The Role of Heat Tolerance Testing in Recovery and Return to Duty

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Report Documentation Page

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Heat balance

Exercise

↓

Heat production

↓

Heat gain → Hyperthermia

↓

Heat stroke

Heat dissipation:
Convection
Evaporation

Heat stroke

Preexisting susceptibility

Heat intolerance ?

Temporary (weeks/years?)

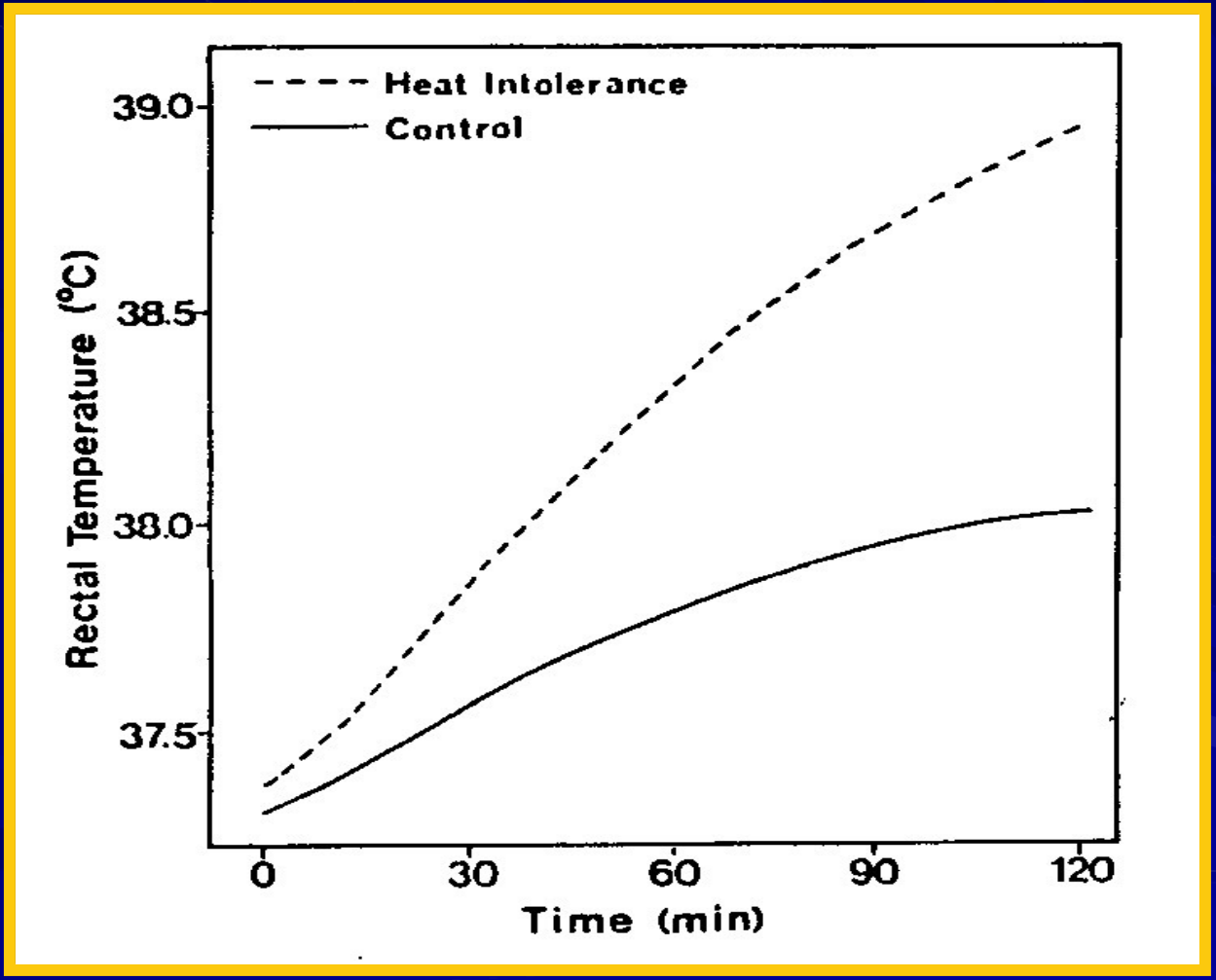
Permanent ?

Exercise heat intolerance

- The inability to adapt to work in the heat

Strydom NB: S Afr J Sci, 76:154-156; 1980

Heat tolerance evaluation



Epstein et al: J Appl Physiol, 54:831-836;1983

Goldmine workers in South Africa

- Hot and very humid conditions
- 90ºF (37ºC)
- Many heat stroke cases
- Prior acclimatization
- Wyndham et al: 1965- "even after acclimatization there are still large differences between individuals in their temperature reactions to a standard stress of work and heat"
- Wyndham et al: 1973 - "2- 4% of the population was heat intolerant, without manifesting apparent disease process"

Factors underlying heat intolerance

Physiological perspective

Pathological perspective

Factors underlying heat intolerance - pathological perspectives

Concurrent disease:

CNS lesions	Sweat gland dysfunction	Extensive burn scare
CV diseases	Hyperthyroidism	Pheochromocytoma
Infectious diseases	Diabetes mellitus	
Psychiatric illness	Parkinsonism	

Congenital abnormalities:

CF	linear skin dystrophy	Ectodermal dysplasia
Scleroderma	Chronic idiopatic anhydrosis	Genetic disorders

Drugs:

Medications	Drug abuse/Supplements	Alcohol

Factors underlying heat intolerance - physiological perspectives

Functional-physiological factors:

Dehydration	Lack of acclimatization	age
Low physical fitness	Obesity (low AD/W)	fatigue
Sleep deprivation	previous heat stroke?	heavy clothing

* Even after correction of these factors, variability still exists!!!!

Is heat intolerance related to previous heat stroke?

Is heat intolerance temporary or permanent?

Case report

Phase 1- Collapse 1

- 19 years old soldier.
- March with 36 kg backpack in a moderate heat load.
- Collapsed after 8 km walk and lost consciousness.
- Treatment included one sprinkle of water and saline infusion.
- Temperature was not measured.
- Clinical picture: weakness, fatigue, diarrhea.
- 15 h after the collapse, patient awoke.
- Neurological sequel: negative.
- Oral temperature: 37.5^{o}C.
- Laboratory examination: blood clotting normal; GOT 293 IU (N=30), CPK 668 IU (N=100), LDH 530 IU (N=350); chest film and ECG – normal.
- Released from hospital after 5 days, clinically recovered with normal enzyme levels.
- Returned to his unit a few days later.

Keren G et al: Aviat Space Environ Med, 52:116-117; 1981

Case report (cont.)

Phase 2 – Collapse 2

Three weeks following the first incident:

- **Participated in vigorous march in high heat load.**
- **After 12 km became confused and irritable and vomited.**
- **Collapsed and a generalized convulsive seizure was observed.**
- **Arrived at the hospital within 1 hour of collapse, having been unconscious most of the time**
- **Rectal T: 39^{o}C; HR 120; BP 120/80; CPK 1252 IU; GPT 277 IU; LDH 1447 IU; GOT 350 IU; clotting and kidney function normal.**
- **Released from hospital after 4 days, clinically recovered with normal enzymes levels.**

Keren G et al: Aviat Space Environ Med, 52:116-117; 1981

Case report (cont.)

Phase 3 – Heat tolerance test 1

After one month (in August), patient went through a heat tolerance test and was diagnosed as heat intolerant

Phase 4 – Heat tolerance test 2

After 5 months (during the winter), patient went through another heat tolerance test and was found to be heat tolerant having normal physiological response

Keren G et al: Aviat Space Environ Med, 52:116-117; 1981

Conclusions

- The second collapse might have been associated with a heat intolerance state caused by prior heat stroke
- Heat stroke might have been the reason for the temporary heat intolerant state

Heat intolerance in former heat stroke patients – study 1

Participants:

- Group 1 -Nine young men who suffered from severe heat stroke and diagnosed as heat intolerant 2 to 5 years before study.
- Group 2 – Ten young control subjects.
- Participants in both groups were sedentary and unacclimatized to heat at time of examination.

Measurements

- Anthropometric
- Orthostatic
- VO_{2max}
- Heat tolerance test

Shapiro Y et al: Ann Int Med, 90:913-916; 1979

Heat intolerance in former heat stroke patients - study 1 (cont)

Results:

- No significant differences were found in anthropometric measurements, VO_{2max}, orthostatic function or sudomotor function.

- All previous heat intolerant subjects were diagnosed as heat intolerant (2-5 years after the first positive test); control subjects were found to be normal.

Conclusion:

- Heat tolerance may last years after heat stroke.
- Was heat stroke associated with preexisting susceptibility ?

Shapiro Y et al: Ann Int Med, 90:913-916; 1979

Heat intolerance in former heat stroke patients – study 2

Participants:

- Group 1 – Ten participants 60 days post heat stroke.
- Group 2 – Five healthy control participants.
- Participants in both groups were sedentary and unacclimatized to heat at time of examination.

Measurements/Protocol:

- Anthropometric
- VO_{2max}
- Heat tolerance test
- Nine days heat acclimation

Armstrong LE et al: Eur J Appl Physiol,60: 202-208; 1990

Heat intolerance in former heat stroke patients – study 2 (cont)

Results:

- No significant differences were found in anthropometric and fitness measurements.
- Four prior heat stroke participants (out of 10) were heat intolerant in day 1.
- One prior heat stroke participant was heat intolerant after heat acclimation.

Conclusions:

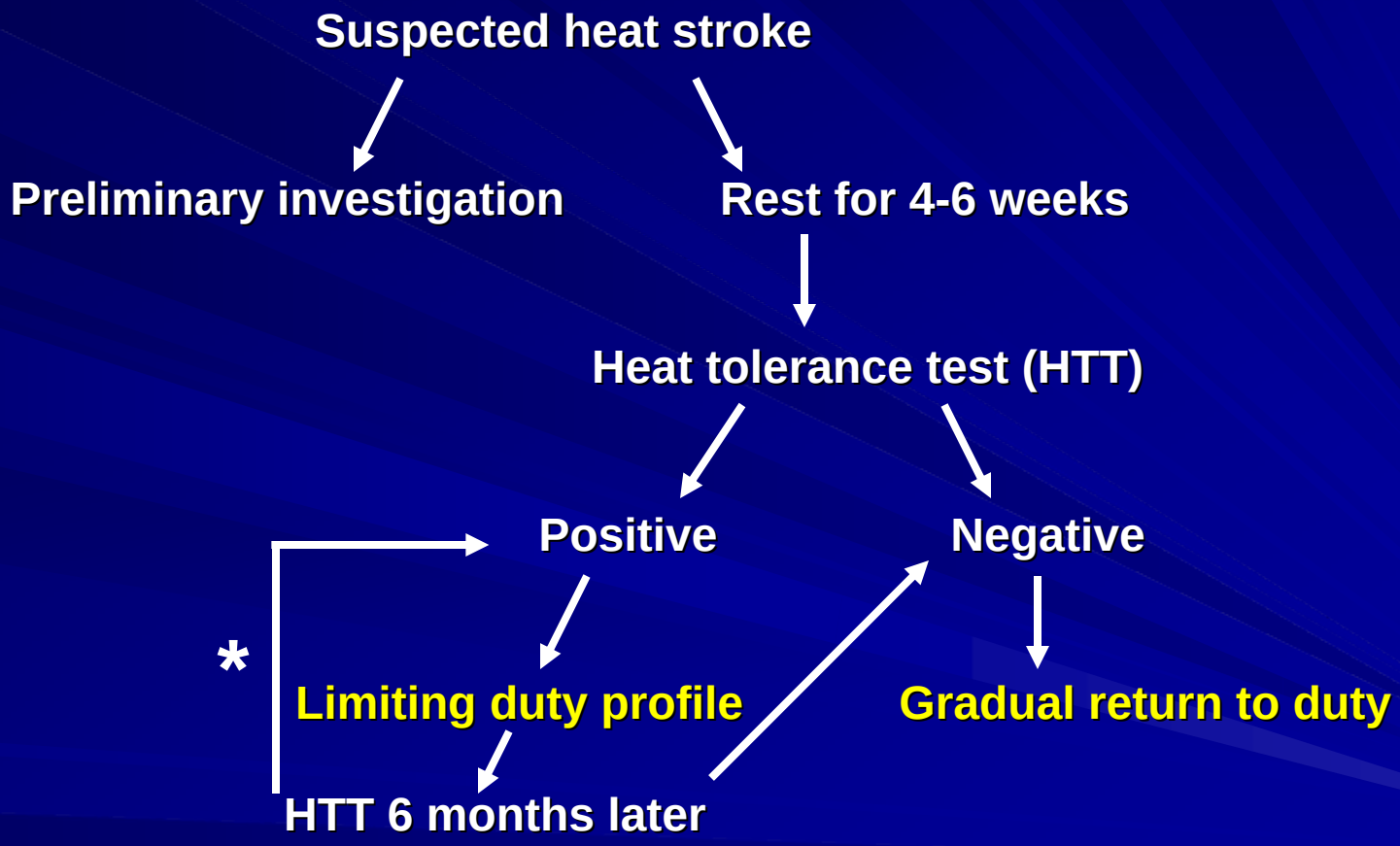
- Heat tolerance may last months after heat stroke.
- Heat acclimation does not necessarily improve the heat tolerance state in heat intolerance patients.

Recovery from heat stroke

?

When can a subject return to duty/play after heat stroke (if at all)?

The IDF's general regulations for return to duty after heat stroke



* Usually conducted only once, but in special cases, twice or more.

Heat tolerance test (HTT)

Aims:

- **To assess the readiness/risk for exercise in hot environments.**
- **To assess the heat tolerance status of prior heat stroke patient.**

Heat tolerance test (HTT)

“HTT was effective in evaluating the heat tolerance status in prior heat stroke subjects”

Shvartz E et al: J Appl Physiol; 1977

Heat tolerance test

- 4 to 6 weeks after injury (rest)
- Medical examination
- Questionnaire
- Heat chamber (40^{o}C, 40% RH)
- Walking on treadmill (3.5 mph, 2% slope) for 2 h
- Measures: dynamics/kinetics of Tre, Tsk, HR
- Physiological indices
- Calculation of sweat rate
- Discomfort scale

Heat Intolerance - Criteria

Primary measurements

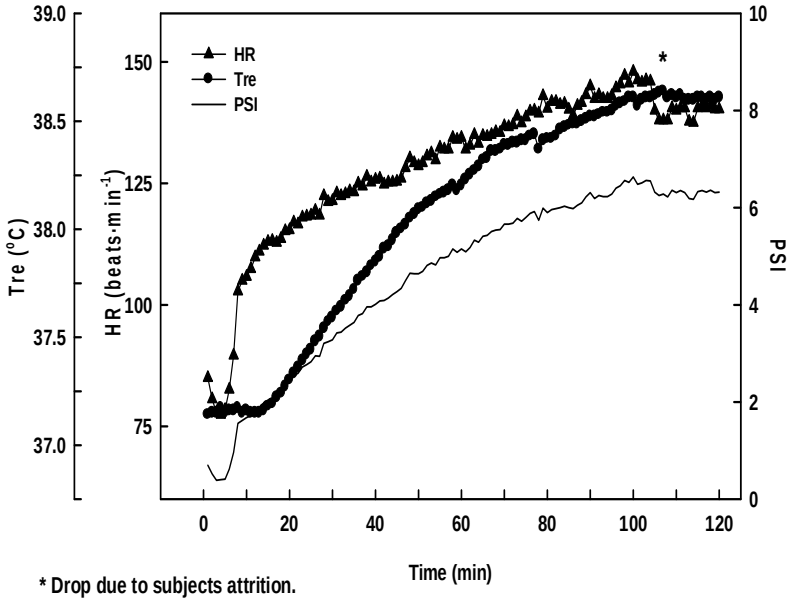
- Rectal temperature > 38.5°C
- No plateau in the dynamics of rectal temperature

Supportive measurements

- HR > 150 bpm
- Subjective feeling
- Physiological indices (Physiological Strain Index - PSI and Cumulative Heat Stress Index - CHSI)

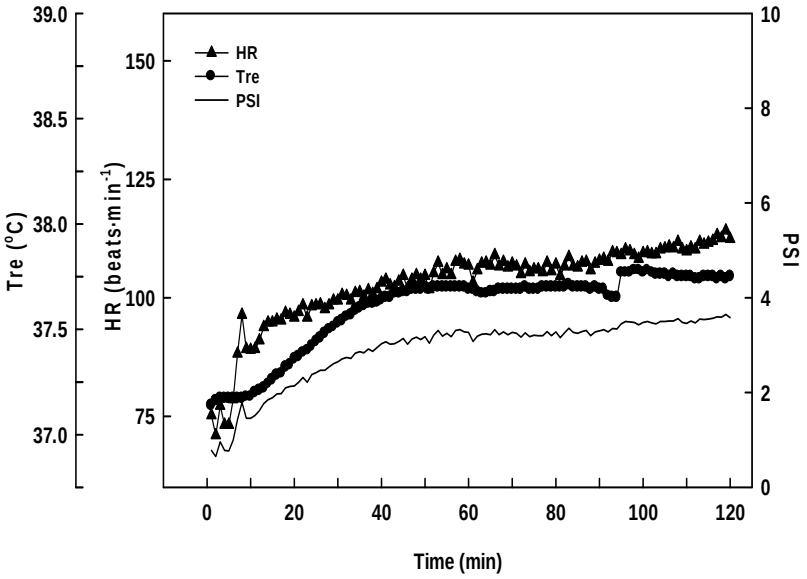
Heat tolerance test

Heat intolerance



* Drop due to subjects attrition.

Heat tolerance



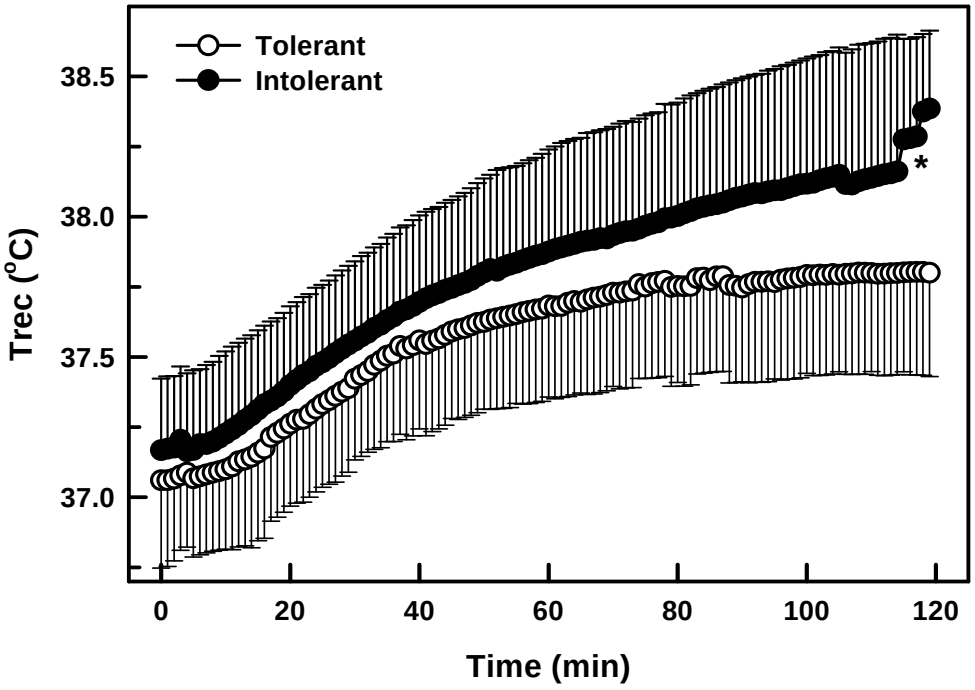
Moran SD et al: Med Sci Monit, 10:CR252-257; 2004

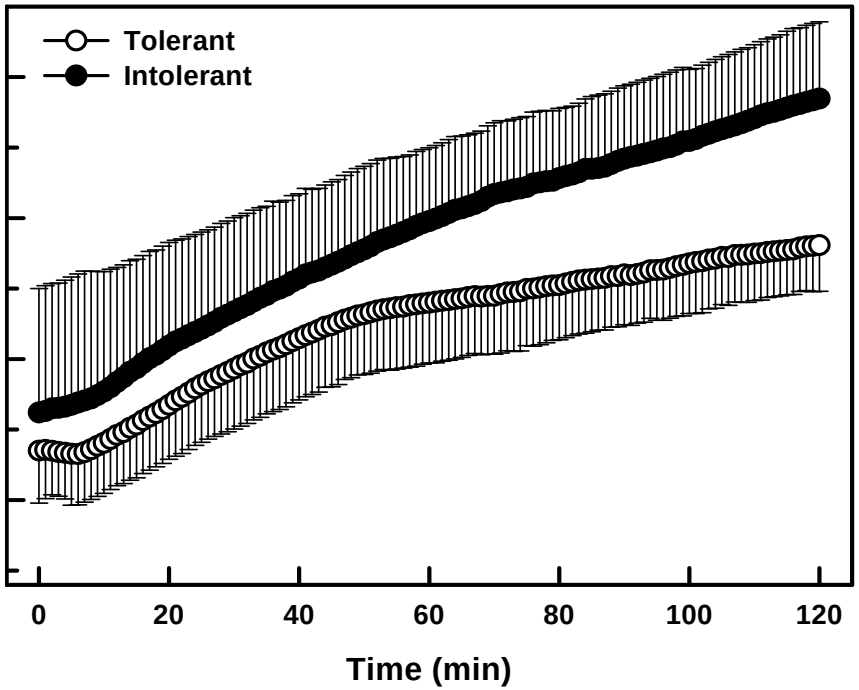
Heat tolerance during 6 months

T = 24
IT = 12

8/12 IT

T = 4
IT = 4





*Due to subject attrition

Heled et al: not published

Assessment of HTT for post heat stroke individuals

Aims:

- To evaluate the HTT for exposure duration and for comfort climate conditions in post exertional heat stroke patients.

Participants:

- 19 post exertional heat stroke males

Measurements/Protocol

- HTT
- Comfort tolerance test (CTT;20^{o}C, 50^{o}RH)
- VO_2
- VO_2 max
- Anthropometry

Moran SD et al: Med Sci Monit, 10:CR252-257; 2004

Assessment of HTT for post heat stroke individuals (cont.)

Results:

- 5 participants (out of 19) were heat intolerant
- No differences in the physiological measures during CTT
- No differences in VO2 max and VO2 during the test
- For the heat intolerant group HTT should be 120 min

Conclusions:

- HTT is a reliable test for heat tolerance assessment
- HTT should last 120 min
- CTT is not relevant for heat tolerance assessment

Moran SD et al: Med Sci Monit, 10:CR252-257; 2004

However…some research is still required:

- Borderline cases? - In progress
- Special forces!!! advanced protocols? – In progress
- Different conditions?- In progress
- New mathematical indices for more reliable results – In progress
- Heart rate variability as a supportive measure - In progress
- Mechanisms of heat intolerance-intervention? – In progress

Summary

- ✓ An exertional heat stroke incident may cause heat intolerance for an unpredictable length of time.
- ✓ In most cases, we do not know if the person had suffered from some degree of heat intolerance before the heat injury.
- ✓ One factor that probably influences the duration of heat intolerance after heat stroke is the severity of the heat injury (CNS damage?).
- ✓ A heat tolerance test, after an appropriate rest period, is the only method available for evaluating when a soldier should return to regular training/play in a reasonable time period.
- ✓ Within the IDF, no soldier with a negative (normal physiological response) heat tolerance test (because of a heat stroke event) has experienced a second heat stroke incident.
- ✓ As a result of borderline cases and significantly different fitness levels among soldiers, advanced protocol with more supportive measures may be required.


Thank you