

MINES **RESCUE** **SERVICES** South Africa

HEAT - OUR RESCUERS' HIGHEST RISK

How can technology assist?

Mannas Fourie

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Challenges and Risks associated with Heat

So, what are the challenges?

How to accurately do a measurement of the core body temperature of Rescuers whilst busy working?

➤ **Point of Measurement**

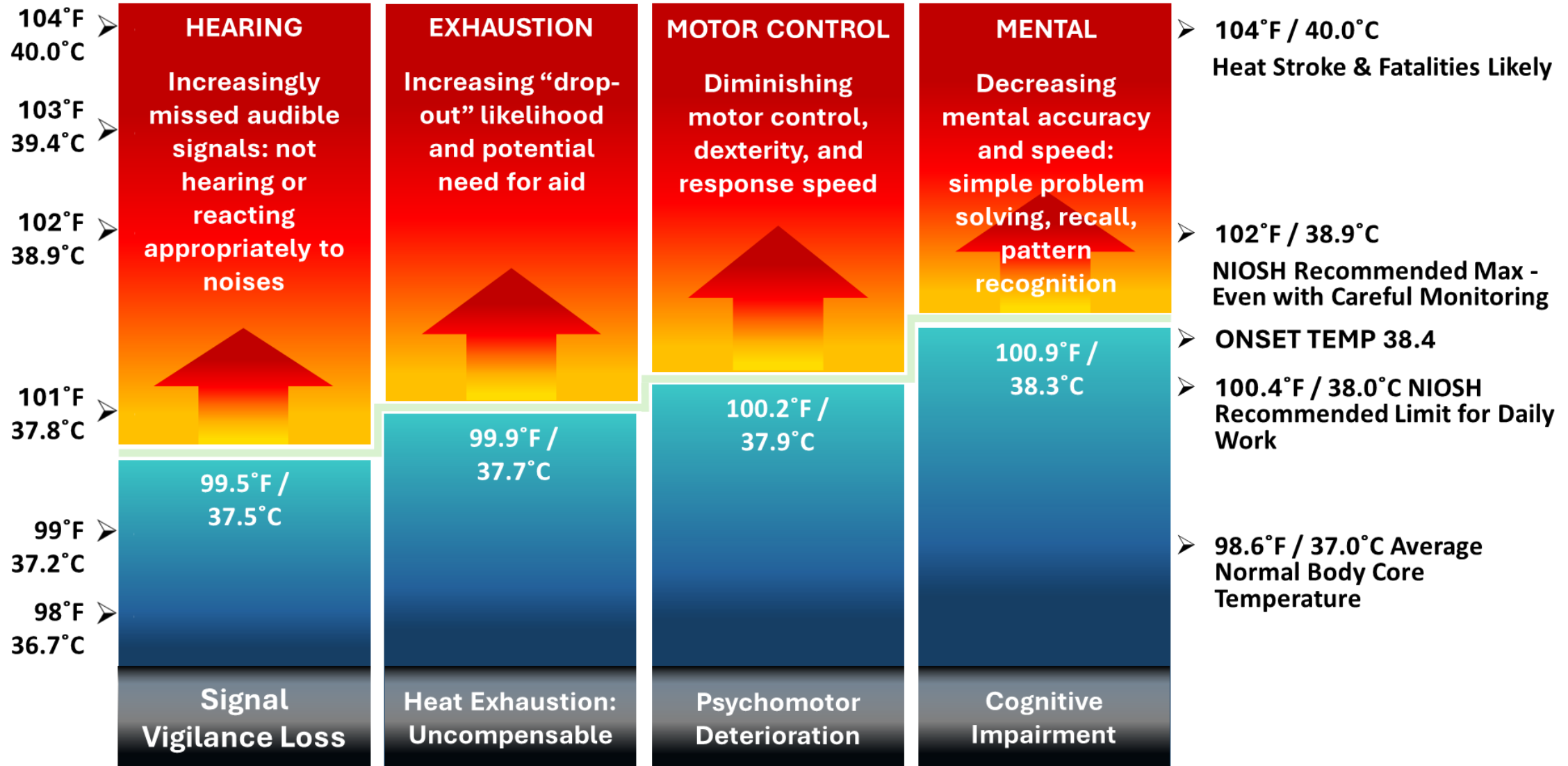
- Rectal
- Temple
- Sternum

➤ **Possible Methodology**

- Thermometer
- Body Patches
- Hard Hat
- Pill Swallowed
- Body sensor
- Watch

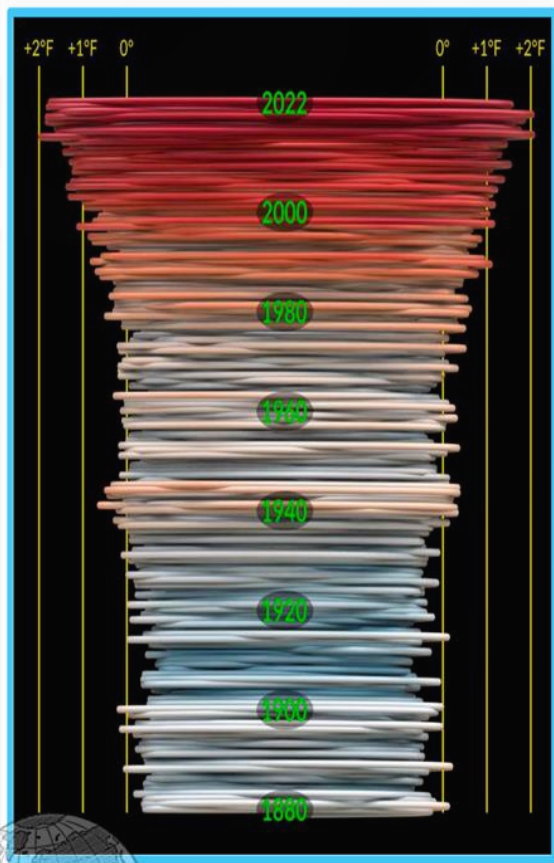


Effects of Rising Body Core Temperatures



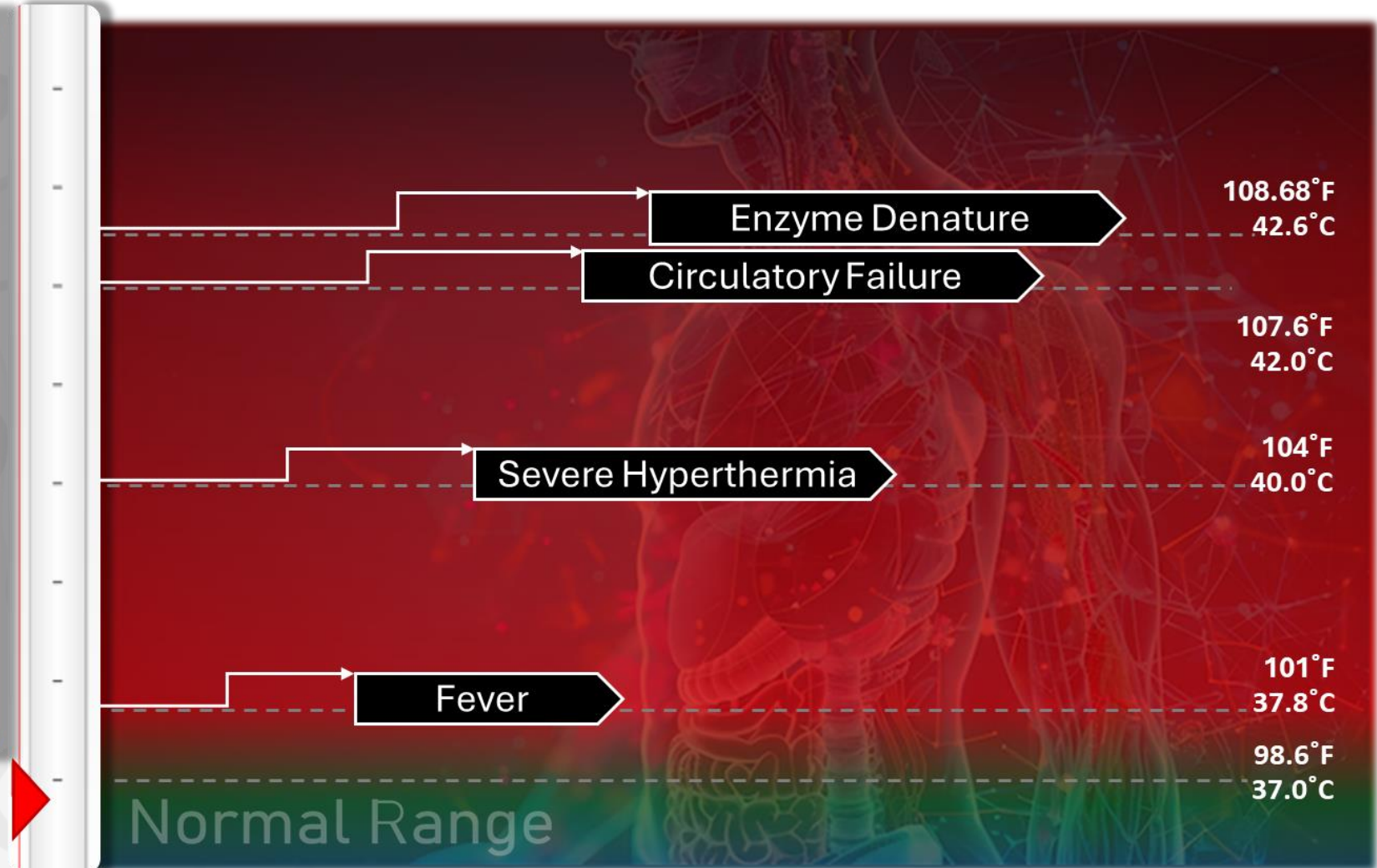
Symptoms intensify in occurrence and severity as the body core temperature rises

Interaction between physical and biochemical processes in cells, tissues and organs



WORLD WARMING:

Schmidt, Thews Physiologie des Menschen (2000)



Contributing Risks

Environmental Heat

An abnormally hot environment means any environment with a dry bulb temperature (DB) $\geq 37.0^{\circ}\text{C}$, globe temperature (GT) $\geq 37.0^{\circ}\text{C}$, wet bulb temperature (WB) $\geq 32.5^{\circ}\text{C}$, or wet bulb globe temperature (WBGT) index ≥ 34

VIRGIN ROCK TEMPERATURE [approximate]					
	Rock Start Temp $^{\circ}\text{C}$	Gradient $^{\circ}\text{C}/\text{m}$	900,0	m	= Depth in m
VRT = Gauteng	16,0	0,0105	25,5	$^{\circ}\text{C}$	
VRT = Free State	20,0	0,0146	33,1	$^{\circ}\text{C}$	
VRT = Klerksdorp	22,0	0,0105	31,5	$^{\circ}\text{C}$	
VRT = Phalaborwa	27,0	0,0186	43,7	$^{\circ}\text{C}$	
VRT = Amandelbult / Rtb	23,9	0,0192	41,2	$^{\circ}\text{C}$	
VRT =			0,0	$^{\circ}\text{C}$	
VRT =			0,0	$^{\circ}\text{C}$	
VRT =			0,0	$^{\circ}\text{C}$	

VIRGIN ROCK TEMPERATURE (Calc with Geothermal gradient Data)		
Geothermal gradient (Eg.: 0.0113)	0,0180 $^{\circ}\text{C}/\text{m}$	Enter
Geothermal Surface temp	25,3 $^{\circ}\text{C}$	Enter
DEPTH IN METERS	460,0 m	Enter
VRT =	33,6 $^{\circ}\text{C}$	

VRT = $N27 + (N26 * \text{depth})$
 VRT of 40degrees - requires fridge plant - but dependant on ventilation
 unventilated area with vrt of 30degrees -the air will take on temp of rock
 ventilation regulates temperature if vrt under 30deg

CALCULATION OF VRT = GEOTHERMAL SURFACE TEMP + (GEOTHERMAL GRADIENT X DEPTH)

- * VRT of 40 degrees requires a fridge plant, dependent on ventilation
- * In an unventilated area with VRT of 30 degrees, the air will take on the temperature of the rock
- * Ventilation regulates temperature if the VRT is under 30 degrees

Environmental Heat

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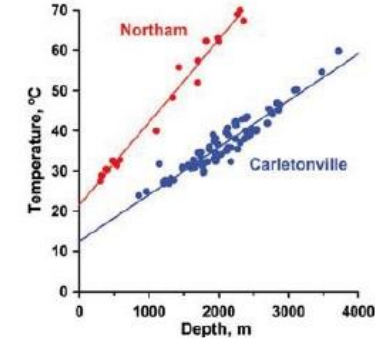
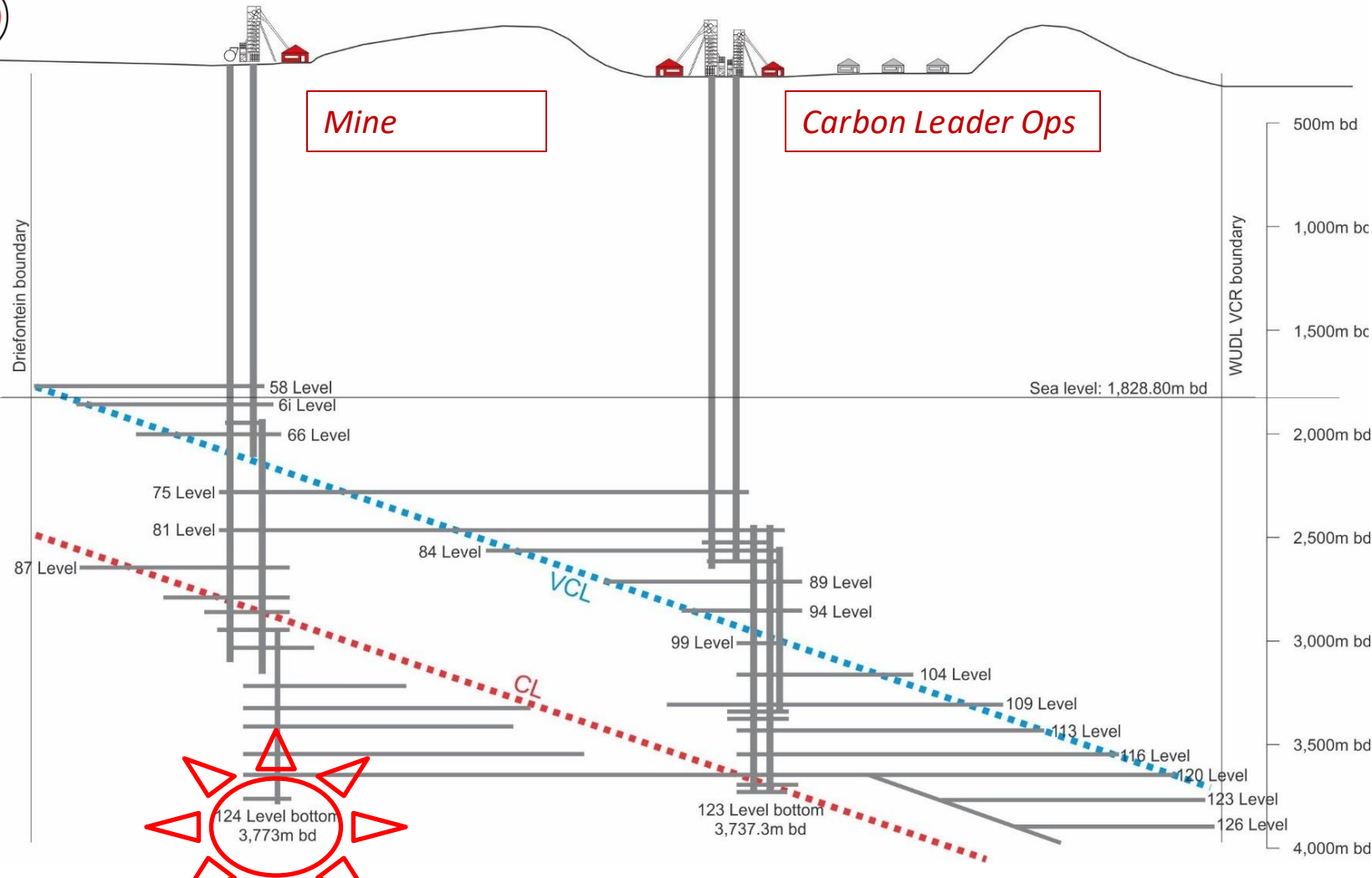
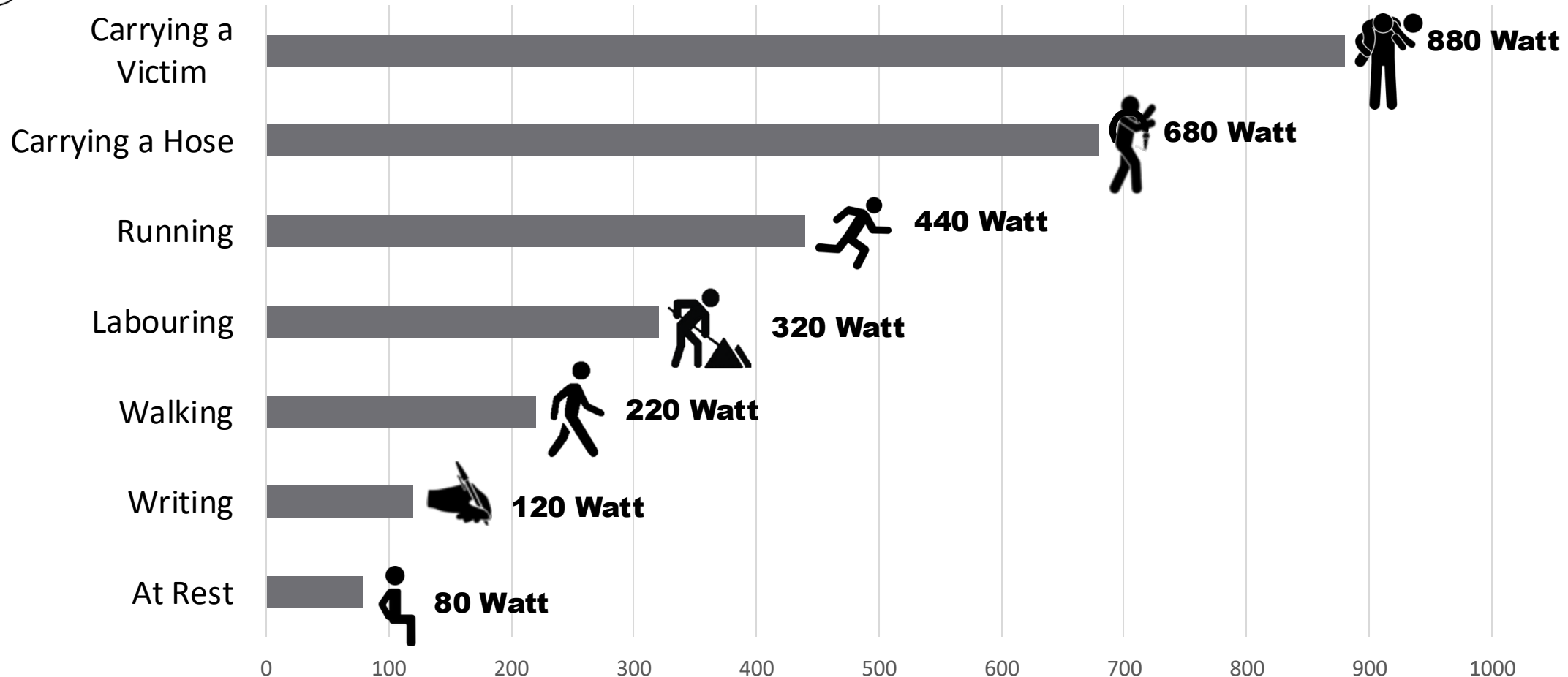


Figure 6—Bottom-hole temperature data from boreholes north and northeast of Northam in the Bushveld Complex, and virgin rock temperature data from the Carletonville area (after Jones, 2003a) in the Witwatersrand Basin. The least-squares regression line for the Northam data is $T=21.6+20.5x$, and for the Carletonville area $T=12.5+11.7x$

61,6°C at 3 773m

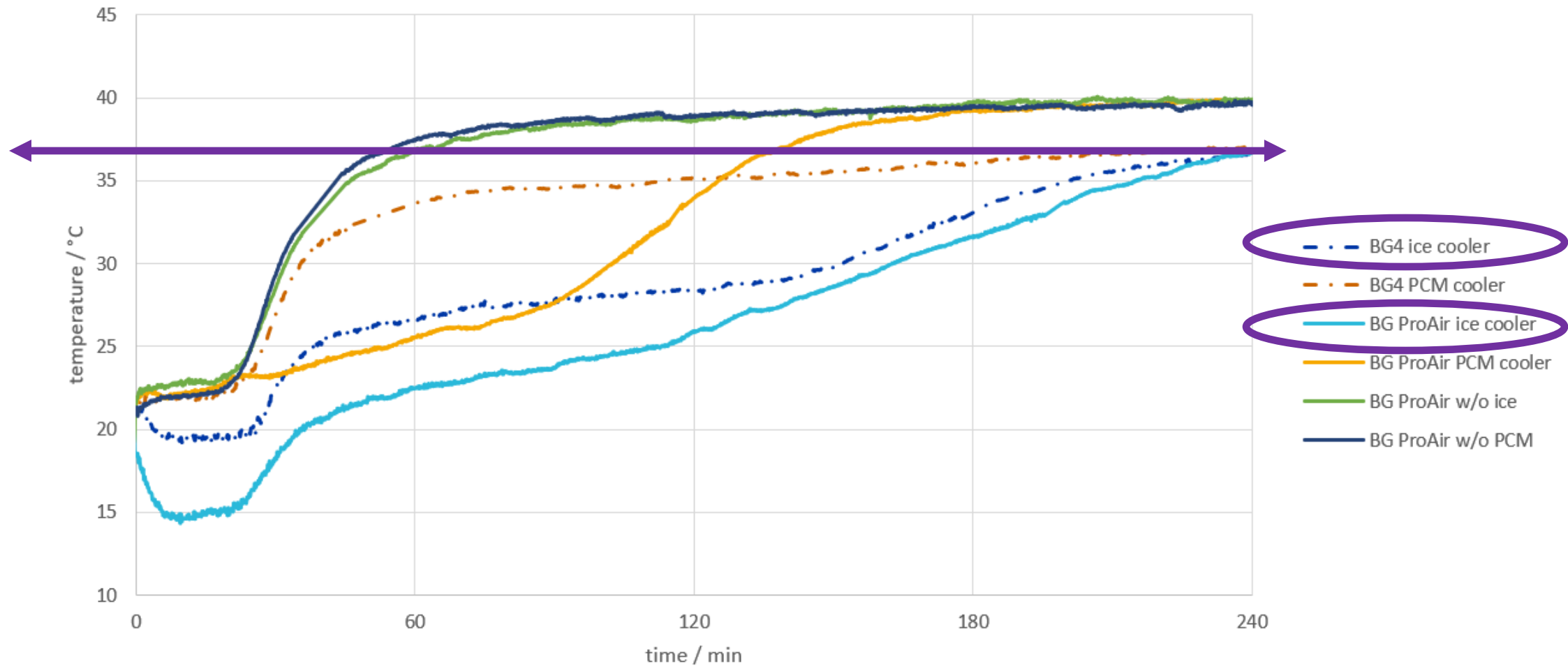
Natural Heat & Heat behaviour

Heat stress refers to the total heat-related load on the individual from all natural and man-made sources. If this heat load is not reduced or eliminated, workers can suffer from mild to dangerous heat-related disorders and illnesses.



LDBA Set - additional Heat

Mines Rescue Scenario (30 L/min at 21°C) → EN 145



Preventative Measures

Heat Tolerance Testing

Wet Bulb: 31.7°C

Dry Bulb: 33.2°C

80% humidity

0.4 m/sec velocity

24 bench steps per minute

54 Watts Work rates

Preventative Measures



EMERGENCY HEAT STRESS INDEX CHART (EHSI)

1. Take Wet Bulb Temperature = 35,4°C
*Round up = 36 °C
2. Take Dry Bulb Temperature = 37,6 °C
*Round up 38 °C
3. Add both Results and take Average
* i.e. 36 °C + 38 °C = 74 °C
*Average = 37 °C EHSI
4. Determine the Maximum Tolerance Time (Min) on the Chart

RESULT:

1. No Cooling Garment = 25 min
2. With Cooling Garment = 55 min

Note: Recommended Limits are based on experimentally determined limits in the interest of convenience to cater for moderate and strenuous work

INDEX CHART:

For Rescue Team Members Performing Strenuous Work During Emergencies

EHSI °C	Maximum Tolerance Time (min)	
	Without Cooling	With Cooling
28-29,9	No Limit	Not Applicable
30	230	Not Applicable
31	180	210
32	140	170
33	110	140
34	85	114
35	60	90
36	40	70
37	25	55
38	No Work Without a Body Cooling Garment	30
39		30
40		25
41		24
42		23
43		21
44		20
45		Risk Assess

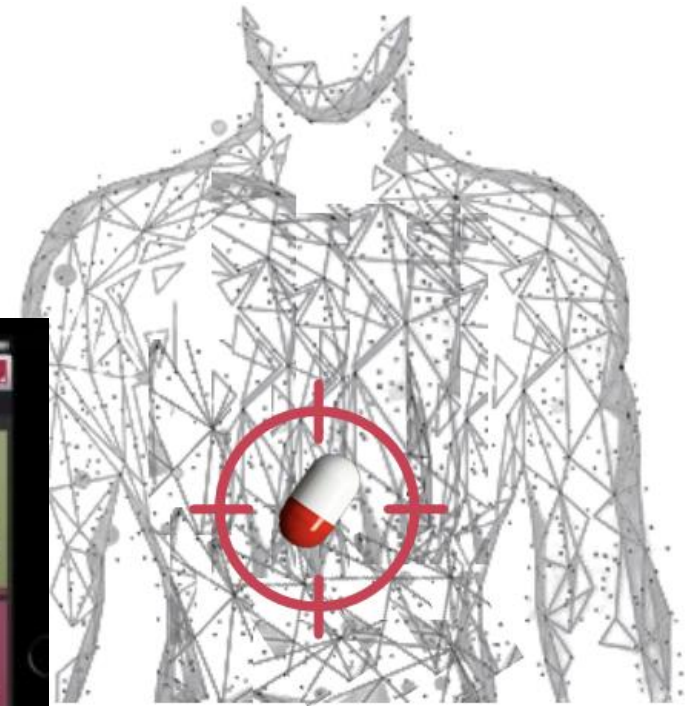
≥45°C Consider mitigating factors / Risk Assess the situation with reference to the tolerance times for various EHSI levels

Technology

Voluntate

Servicio

Devices



Study on mine rescuers during HTT

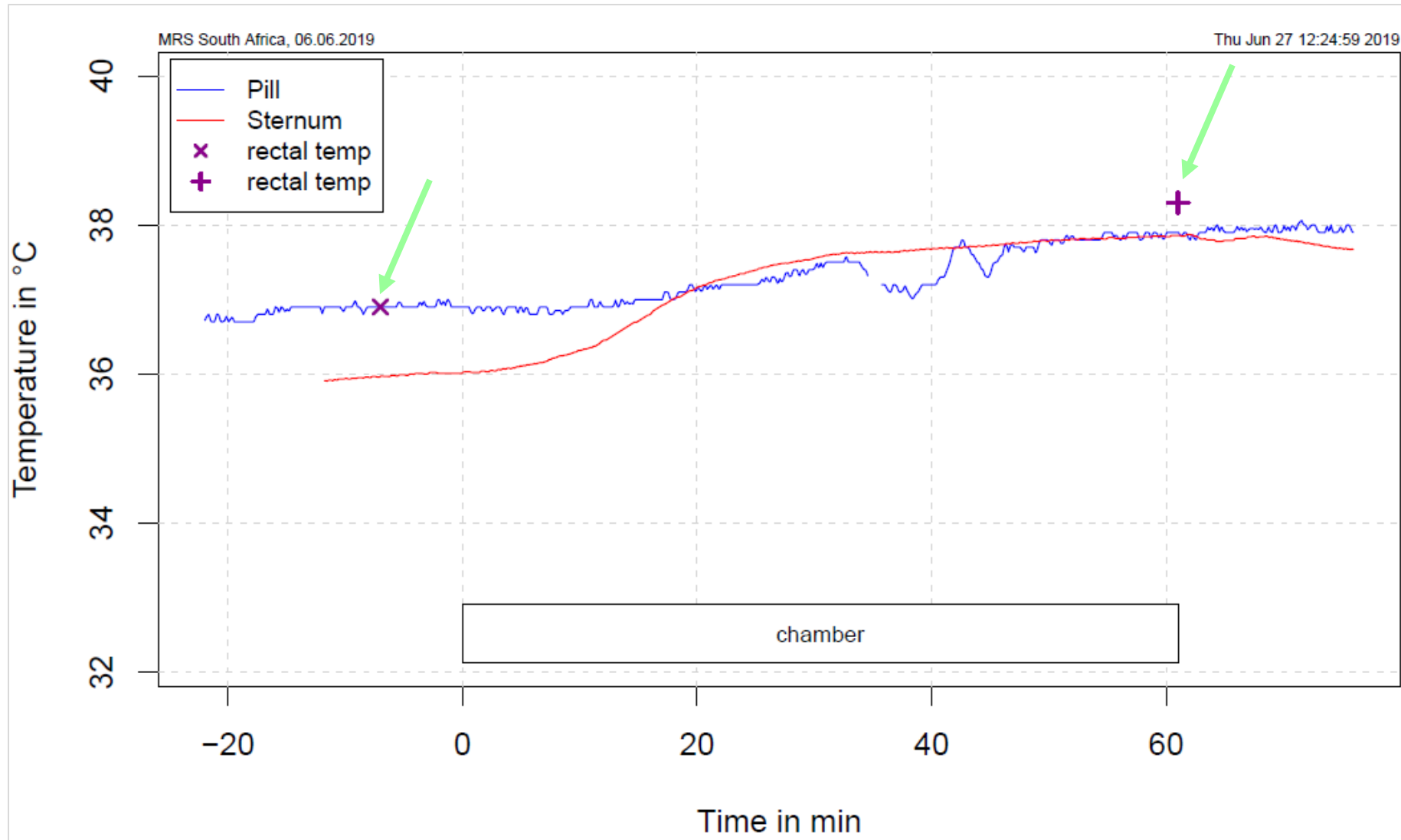


10 Mines Rescuers was tested and monitored during HTT, with controlled ambient conditions using the sternum core body measurement of the Double Sensor with comparison to the rectal temperature and pill

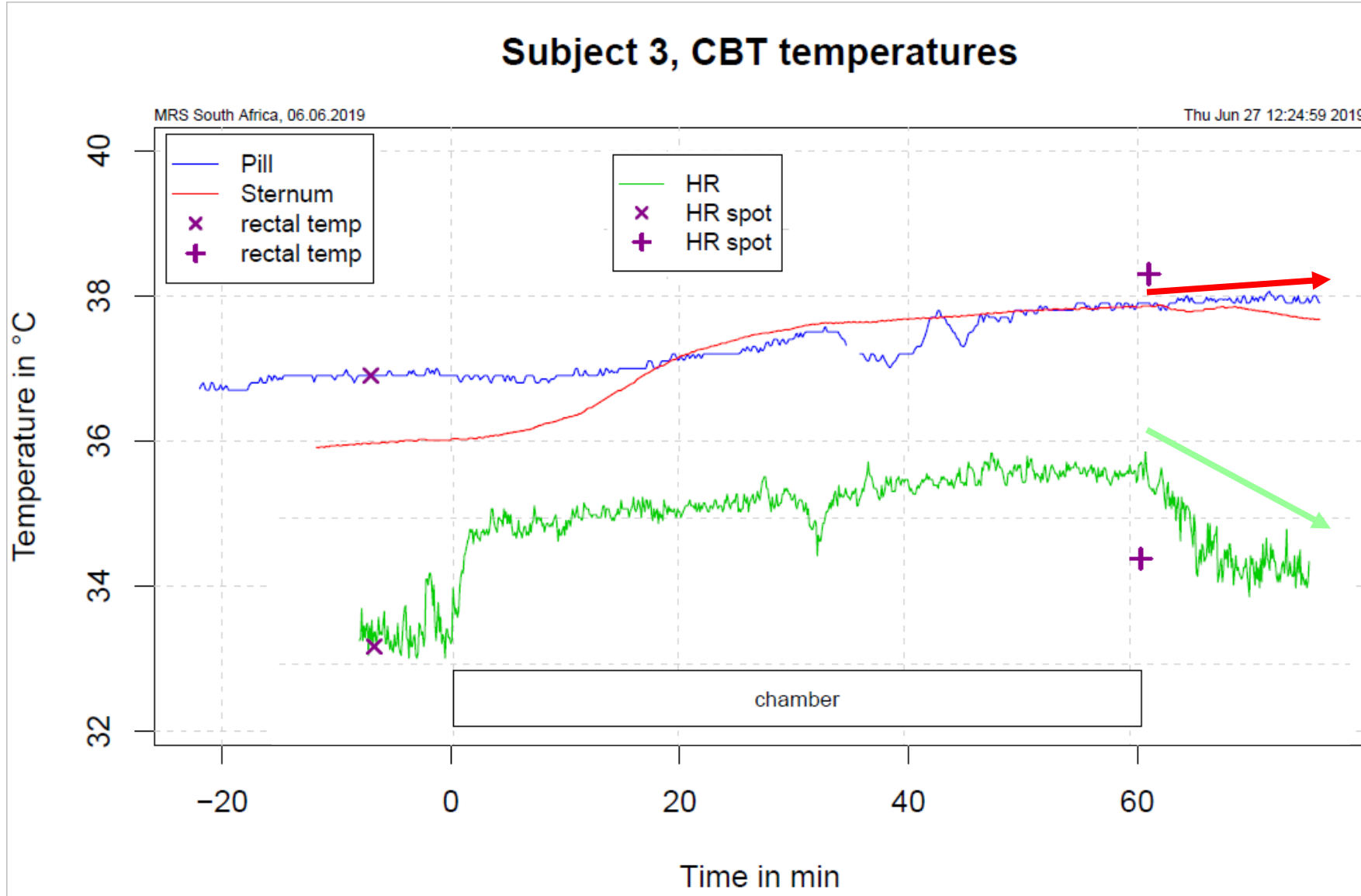


Study on mine rescuers during HTT

Comparison - the **Sternum Double Sensor** | the **Rectal Thermometer** | the **Pill** being swallowed



Study on mine rescuers during HTT



Comparison between 3 devices:

- the sternum double sensor,
- the rectal thermometer
- and the pill being swallowed



Vigilife - Garmin Core Body Temperature Testing

- ✓ Vigilife App vs **Rectal Temp** vs **Oral Temp** and **Polar Chest strap**
- ✓ App Based to an iPad
- ✓ And also on the Watch Displayed
- ✓ 5 Candidates Tested per day for 3 months

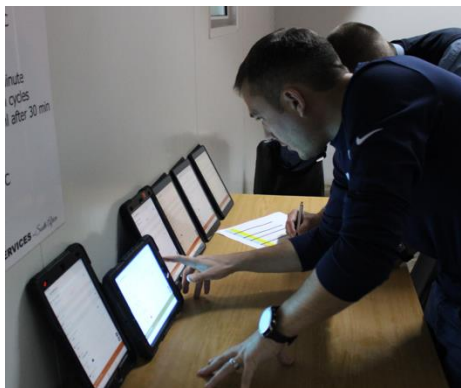


Heat Tolerance Testing



Testing was conducted over **3 months**
Heat Tolerance
Testing sessions

This is the **largest recorded sample testing of rectal temperature**
readings to draw comparison for algorithm and sensor accuracy



Heart Rate Graphs

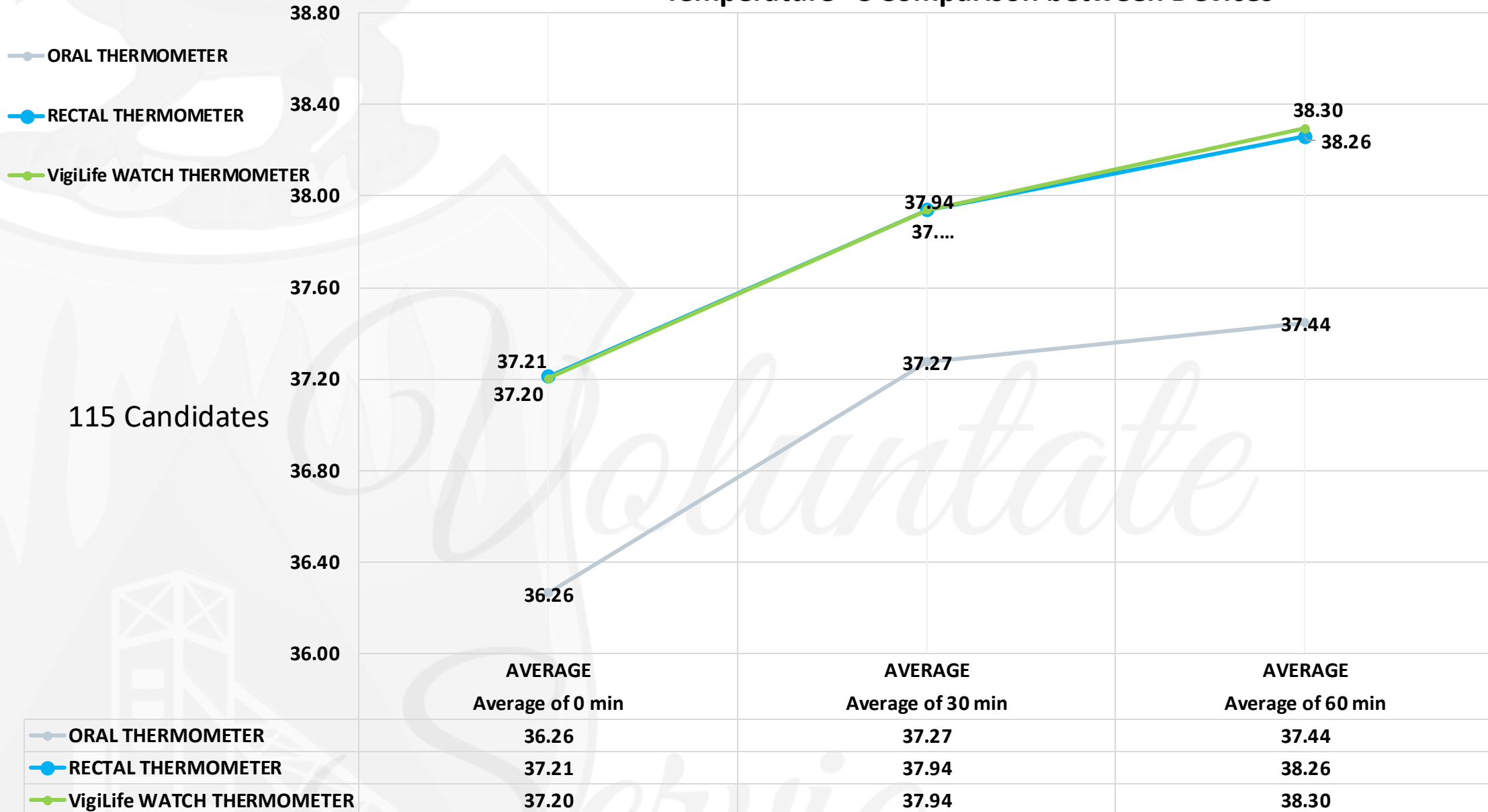
Heart Rate Comparison between Devices

115 Candidates



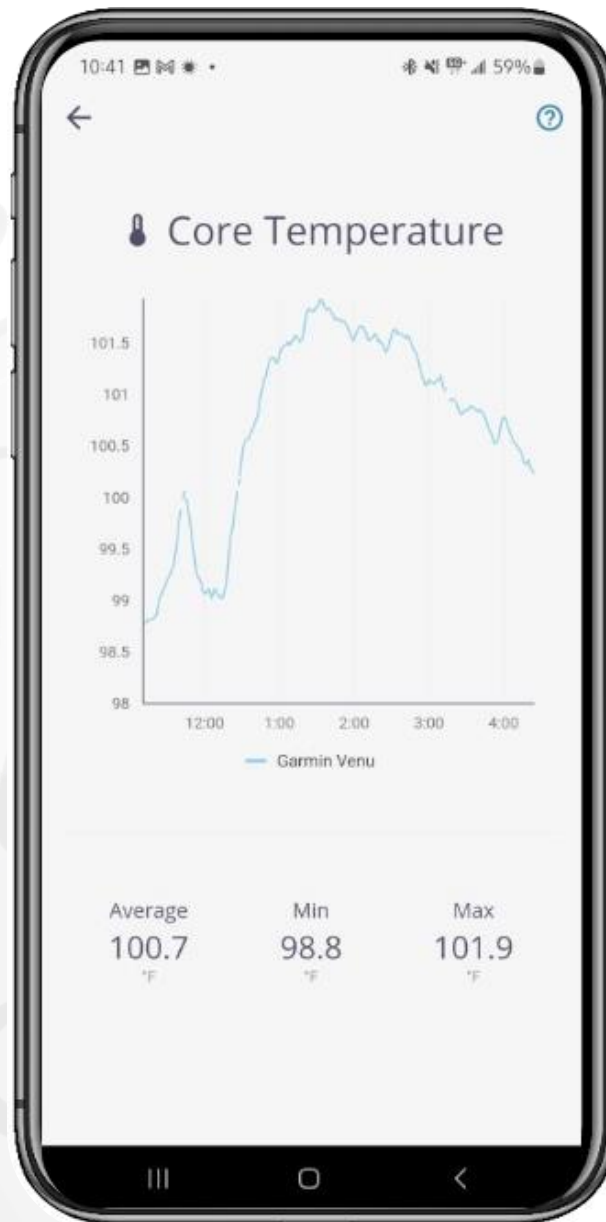
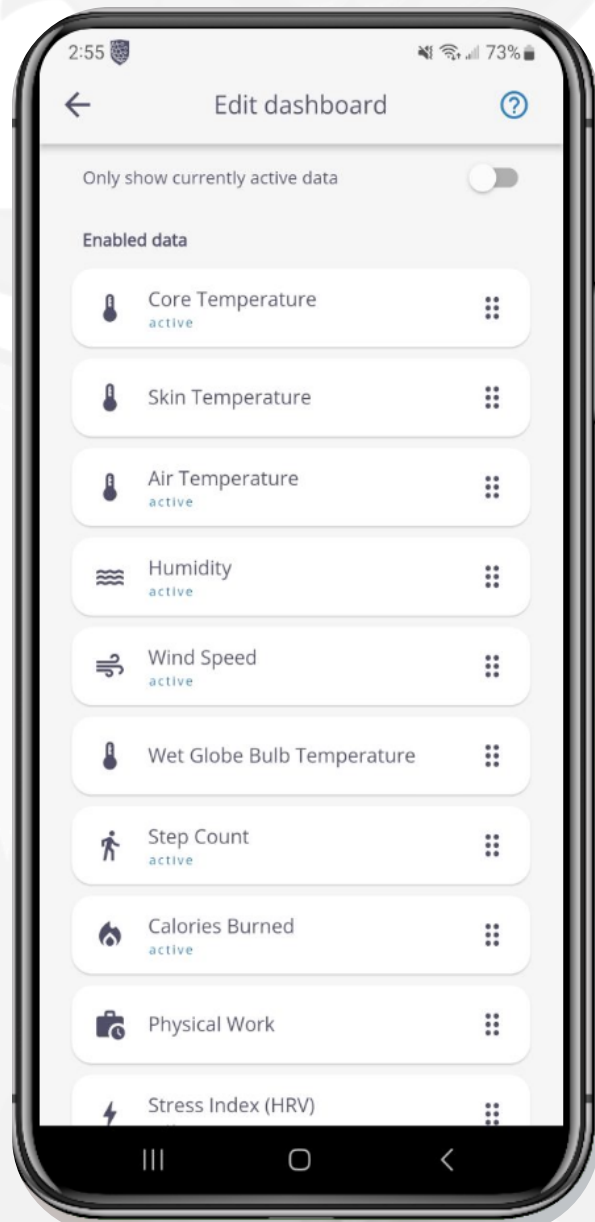
Temperature Graphs

Temperature °C Comparison between Devices



Factors	0 Minutes	30 Minutes	60 Minutes	Number
Candidates	115	115	115	115
Rectal Temp	37,21	0	38,26	
Vigilife app Temp	37,20	37,94	38,30	
App Comparison	99,982%		100,108%	
Oral Temp	36	37,27	37,44	
Oral Comparison	97,450%		97,873%	
1 °C out on rectal	1		1	Number
0,5°C out on rectal	13		27	Number
% out on 0,5%	(11%)		(23%)	
Ave Age				38
Ave Weight				89,3
Ave BMI				28,7
Ave Height				176,3
Ave HR Polar Ave	91		134	
HR Garmin Ave	86		134	

Data Available



Next Step Going Forward

- Underground testing
- Interconnected with the Breathing Apparatus
- Possibility to relay through Rescuer communication system – live feed
- New technology Mines could relay to Surface Control room center
- Cloud Base Data storage and rescuer History

Possible Stumble Blocks

- Costs and affordability
- Possible Legislation in various Jurisdictions

Questions?

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t: +27 18 781 1141 | m: +27 82 555 5911

w: www.minesrescue.co.za



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