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# Spacetex-2

***Performance Apparel with Enhanced Evaporative Heat Loss for An Astronauts' Daily Exercise on Board the ISS***

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# Aerial View of the Campus


# Hohenstein - Textile Expertise and Family business in 3rd generation since 1946



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***Focused on the Textile - Human Interface***

(Apparel-) Product Know - How under one roof

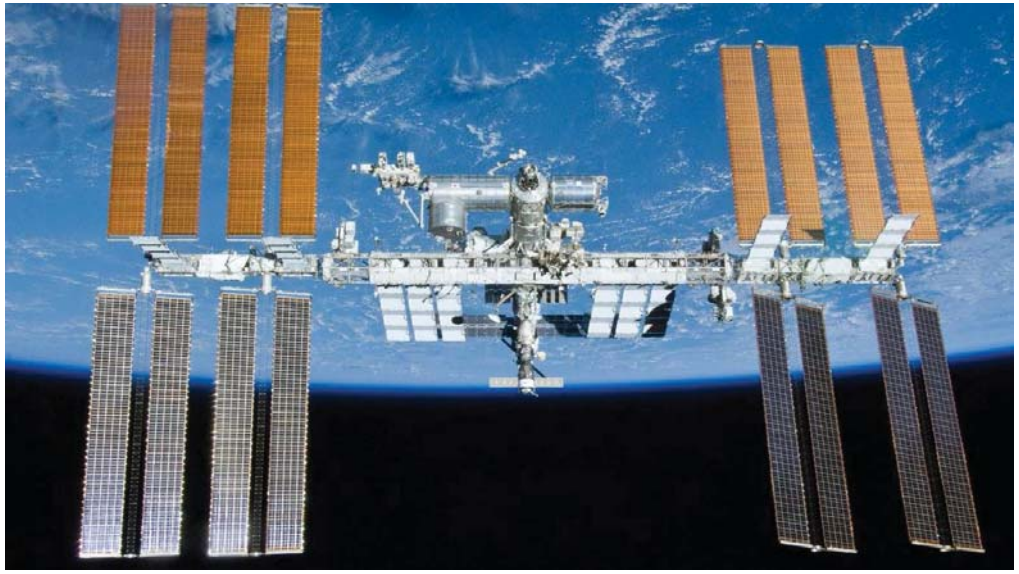
## Clothing Physiology
## Body - Clothing - Climate

- Hohenstein's core competence since the 1950's
- 60+ years of experience in thermo-physiological comfort of textiles
- 150+ research projects (public funded and contract research)

**... on earth**



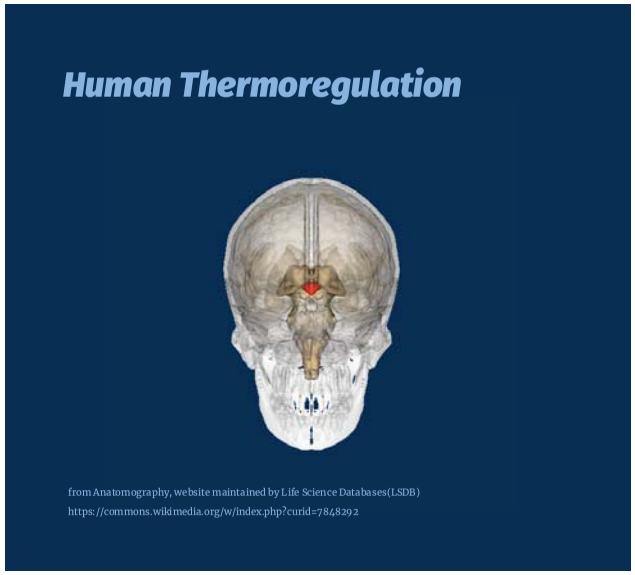
# Why Comfort Research in Space?

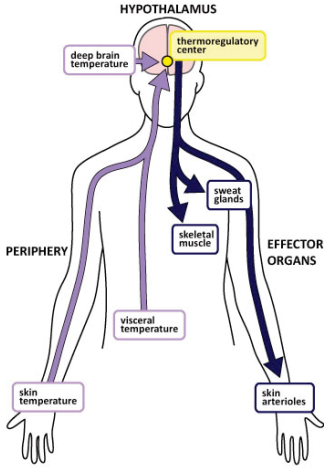


## Science Background

- Crewmembers perform approx. 2 hrs daily exercise during space flight as countermeasure for cardiovascular deconditioning
- With identical metabolic rate, exercising on the ISS leads to quicker and higher increase of body core temperature compared to exercising on earth

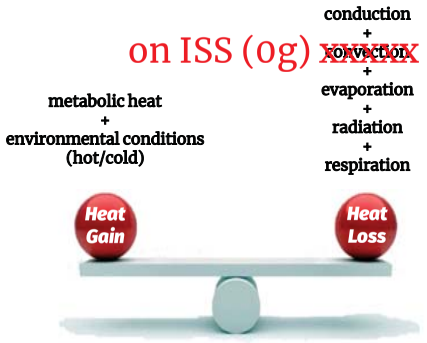
.... why's that?

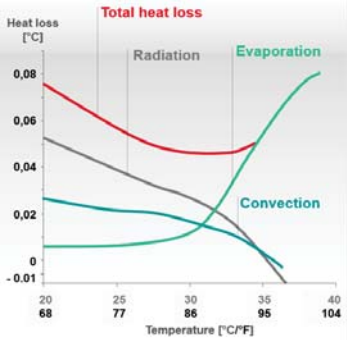


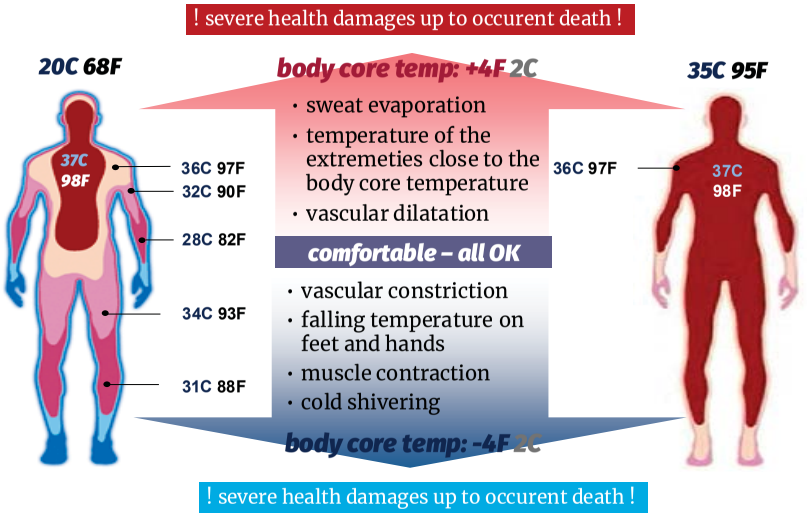



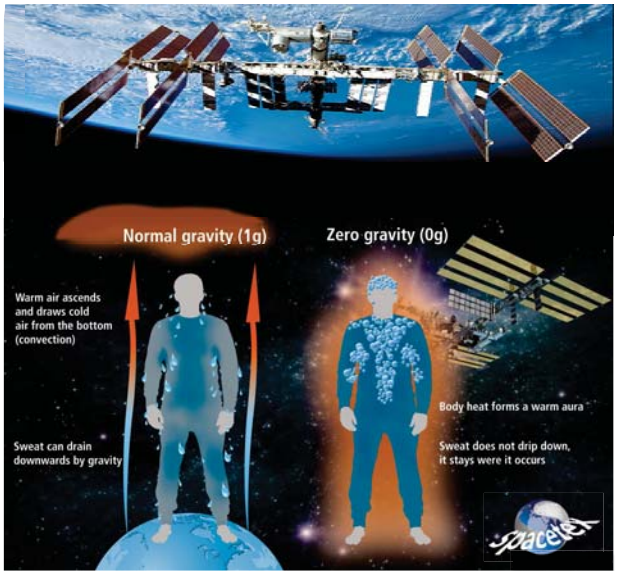

# Thermal balance and total heat loss

**Aim: Balanced relation between heat loss and heat gain**




# Heat loss and sweating 1g vs. 0g

Need:
Exercise shirts with enhanced evaporative heat loss for exercise on the ISS (0g) to improve thermal comfort of the astronauts

# Spacetex(-1) In-flight Sessions @ ISS, Oct 2014

DLR

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CHARITÉ

schoeller® Switzerland

- 3 T-Shirts with increasing evaporative heat loss
- Custom engineered fabrics & fitted T-shirts
- Dr. Alexander Gerst again as subject
- Body Core Temperature, Heart Rate Data, Questionnaires
- Linking with the MetaSpace-Project resulted in additional Spiroergometric Data

# Spacetex-2 Experiment Design

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- Test new fabrics which facilitate heat transfer / heat exchange from the human body in space
- Increase basic knowledge about heat loss from the human body to environment under terrestrial and micro-g conditions esp. the evaporative part of heat loss in space during physical exercise
- Further develop more adequately textiles for humans living and working in space
- Improvement of the overall comfort and well-being of the astronauts and improve initial findings from Spacetex(-1) 2014
- Pre-investigations for long-term explorative mission IVA textiles

# Reflight 2018 Spacetex-2 Objectives

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# August 2018 Spacetex-2 inflight sessions

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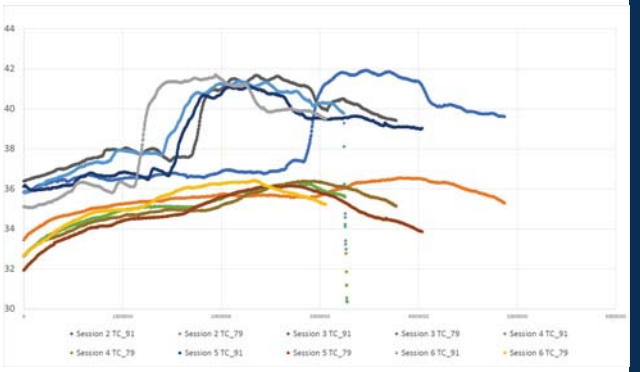


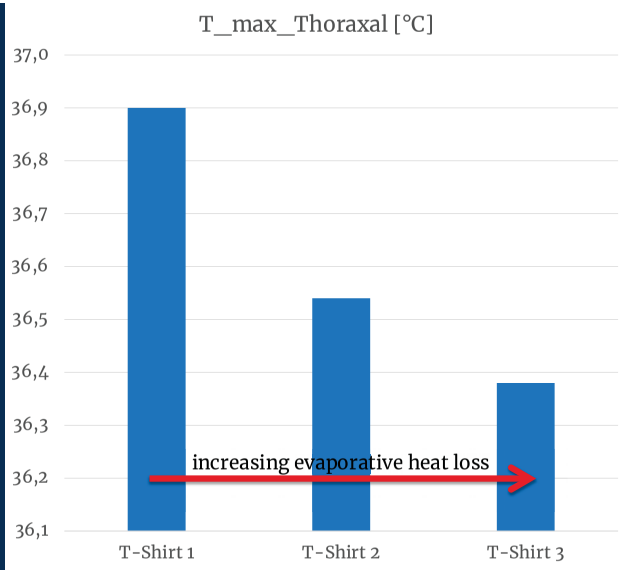

***Thermolab Raw Data Body Core Temperature [°C]***

***($T_{head}$ & $T_{thorax}$)***

... alignment and timecode sync is challenging

# Collected Data

***Maximum $T_{core}$ (thoraxal) per each fabric in all sessions***



## Questionnaires single materials

**T-Shirt / Material 1**
Ratings: 1x extr.poor, 3x poor, 1x average, 1x good
*"Too warm, too inelastic, too thick, too rough surface. Constrains arm motion."*

**T-Shirt / Material 2**
Ratings: 5x average, 1x good
*"Material is slightly too thick and not quite elastic enough. Therefore it is constraining when moving arms."*

**T-Shirt 3 / Material 3**
Ratings: 6x good
*"Thin material, therefore does not build up heat. Does not stick to skin. Very elastic. Keeps skin dry."*

## Summary

- From PI's view the experiment was successful
- T-Shirts / Materials could be differentiated
- T-Shirt / Material 3 with highest evaporative heat loss came out best performing
- Thermolab Data assessment challenging
- Questionnaires provided valuable subjective feedback
- Data of pre & postflight BDC sessions challenging due to altering environmental conditions
- Of course, results must be seen under limited statistical relevance (1 subject, 2 replicates)...
- ... nevertheless findings were further improved to develop more adequately textiles for humans living and working in space with good thermal comfort and wellbeing.

## Questionnaires comparative

**Comparative ratings**
T-Shirt / Material 3 mostly preferred in liquid sweating scenarios – but T-Shirt / Material 2 is close

**Comments AG**
*"Material 2 is closest to the thin UnderArmor shirts that I use up here. I like it because it is a very thin and elastic material, which does not build up much heat underneath. It also transports sweat away from the skin nicely. It nevertheless does not stick to the skin (which sometimes very thin materials do).*

*In general I noticed that all 3 materials start smelling comparatively early, right after using it once. This is a property that should be improved if possible.*

*As for the cut, I prefer sleeveless shirts, because they cool even better by covering less skin (but this is an individual preference - some of my colleagues prefer standard shirts)"*

## Spacetex-2 benefits for life on earth

- New approaches in development of enhanced evaporative cooling fabrics for extreme environments on earth (climate change)
- Understanding the effects of uncoupling the convective from the evaporative part of the heat loss

## What's next ? The Journey to Moon in 2024 and later Mars

- Longterm missions, 9 month one way (Mars)
- No resupply missions from earth possible
- Special IVA garments required (daily work & exercise)
- Reprocessing / washing of IVA garments required
- But water is limited to life support...
- ... so how to do the laundry on long-term space missions?

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## Thank you !

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- DLR & ESA (opportunity & coordination)
- ESTEC (PIM), CADMOS (USOC)
- ESA-Astronaut Dr. Alexander Gerst
- Coolcore (custom manufactured fabrics)
- Angela Mahr-Erhardt (T-Shirts, cut & sew)
- MetaSpace team (PI Tino Schmiel)