patterns was incredibly aggressive. In that two hour window that he went down, he drank almost three liters- which is far above what would be recommended by military standards. And so, he was trying to drink his way to protection. That was his chosen safety net as opposed to just backing off. It was a very hot ambient condition. I mean, it was almost 110 at that fire in Leavenworth, Washington. So that was a really unique case study, that we published in Wilderness and Environmental Medicine. You can't drink yourself to safety, you have to make good choices in terms of managing heat production.

CP: Yeah I know from talking to you the other times that you've said that the most important part of the 'water break', is the break part and not the water part.

BR: And the water is a bonus, if you can get into the shade and if there's a way that you can get cool drinks out there, that would be more optimal. Nowadays some vessels will allow for insulation, so maybe you can carry some very, very cold ice-water that would be really nice out there as well.

CP: Yeah, firefighters will often carry a cold canteen that's just frozen. Would you recommend that cold water over room temperature water, or a warmer water?

BR: Ah yeah. If you had the ability to have the occasional ice slurry out on the line, you'd be in great shape, but that's not real practical. Some of the commercial vessels that will provide better insulation. It's not like you have the luxury of a lot of ice, even in the most optimized fire camp, but if you could have ice in that vessel and then water on top of it- some of those vessels will insulate and keep that water cold all day long. And yeah, that is an advantage because you don't have to drink as much to promote the same thermoregulatory response, if the water is very very cold.

CD: Clearly drinking, for the wildland firefighter is very important, like Brent said. For all the reasons we talked about They're exercising in the heat, they're going to be sweating, they have greater hydration needs than the people who are sitting at home watching TV, clearly. In fact, it's been measured at the University of Montana –they need upwards of about 7-9 liters a day, to kind of meet their needs, probably.

BR: That's in a 24-hour window. That's not 7-9 during the work shift. That's in a 24-hour period, it's about 7-9 liters.

CP: So, that's including your downtime, however how long that is...

BR: Yes.

CP: In addition to your operational work period?

BR: So, on the line that might be five liters or four and a half liters, something like that. And it's important, as exercise physiologist we are sort of habituated to the metric system, but that's basically one of the standard issue canteens. That's a quart/ a liter, close enough.

CP: Yes, and often times you'll hear about a quart or a liter an hour, as far as consumption rates. Does that jive then? Or is that maybe too aggressive?

CD: Well certainly sweat rates can be well over a liter an hour when you're working hard, you know? That might be on the hike in, depending on the situation on the fire. You've got a 30-minute hard hike? Yeah, you might need some additional fluid because of that exertion. But realizing a liter an hour is, during those type of times, not across the whole day when, you know, hiking is about 15 percent of your day, digging line is maybe another 20 percent of your day. So, that will probably be on the top end, and you don't want to try to say then, "Oh twelve hours, that's twelve liters!" Right? That's an incorrect conclusion to come to perhaps. You talked about frozen canteens, and I've actually tried this in racing in hot environments. One of the dangers there, is not meeting your hydration needs because, 'this thing is not melting quick enough'[laughs]. So if you don't already have availability to fluids, Yes, cool fluids can better cool your body, but you don't want to limit your overall intake as well. Again, Brent made the great point, it's not going to keep you from getting heat stress, but certainly it's an important part of the wildland firefighters tools in completing their jobs, and being safe.

CP: Yeah, I know as a firefighter it was extremely beneficial to me to be able to have a cold canteen- to be able to stop, and take a drink of very, very cold water. Sounds like there was some physiological benefit to that too. In addition to just the psychological benefit of, 'Gah, that tastes nice!'

BR: Absolutely! And the benefit of keeping that as, sort of, in reserve! So, the problem sometimes with the drinking systems is that, yeah they're convenient, because they're right there on your collar –just pick the hose up and you get rid of that hot fluid or, 'hotter' fluid. And then you have instant access. The difficulty with that, is they make drinking conducive, but they are counter in terms of forcing you to slow down. The benefit of going into your pack, pulling out the insulated thing, taking the lid off, taking a drink- now you've slowed down. You've reduced your metabolic load, whereas it's easy to reach into your camelback, and just keep digging. You get the hydration, but what you really need is adequate recovery, and to slow that metabolic heat production down.

CP: So, are there other avoidance, or protective strategies that we need to talk about or mention that are going to help

BR: I think we mentioned most of them. In the early stages of the season or the fire, just becoming in tune with your own body in terms of what your expected sweat production looks like, feels like –relative to the intensity that you're selecting. And just developing that sense of protection in that experience is super important. And to just communicate with each other. I mean, 'How does your skin temperature feel?' or 'what is your sweat rate like?' Just communicating and sharing those experiences with your crew members I think help solidify the good decisions that you're making. It helps correct the 'not-so-good' decisions, that maybe some of the inexperienced people on the crew are making and it increases that sort of crew cohesiveness around a common thing which is sweating on the line! And so, talking about it is I think, is really really productive.

CD: I think, we also mentioned acclimatization. Clearly, you know fitness is probably the ultimate protector. Brent brought up this human factor in talking about it, and even letting [other crew members] know, if you recognize symptoms of heat exhaustion. Letting your crew boss know. We recently completed a study where, in the lab, albeit mimicking wildland firefighter hiking, acclimated people. Indeed, over three days, over the course of a week, with a day off in-between. We 'heat acclimated' people, and indeed in a heat stress trial, pre-and post this acclimation period, we are capable of reducing heart rate by over 15 beats per minute at the same intensity, at the same environment, with PPE. Now I bring that up, not to try to encourage people to necessarily go exercise in a sauna before they go out on a fire line. But it brings back this earlier point about –when arriving on a fire, give yourself some time. Don't try to impress anybody with your work output in the first day, before you can adapt to that environment. Adapt to the workload, know what you're capable of in that environment. And I realize that you're working within a crew, and you're keeping up, and everybody is trying to do the same thing. But at the same time, you're going to impress somebody more, at the end of your two-week shift by not reducing, or falling apart, or having to go to the hospital, by perhaps being smart early on.

CP: So, you're saying that that acclimatization process can happen fairly quickly, you just have to be smart about how much we take on early on?

CD: By putting yourself in a hole, by trying to produce too much work too early, can be a risky situation. Again, that doesn't mean you are going to be all of a sudden able to do three times the amount of work in the second week on the fire. But, you will see less of a reduction in your workload. You know, in a race don't start out too hard –use an appropriate pacing strategy.

CP: From a treatment standpoint, what sorts of things can be done?

BR: Once a person drops, because of heat exhaustion, hopefully not heat stroke. Heat exhaustion can progress to heat stroke in minutes and you have to be super careful to shut it down before it gets to that point. But hopefully you can shut it down before it even gets to heat exhaustion. It's not like fire fighters are running around with rectal thermometers all day long, checking each other, checking themselves to make sure, 'okay I'm normal, I'm staying normal.' You have to be more in tune with your skin temperature, and with your surroundings. But once a person drops from heat exhaustion, it is imperative that treatment begins immediately. And that means, probably getting some of those extra clothing layers off, cooling down the skin temperature, creating the opportunity for a large temperature gradient between the core and the skin, and the environment. So, getting them into the shade, reducing the ambient heat pressure, and taking some of the clothing off, and cooling down at least the torso of the body will facilitate an offloading of that heat. And then getting them off the line as soon as you can. That's where your treatment as a crewmember ends, and then you hand it over to the clinical care, and the emergency services folks. They're the ones that take it to the next level. If that means aggressive cooling in a helicopter, or in an ambulance, or once they get to the hospital, but then it's in their hands at that point.

CD: The ultimate treatment, and likely what a clinician will do is cold water immersion –in ice. That's not likely possible, so doing the things Brent said –getting in the shade, cooling down. One thing that has been interestingly pointed out in the literature, there have been some pre-performance strategies in trying to cool the body temperature before the anticipated rise in temperature. One of the interesting examples in the literature has been ice vests. They'll use an ice vest to cool the core temperature before somebody is anticipating exercising in the heat. One of the dangers of that actually is centralizing of your blood volume. So, the things that Brent said are good, getting in the shade, drinking some hopefully cool fluids –not excessively, right? Because again it's not gonna rescue you. But what I'm possibly concerned with, is throwing one available ice pack under somebody's arm, is not going to rescue this person. They need to have prolonged treatment. So, what I'm referring to is, if you're trying to cool the skin with some kind of quick mechanism that is going to exhaust itself. Meaning you've got one bag of ice –I'm not saying don't use it. But if you remove the blood flow from the skin too quickly you can actually heat up the core. Because all of that blood volume goes into the core. Just like, how do you treat altitude? You get them off the altitude. How do you treat heat? You get them out of the heat. And you have got to reduce that core temperature. And we cannot speak to all of the different possible situations of what might be available in the field. It's simply, how can you get their core temperature down? Get their PPE off, if you can get them in the shade, if you can drink cold fluids –those are the treatment strategies that might be available to a crew boss.

BR: There's a really cool product that we played around with. It's a technical fabric that's saturated with a propylene glycol. By itself, when you put it on the skin it will begin to lower skin temperature, which when you do that it creates the potential for a big gradient, where you can start offloading heat. But if it's anything like water, if you put a cold rag on the skin, or a cold towel on the skin, after the skin temperature heats up that water which is very effective at insulation. Then it becomes an insulator. So, you can't just put a cold sheet on and hope for the best, and leave it on there for longer than a minute. With the project that we did, we had to strip those sheets off every minute and then add a new one, and then add a new one. Then we recycled those sheets in a small amount of ice water, and we could effectively offload heat of those individuals and bring their core temperature down very quickly. Much

quicker than we thought we could, probably not as quickly as cold water immersion. But, kiddie pools and ice water is not often readily available on the fire line. This product, in a rig or on a rig or a helicopter might be good simple aid to assist in that initial treatment. Fire fighters are fire fighters. Their second skill set might be emergency care, but that's not their primary skillset. They're not in the business of search and rescue, and evacuation. They're in the business of fire suppression. And so, making those decisions so that those injuries don't happen is of primary concern.

CD: So, I think something that's interesting that pops out from the literature that was kind of half-heartedly mentioned earlier by me was, it depends where you start. We've had people show up in the lab, colder than other people, or hotter than other people. So, your rate of rise of core temperature is going to be the rate of rise. So, how quickly you get to a high core temperature might depend on where you started. So, if you start with a high core temperature, you're putting yourself at risk of reaching too high of a core temperature too early. So how this applies to the wildland firefighter? Basically, avoid getting hot early. So being overdressed in camp, on your way to going up to the trucks to get taken out to the line. Avoid getting hot, and starting with a hot core temperature when you have to put on your PPE and head out to the line.

BR: We mentioned the protection of fitness, we mentioned the protection of work to rest ratio. Those two are critical. Those are like upper echelon important. Then we mentioned hydration. That's farther down, in your priorities in protecting yourself. But one thing we haven't mentioned, Chuck touched on this, if you start with a higher core temperature you've got less room to go before you hit that red zone, or that troublesome zone. If you've had a recent infection or sickness, then that predisposes you to risk. So, if you are just getting over a bad cold or an upper respiratory tract infection. You're at an elevated risk, no matter if your hydration practices are aggressive or adequate. No matter if your fitness levels are adequate. Having that elevated core temperature due to an infection or sickness, you're at risk. So, you have to slow down in the days that either you're having that, or dealing with that, or recovering from that. That's really important.

CP: We know that those upper respiratory tract infections are very, very common. Especially when you start getting into the large camp situations and that sort of thing.

CD: Something we need to mention here is that, some of the deaths. And this goes back to some of the wrestlers that died in the 90s, which resulted in a whole bunch of NCAA regulations. And a bunch of football players, you know -Cory Stringer- dying, in the heat. And causing heat related injuries. They were linked to dietary supplements. And we haven't talked about that yet. That's something that's found in the fire camp as well. The big concern is with what we call 'sympathomimetics', which are ones that stimulate the central nervous system. A lot of people think, Caffeine. But that's some of the most innocuous of all of them. There's things out there like in 'Craze' called DMAA that are sort of weight loss supplements. And I know that the military has problems with these, with recruits. People trying to lose weight quickly during basic training. They'll have people taking these weight loss supplements. Things like hydroxycut, ephedra, DMAA. Those, by stimulating the Central Nervous System can cause a redirection of blood flow that promotes elevated core temperatures, and stimulating resting metabolic rates. Which again, adds to that centralized core temperature, that we've been referring to. And can predispose a person for the risk. If you're taking a weight loss supplement, you might be overweight. They also, are more at risk perhaps, for developing high core temperatures by an inability to dissipate that heat. Now,

I'm not trying to take away somebody's early morning coffee, [laughs] we're not going to try to do that. But when taking these doses of dietary supplements in order to cut weight when exercising in the heat is a recipe for disaster.

CP: So, my Red Bull breakfast is still okay?

CD: [laughs] Only when taken with frosted flakes. Red Bulls in moderation might not be the biggest risk. But certainly, in excess can keep somebody alert. Athletes use this all the time as a stimulant. You're tired, you're fatigued – 'I need a pick me up'. But at high doses and a little bit of excess, is when that might be a problem.

BR: Red Bull is not going to give your Pulaski wings. [laughs] But it might facilitate –any product for that matter, like that or caffeinated gum, whatever –I mean 4:20 on the fire line is way different than 4:20 in Seattle are...

CP: That is very true [laughs].

BR: ...Shit can hit the fan quickly in terms of fire behaviour, and so having a little bit added vigilance is gonna be a good thing in terms of making decisions.

CP: Closing thoughts? What do we need to throw out there to wrap all this up?

BR: I think the importance of coming to the season with realistic expectations in reference to how hard you can work safely and avoid the run-away core temperature. Fitness, we've said this over and over but we're never going to stop saying it, that is your biggest ally. That is so much more in your corner in terms of providing protection, than trendy obsessive conversation about hydration.

CD: I think we covered a lot [laughs]. I think one of the things that can't be undermined is self-recognition. Knowing what you're capable of, when you're putting yourself at risk, seeing it in your buddies. 'Hey dude, you're working too hard! Slow down. You're going to put yourself in jeopardy, and by putting yourself in jeopardy you put our crew in jeopardy'. So, that human part of it all. Understanding that you're out there and you're at risk –is a safety issue, not just from the literal fire but from the internal metabolic fire, that could put you at a heat injury risk.

BR: Yeah, check in your ego at the crew rig. If you're gonna have an ego on the fire line, have an ego that is related to your ability to recognize good decisions and make good decisions. Not digging, digging, digging as fast as you can. Making good decisions and recognizing the risks in yourself, and in your coworkers –those sort of skill sets are the ones you need to take pride in.

CP: Doctors Dumke, Ruby. Thanks for your time!

BR: Right on.

CP: We'll see you next time, on the line.

You've been listening to 'On the Line', a podcast for today's wildland firefighter. Our audio engineer is Mike Mathews, our production assistant Joey Moore, and I'm your host, Charlie

Palmer. Thanks for listening. We hope you connect with you again in the future, 'On the Line'.