Scenario Overview

The heat stroke scenario simulates the body's temperature regulation system. This scenario highlights the ability of the Pulse physiology engine to simulate the energy exchange between the human body and the enviroment.

Base Physiology	Insults and injuries	Assessments	Interventions
A 25 year old physically fit male.	Strenuous activity combined with over dressing leads to heat stroke.	Core Temperature Sweat Rate Heart Rate Complete Blood Count Metabolic Panel?	Active Cooling IV Fluids

Scenario Narrative

Segment 0	Engine initialization period.
Segment 1	A 25 year old male is hiking to a rock formation near Fort Carson to begin a recreational free climb. It is a chilly morning, and the man has decided to wear a thick jacket, heavy pants, and thick socks. The terrain is steep and the man is excited to begin his climb. The man's rate of perceived exertion is 13 on the Borg scale (0.5 on a 0-1 scale) during the hike to the rock formation. It takes him about 20 minutes to hike to the rock formation.
Segment 2	The hiker takes a moment to rest.
Segment 2	When the man arrives at the rock formation, he is so excited that he begins climbing without removing any clothing. He climbs at an intensity of 18 on the Borg scale (0.857 on a 0-1 scale). It takes him about 5 minutes to climb to the top of the rock formation. At the top of the rock formation the man becomes dizzy and sits down. A hiker at the top of the formation notices the man and offers assistance. The man explains that he had not had very much to eat or drink that morning and he thinks he may have overexerted himself during the climb. Then the climber passes out.
Segment 3	The bystander, an off-duty medic stationed at Fort Carson, recognizes that something is wrong and takes action. First, the bystander removes some of the man's clothing. Being a well-prepared medic, the hiker has a small first responder kit with her. She measures the man's core temperature, and the resultant abnormally high temperture coupled with the loss of consciousness suggests that the climber is suffering from heat stroke. She begins active cooling using some instant cold packs from the kit, starts an IV of isotonic saline, and calls for help.
Segment 4	The off-duty medic calls for help. An ambulance arrives to transport the man to Evans Army Community Hospital. During transport, the man's core temperature begins to decrease toward normal. Upon arrival at the hospital, the ER physician orders a comprehensive metabolic panel.

References

Publications:

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3	Bouchama, Abderrezak, and James P. Knochel. "Heat Stroke." New England Journal of Medicine (Mass Medical Soc) 346, no. 25 (2002): 1978 - 1988.
4	Brutsaert, Tom D. et al. “Higher Arterial Oxygen Saturation during Submaximal Exercise in Bolivian Aymara Compared to European Sojourners and Europeans Born and Raised at High Altitude.” American journal of physical anthropology 113.2 (2000): 169–181. Print.
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6	O’Donnell, Thomas F. “The Hemodynamic and Metabolic Alterations Asociated with Acute Heat Stress Injury in Marathon Runners.” Annals of the New York Academy of Sciences 301.1 (1977): 262–269. Print.
7	Pickering, Thomas G., Gregory A. Harshfield, Hollis D. Kleinert, Seymour Blank, and John H. Laragh. "Blood Pressure During Normal Daily Activities, Sleep, and Exercise: Comparison of values in Normal and Hypertensive Subjects." (Journal of the American Medical Association) 247, no. 7 (1982).
8	Universtiy of California San Fransico Medical Center, www.ucsfhealt.org/tests/003468.html

SMEs:

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Key

	Good Agreement with data/trends
	Agreement with most trends, some deviations from validation data/trends
	Some major disagreements with validation data/trends

Heat Stroke Breakdown

Segment Number	Start Time (s)	Segment Duration (s)	Event (to begin segment)	Notes (End Segment Expected Physiology to right)	HeartRate (BPM)	Engine HeartRate (BPM)	HeartStrokeVolume (mL/Beat)	Engine HeartStrokeVolume (mL/Beat)	BloodVolume (mL)	Engine BloodVolume (mL)	MeanArterialPressure (mmHg)	Engine MeanArterialPressure (mmHg)	SystolicArterialPressure (mmHg)	Engine SystolicArterialPressure (mmHg)	DiastolicArterialPressure (mmHg)	Engine DiastolicArterialPressure (mmHg)	CardiacOutput (mL/min)	Engine CardiacOutput (mL/min)	RespirationRate (Breaths/min)	Engine RespirationRate (Breaths/min)	OxygenSaturation (fraction)	Engine OxygenSaturation (fraction)
0	0	60	**Initialization** (Advance time 1 minute)	Standard initialization buffer for scenarios.	72	72	85.6	78	5500	5940	92	95	120	114	79	73	5600	5729	12 - 20	16	Decreased [1] < 90 [4] Decreased, rising to a new lower normal with acclimation [52]	0.89
1	60	1200	**Hike** (Hiking at exercise intensity 0.1)	At the end of this segment patient has been exercising heavily for 20 minutes in bulky clothing at an ambient temperature of 16 to 20C	> 80 [51]	177	Increase [51]	40	No change [51]	5685	Increase [7]	99	Increase < 34.4% above resting (168) [5] < 28.8% above resting (161) [7]	110	No significant change (80) [5], (80) [7]	86	Increase [51]	6635	increase [35, 36, 39]	19	Decreasing [4]	0.75
2	1260	60	**Rest**		Decrease [51]	177	Some recovery [51]	42	No change [51]	5685	Some recovery [51]	98	Some recovery [51]	110	Some recovery [51]	80	Some recovery [51]	6328	Some recovery [51]	19	Some recovery [51]	0.75
3	1320	600	**Climb** (Climbing at exercise intensity 0.45)	At the end of this segment, in addition to the exercise from the last 20 minutes, the hiker has exercised an additional 10 minutes at an extremely hard intensity while wearing bulky clothing in ambient temperature of 23C (stepped increase during hike). The climber has heat stroke at the end of this segment.	> 120 [51] 120 - 180 [7]	200	121.9 [6] 101 - 121 [5]	35	No change [51]	5300	Increasing [7] then decreasing with heat stroke [6]	101	Increase toward max exertion values 34.4% above resting (168) [5] 28.8% above resting (161) [7]	114	No significant change (80) [5], (80) [7]	87	Increase leading to decrease with heat stroke [51 given reference data on stroke volume and blood pressure]	7570	increase [35, 36, 39]	21	Decreasing [4]	0.72
4	1920	90	**Bystander Actions** (Move to cooler environment, remove clothing, apply cold pack, and start IV fluids)	During this segment the patient's clothing is removed. IV saline is administered and active cooling begun.	Decreasing (to baseline over 12 hours) [6]	185	Decreasing (to baseline over 12 hours) [6]	40	No change [51]	5300	Decrease [6]	99	< 120 [3]	111	No significant change (80) [5], (80) [7] Possible slight decrease [3], [2]	83	Decrease [51 given reference data on stroke volume and blood pressure]	6747	Decrease [37, 39]	20	Increase [51]	0.69
5	2010	600	**Transportation**	During this segment the patient is transported to a medical treatment facility.	Decreasing (to baseline over 12 hours) [6]	140	Decreasing (to baseline over 12 hours) [6]	46	Increase with IV [51]	6190	Decrease [6]	96	< 120 [3]	112	No significant change (80) [5], (80) [7] Possible slight decrease [3], [2]	74	Decrease [51 given reference data on stroke volume and blood pressure]	6037	Decrease [37, 39]	16	Increase [51]	0.86
End	2610		End Scenario																			

Heat Stroke Breakdown

CoreTemperature (C)	Engine CoreTemperature (C)	SkinTemperature (C)	Engine SkinTemperature (C)	SweatRate (mL/s)	Engine SweatRate (mL/s)	Blood Panel AlbuminConcentration (g/dL)	Blood Panel AlbuminConcentration (g/dL)	Blood Panel BUN (mg/dL)	Blood Panel BUN (mg/dL)	Blood Panel CalciumConcentration (mg/dL)	Blood Panel CalciumConcentration (mg/dL)	Blood Panel BicarbonateConcentation (mmol/L)	Blood Panel BicarbonateConcentation (mmol/L)	Blood Panel CreatinineConcentration (mg/dL)	Blood Panel CreatinineConcentration (mg/dL)	Blood Panel GlucoseConcentration (mg/dL)	Blood Panel GlucoseConcentration (mg/dL)	Blood Panel SodiumConcentration (mEq/L)	Blood Panel SodiumConcentration (mEq/L)
37	37	< Core [2]	33	0 [2]	0	3.9 to 5.0 [8]		7 to 20 [8]		8.5 to 10.9 [8]		20 to 29 [8] Acutely decreased due to hyperventialtion [52]		1.4 [8]		128 [8]		136 to 144 [8] Acutely decreased [52]	
Increase [51]	37.5	< Core [2]	32.8	Depends on core temperature. Use direct calculation or [2] For direct calc = 2.3045e-5*(core-37.1) NOTE this may be low [2]	0.05	Acutely, moderate increase [52]		No change [52]		No change [52]		Decreased due to hyperventialation [52]		No Change [52]		Acutely increased [52]		No Change [52]	
No change [51]	37.6	< Core [2]	32.8	No change [51]	0.05														
>40 degC [3]	38.3	< Core [2]	32.8	Depends on core temperature. Use direct calculation or [2] For direct calc = 2.3045e-5*(core-37.1) NOTE this may be low [2]	0.11	Acutely, moderate increase [52]		No change [52]		No change [52]		Decreased due to hyperventialation [52]		No Change [52]		Acutely increased [52]		No Change [52]	
Decreasing with treatment [51]	38.3	< Core [2]	30	Depends on core temperature. Use direct calculation or [2] For direct calc = 2.3045e-5*(core-37.1) NOTE this may be low [2]	0.11	Decreased [52]		Elevated [52]		Hypocalcemia secondary to increased calcium binding in damaged muscle [52]		Decreased [52]		Elevated [52]		Decreased [52]		Decreased [52]	
Decreasing with treatment [51]	38.1	< Core [2]	24.4	Depends on core temperature. Use direct calculation or [2] For direct calc = 2.3045e-5*(core-37.1) NOTE this may be low [2]	0.1	Decreased [52]	3.51	Elevated [52]	13.82	Hypocalcemia secondary to increased calcium binding in damaged muscle [52]	4.87	Decreased [52]	26.14	Elevated [52]	0.95	Decreased [52]	47.94	Decreased [52]	145