

Distractions Hurt Performance

The Science Behind Skin Sensorial Comfort



Hohenstein Testing & Product Development Services

Comfort

- Quantitative thermal comfort assessment
- Breathability
- Moisture management
- Heating & cooling analysis
- Skin sensorial properties
- Range of motion

Fit

- 3D scanning
- Sizing
- Fit analysis
- Pattern making
- Compression

Freshness

- Odor management
- Microbe protection
- Ease of care

Function

- Protection against wind & rain
- Abrasion resistance & strength
- Cut resistance, reduced noise, enhanced visibility
- UV protection

Sustainability

- Harmful substance testing
- GMO-cotton testing
- Biodegradability
- OEKO-TEX®

Quality

- Comparative testing
- Supply chain communications
- Quality labels
- Marketing claim support



Functional Clothing & Wear Comfort

Wear comfort does not come automatically

Comfort is the result of dedicated, in-depth product development



Comfort is **never** the result of just one construction parameter (e.g. fiber materials)

All textile construction parameters must be adjusted to climatic conditions & the range of application

Sports & Outdoor Clothing Functions

Fit

Wear comfort

Sustainability

Multifunctionality

Bio-based raw materials

Performance enhancement

Microtechnology integration



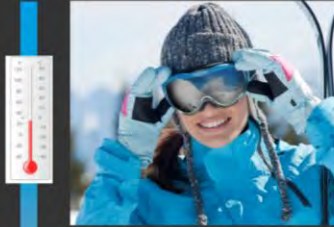
Components of Comfort



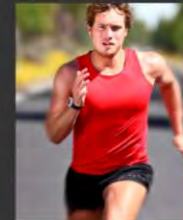
Factors Influencing Comfort

- Fiber material/polymer (raw material)
- Yarn construction
- Fabric construction
- Finishing
- Garment making (ergonomics/fit)
- Composition & interaction of the clothing layers

1. CLIMATIC CONDITIONS:



2. INTENDED USE/LEVEL OF ACTIVITY:



MODERATE ACTIVITY
(Insensible sweating):

- adjusted thermal insulation (thermal resistance R_{cl})
- good breathability (water vapour resistance R_{et} & water vapour absorbency F_1)

INCREASED ACTIVITY
(Moderate sweating):

- reduced heat insulation (thermal resistance R_{cl})
- good buffering of sweat (buffering capacity of water vapour F_1)

HEAVY PHYSICAL ACTIVITY
(Heavy sweating):

- increased sweat absorption (buffering index K_1)
- quick transportation of sweat (F_1)
- short drying time (Δt)

3. PERFECT LAYERING:



BASE LAYER
(Functional underwear):

- adjusted heat insulation
- quick transportation of liquid sweat



MID LAYER
(Fleece, shirt, etc.):

- good buffering capacity for water vapour
- quick transportation of sweat



SHELL LAYER
(Softshell, Hardshell, etc.):

- good breathability

Skin Sensory Functions

How is the feel of the textile perceived by the wearer's skin (cognitive perception)?



Haptics ≠ Skin Sensory Properties

Perceiving with your hands is not like perceiving with your body

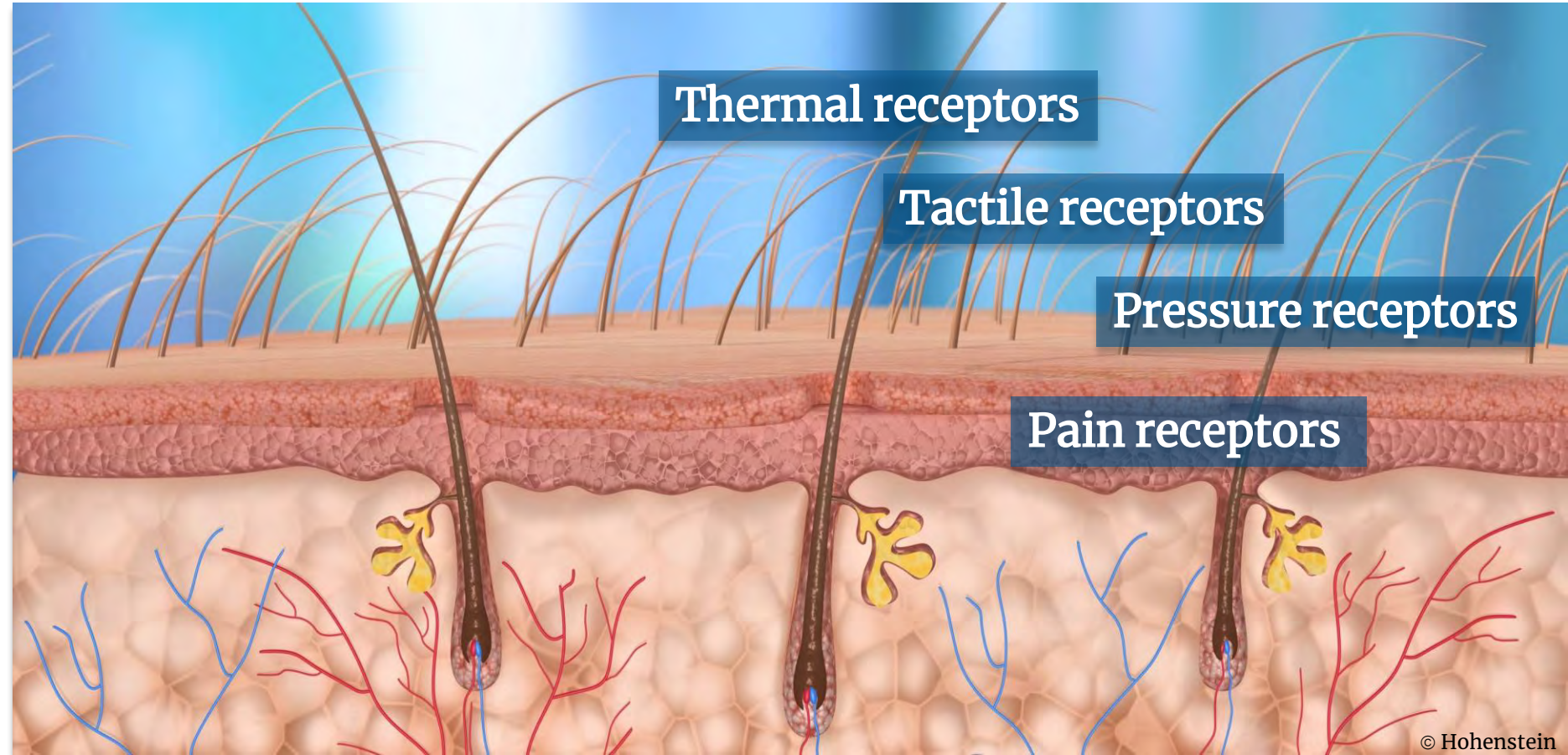
Skin sensory properties – how the textile is perceived by the wearer's skin



Fabric & Skin Contact

Our skin = organ of perception & contact

- Protection against heat loss & external factors
- Reception of sensory stimuli by receptors



Negative Skin Sensory Perceptions



1/3 of comfort is based on skin sensory properties

- Sweat remains on skin
- Fabric clings to skin
- Too smooth
- Too stiff
- Too scratchy



Neuro-physiological Perception



Measurements in the brain

How strongly does the textile affect the wearer's awareness?

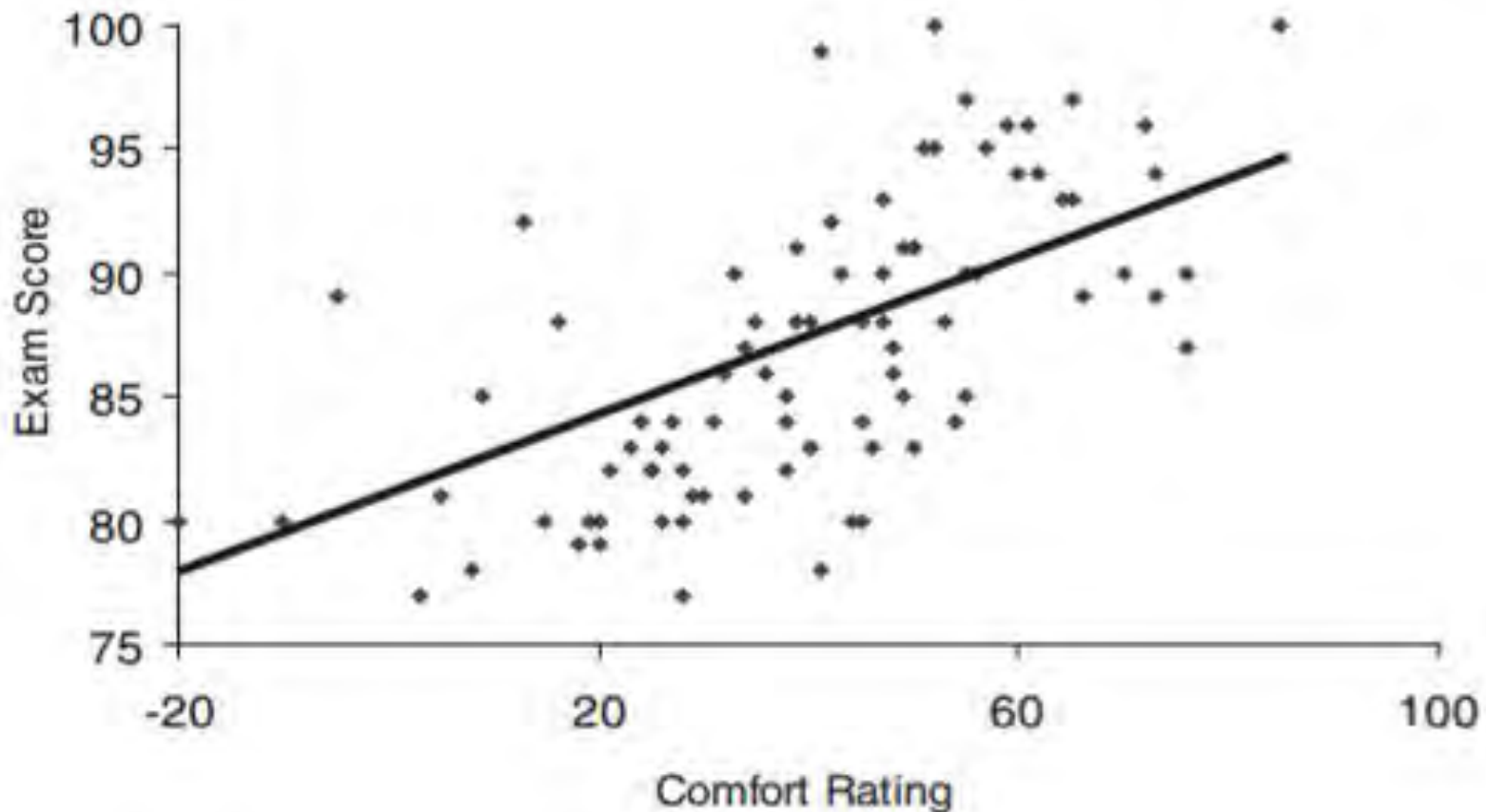
Skin Sensory Properties Matter

US Army Study

Influence of clothing (i.e. stiff collars, scratchy textiles) on the mental performance of test subjects

Applications

- Military/defense
- Competitive sports
- Workwear



Skin Sensorial Assessment

Standardized
fabric measurements:
objective & cost-saving

1. Stiffness

How well does
the textile adapt
to the skin?

2. Sorption Index

How fast does the textile
absorb a drop of water?

3. Surface Index

How hairy or smooth
is the textile surface?



4. Number of Contact Points

At how many points does
the textile touch the skin?

5. Wet Cling Index

How strong does the textile
adhere to skin moistened by
perspiration?



Sorption Index

Sweat moistened skin

- Feels unpleasant
- Is more sensitive to irritations & injury

Measure how fast sweat is absorbed by the textile & transported away from the skin

Applications

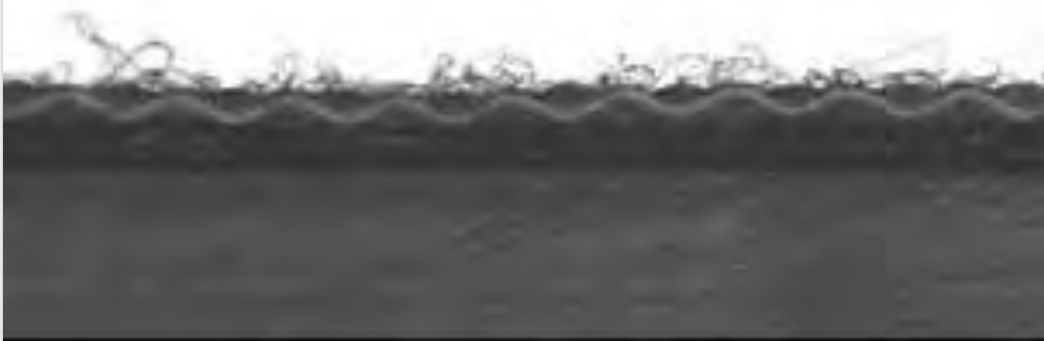
- All skin contact textiles
- Apparel, underwear, outerwear, stockings, socks
- Bedding
- Workwear & PPR

Product Improvement Example

Surface Index

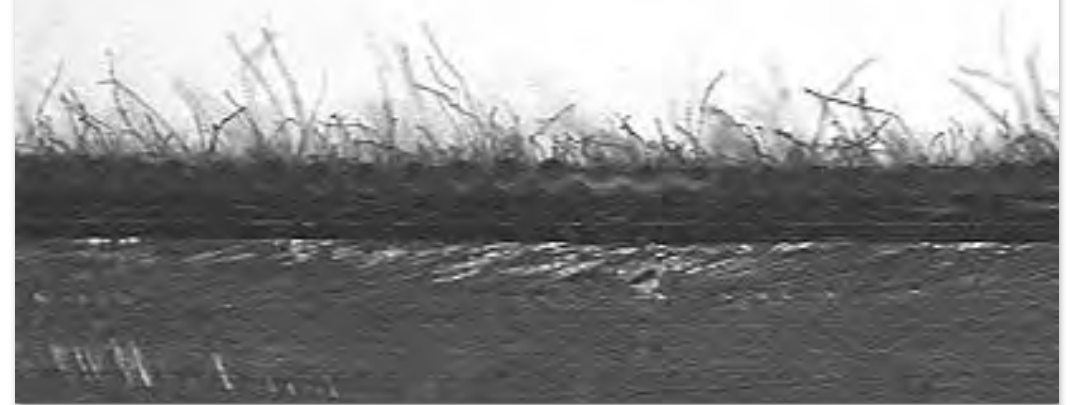
Before

**Too smooth textile feels
uncomfortable on the skin**



After

Brush the surface cozy feel



Skin-Textile Contact Points

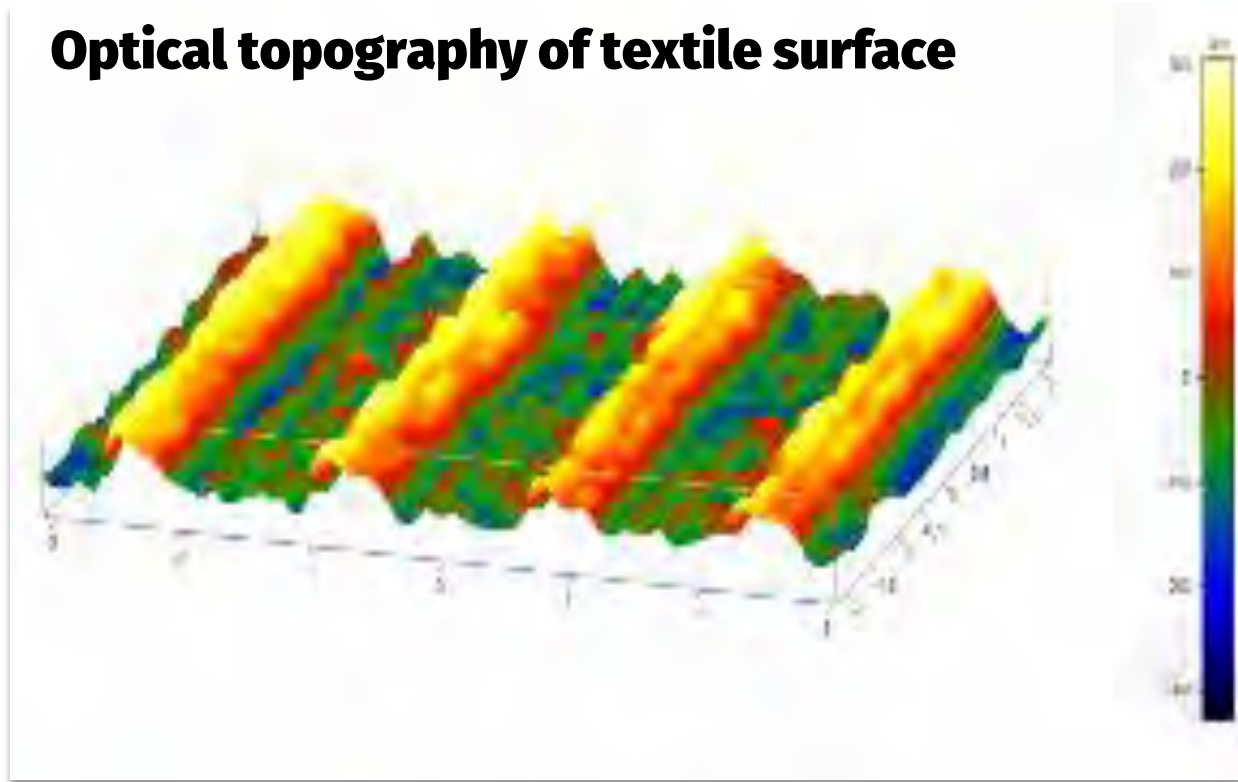
The number of contact points between textile & skin shows if a textile feels clammy/sticky on the skin

- Optimize product development
- Absolute & comparative judgements
- Measure effect after laundering

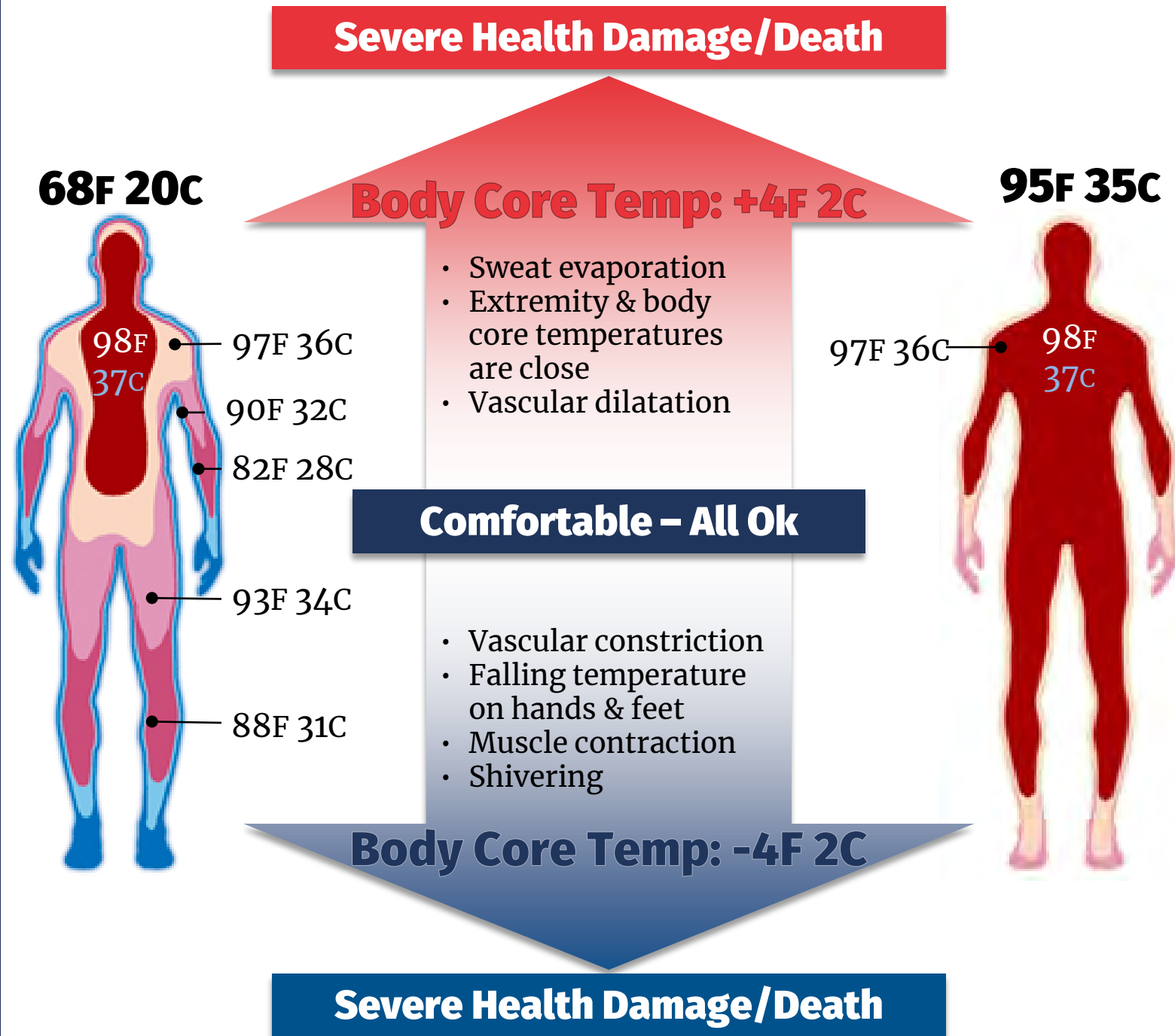
Applications

All skin contact textiles

Optical topography of textile surface



Human Thermoregulation



Moisture
Buffering

Sweating

Moisture
Transport

Ventilation



Metabolic Rate:
 $M = 80 \text{ W To } 1000 \text{ W}$

Skin Contact,
Ergonomics

Radiation

Dry Heat Transport

Convection
& Conduction

Heat & Cold Stress → Impairment of Attention & Performance

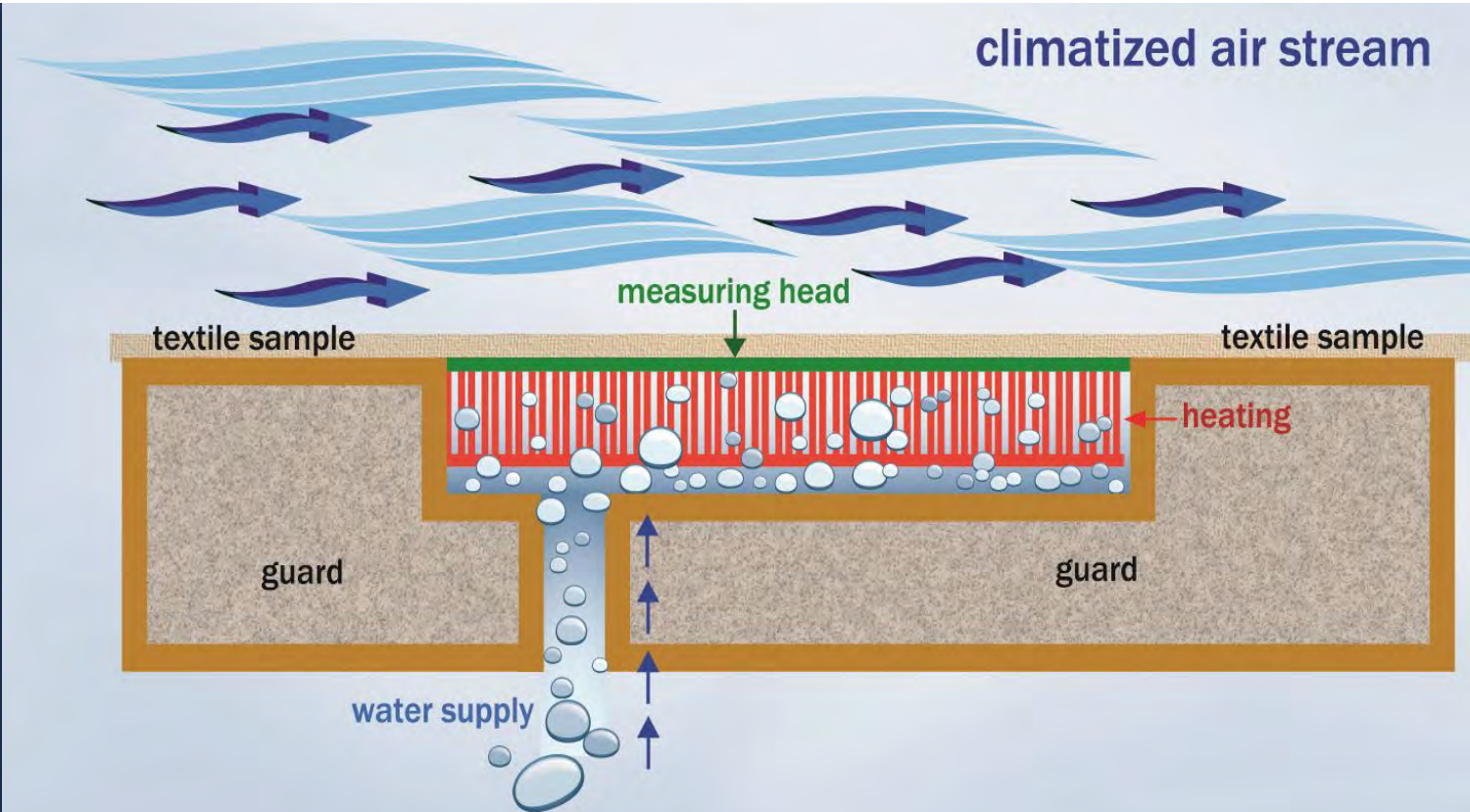
Clothing Physiology: Body – Climate – Clothing Interaction

Skin Sensory + Thermo Physiology = Optimal Comfort

Clammy skin is more sensitive

Important parameters to measure with the Hohenstein Skin Model

- Breathability
- Thermal insulation



Thermo-physiological Measurement

Sweating Guarded Hotplate

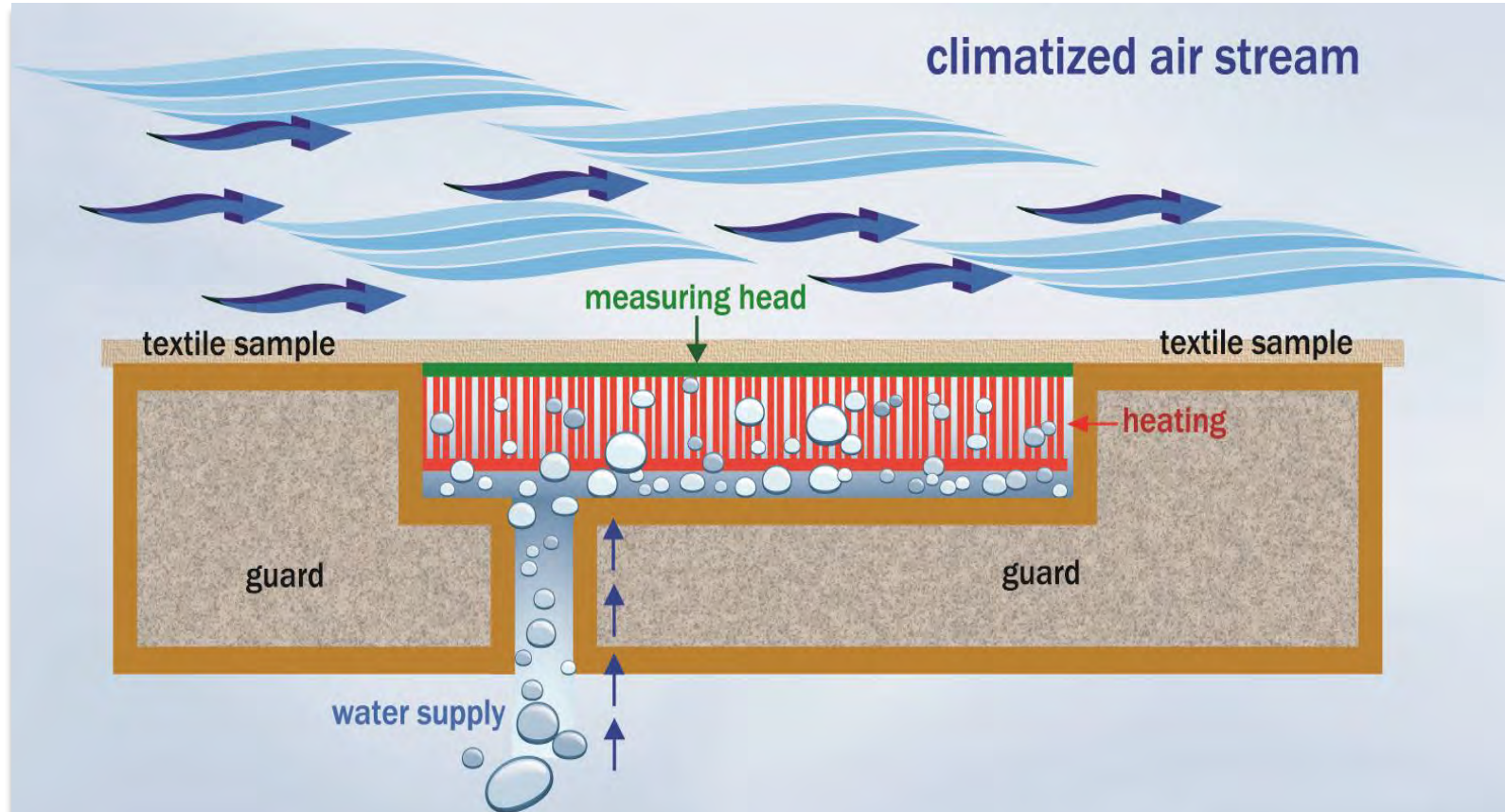
Hohenstein Skin Model

ISO 11092

- Water vapor resistance R_{et} (breathability)
- Thermal resistance R_{ct} (thermal insulation)

Plus Hohenstein modification

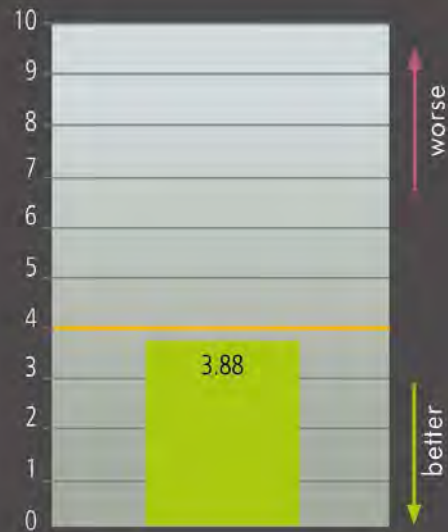
- Buffering of water vapor F_d
- Sweat absorption K_f
- Sweat transport F



Beyond Breathability (R_{et})

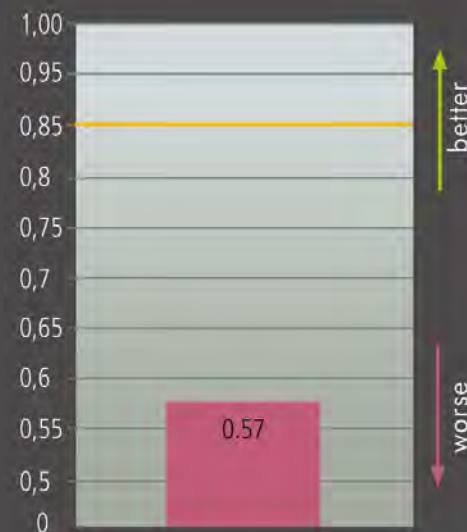
Hohenstein Skin Model

Vaporous sweat transport

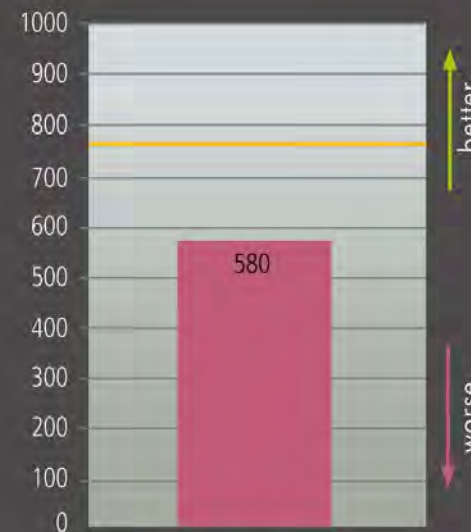


Water vapour resistance -
Breathability - R_{et} ($m^2 Pa/W$)

Liquid sweat transport

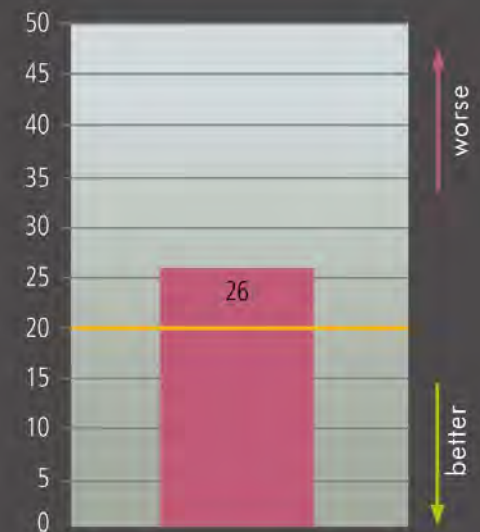


Buffering index
 K_f



Sweat transport F
at 25°C/50% r.H. (g/m^2h)

Drying time



Drying time
(t min)

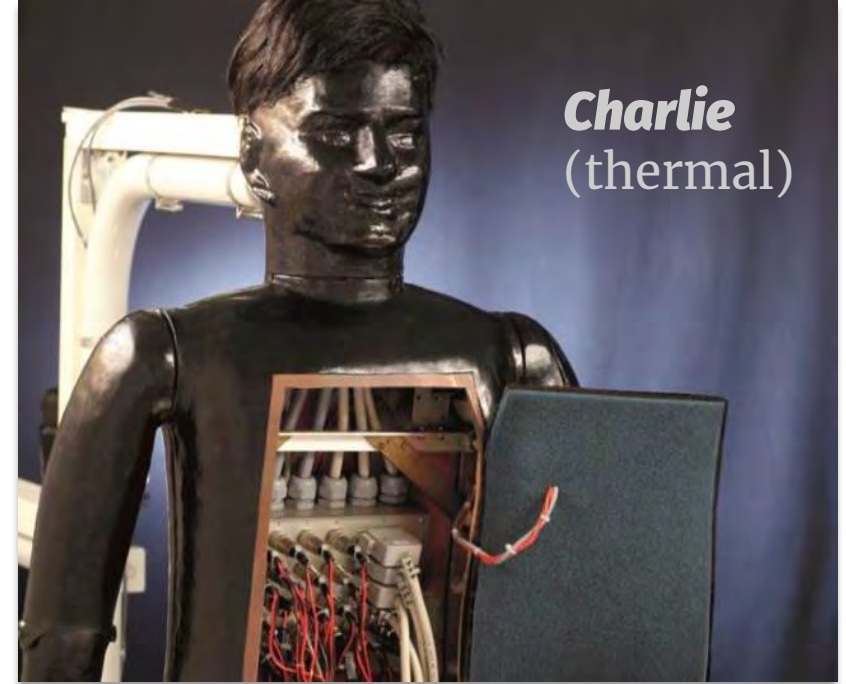
Orange line = minimum requirement

Thermo-physiological Measuring Methods

Thermal / Sweating Manikins

Ready-made garments / clothing systems

- Thermal insulation
- “Breathability”
- Ventilation
- Range of utility

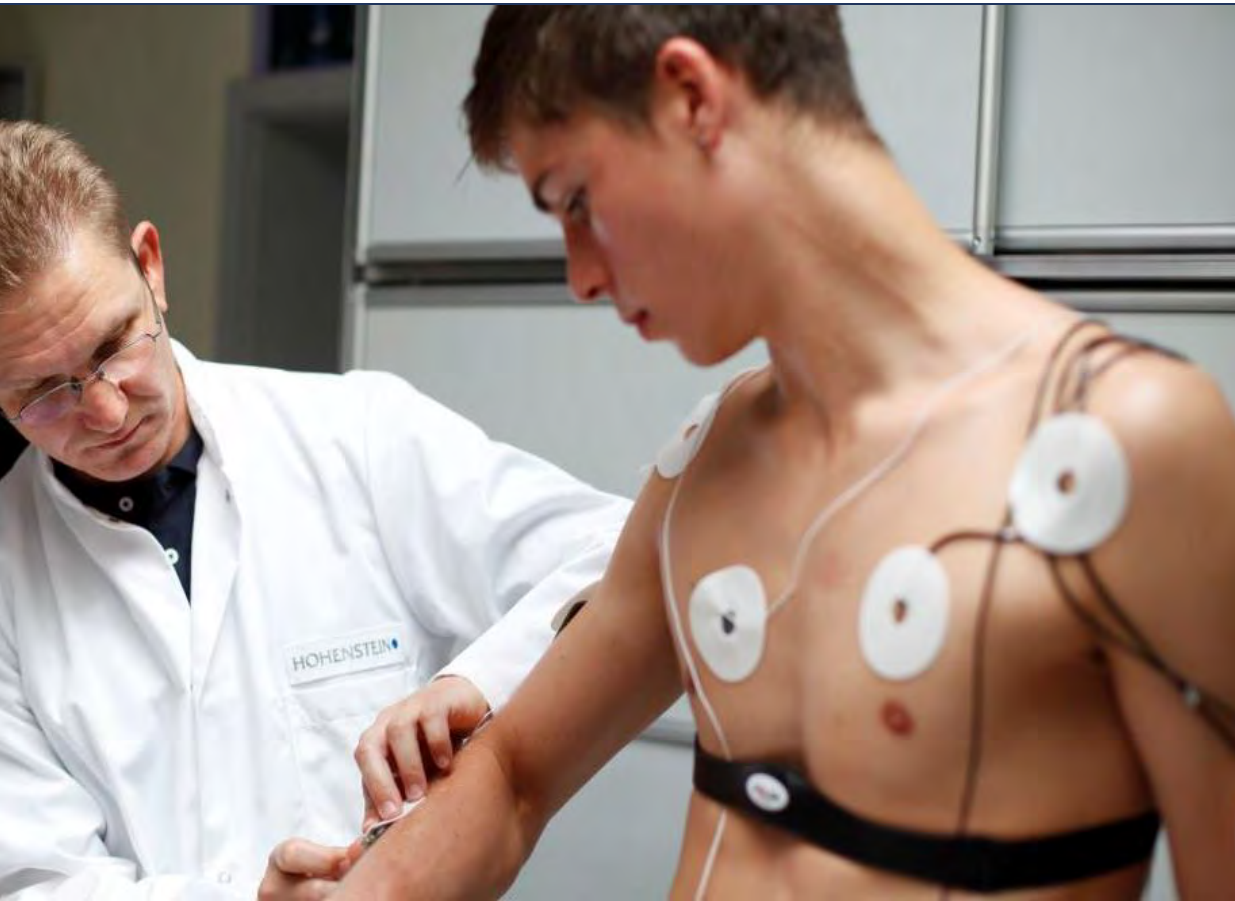


Charlie
(thermal)



Sherlock
(sweating)

Wear Trials with Human Subjects



- Simulation of various ambient conditions in a climate chamber
- Objective measurement of skin temperature & humidity via sensors
- Subjective assessment of the comfort by test subjects



Thank you

Ben Mead

Managing Director

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Hohenstein.US

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HOHENSTEIN ●

Staying Warm in Portland Using Thermal Regulating Performance Gear





***Hohenstein Customer Support
1000+ Worldwide Employees***

Hohenstein

Focus:

Textile-Human -Environment Interface

Comfort

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- Moisture management
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Fit

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Sports & Outdoor Clothing Functions

Fit

Wear comfort

Sustainability

Multifunctionality

Bio-based raw materials

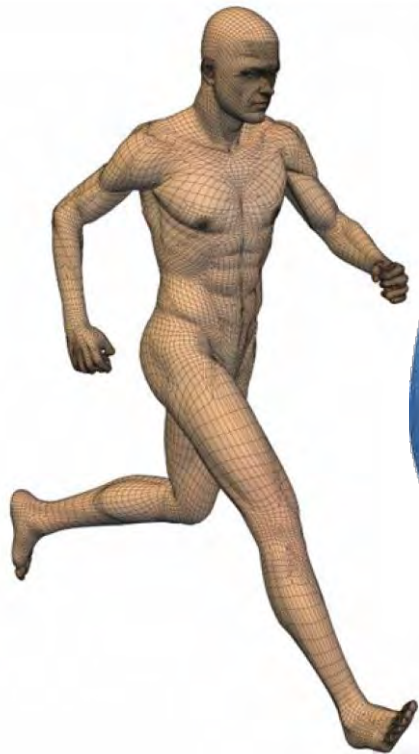
Performance enhancement

Microtechnology integration



Clothing Physiology = Interaction

Bodies



Climate



Clothing



Clothing Physiology - The Science Behind Comfort

Heat Insulation

Charlie
(thermal)

Complete Garments & Clothing Systems

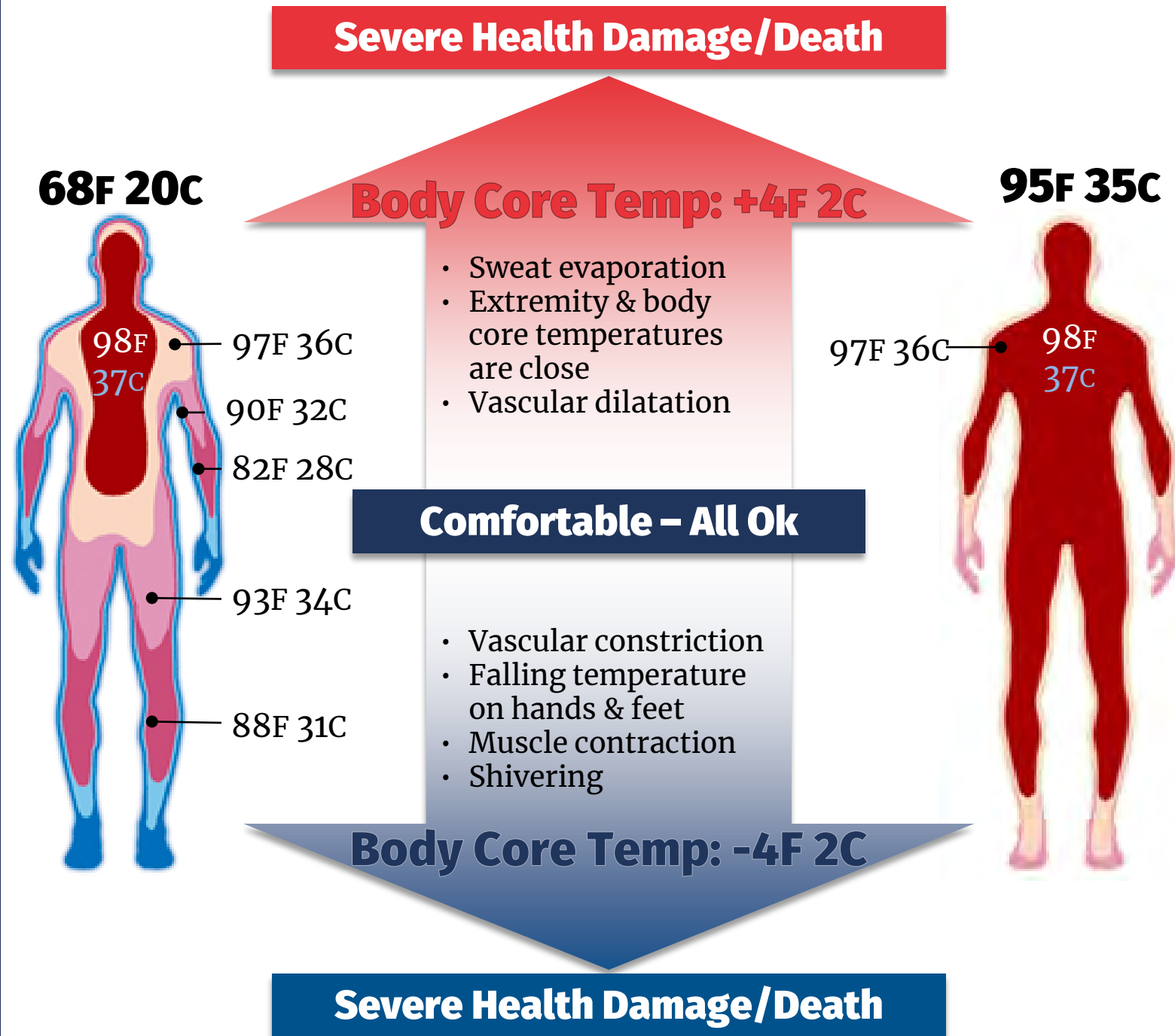
Hohenstein's core
competence since 1950's

- 60+ years of experience
- 150+ public/private research projects in thermal comfort of textiles

Heat & Moisture Management

Sherlock
(sweating)

Human Thermoregulation



Moisture
Buffering

Sweating

Moisture
Transport

Ventilation



Metabolic Rate:
 $M = 80 \text{ W To } 1000 \text{ W}$

Skin Contact,
Ergonomics

Radiation

Dry Heat Transport

Convection
& Conduction

Heat & Cold Stress → Impairment of Attention & Performance

Clothing Physiology: Body – Climate – Clothing Interaction



Metabolic Activity Rates

Activity	Metabolic Rate (Watts)
Sleeping	80
Sitting still	115
Standing	160
Light physical action	200
Medium physical action (walking 2.5 mph)	280



Metabolic Activity Rates

Activity	Metabolic Rate (Watts)
Heavy physical action (walking 3 mph)	350
Heaviest labor	450
Cross-country Skiing (competition)	700
High performance sports	800
Temporary peak performance	1000-1200

Sweat Production during Activity

Activity	Sweat (Liters)
100 m sprint	0.1
90 Min Tennis	2.0
90 Min Soccer	3.0
Marathon	4.6
Triathlon/Ironman	20.0



***Scientific
Measurement
Methods***

Thermo-physiological Measurement

Sweating Guarded Hotplate

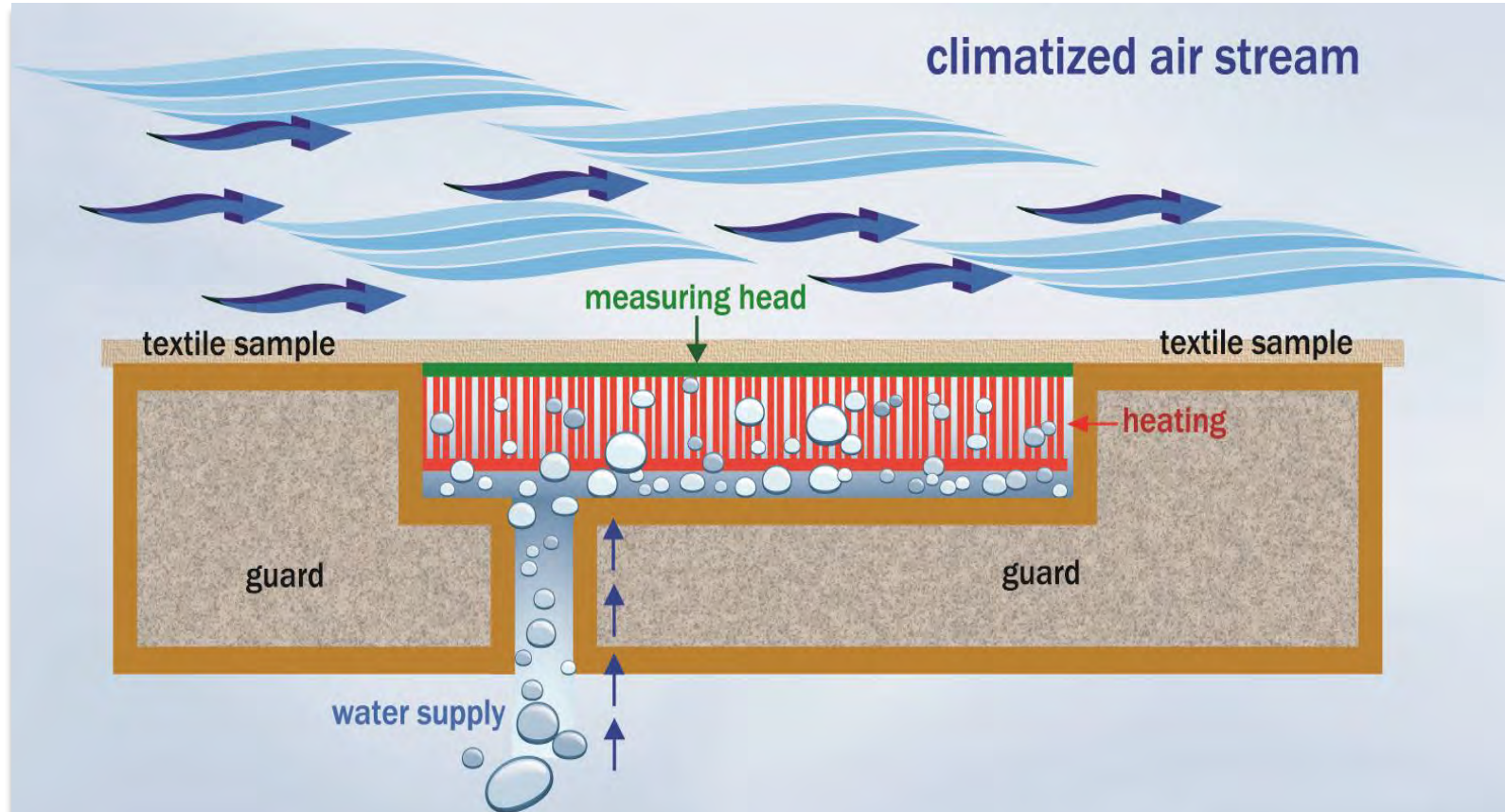
Hohenstein Skin Model

ISO 11092

- Water vapor resistance R_{et} (breathability)
- Thermal resistance R_{ct} (thermal insulation)

Plus Hohenstein modification

- Buffering of water vapor F_d
- Sweat absorption K_f
- Sweat transport F



Thermo-physiological Testing – Fabrics – Hohenstein Skin Model

Measured values (ISO 11 092/DIN EN 31 092)
for the fabric

- Water vapor resistance R_{et} (breathability)
- Thermal insulation R_{ct}

Not suitable for measuring heating or cooling effects under various environmental conditions



**Sample
preparation**



**Skin model in
climatic chamber**



**“Sweating”
skin model**

Measurement Methods - Thermal Manikins

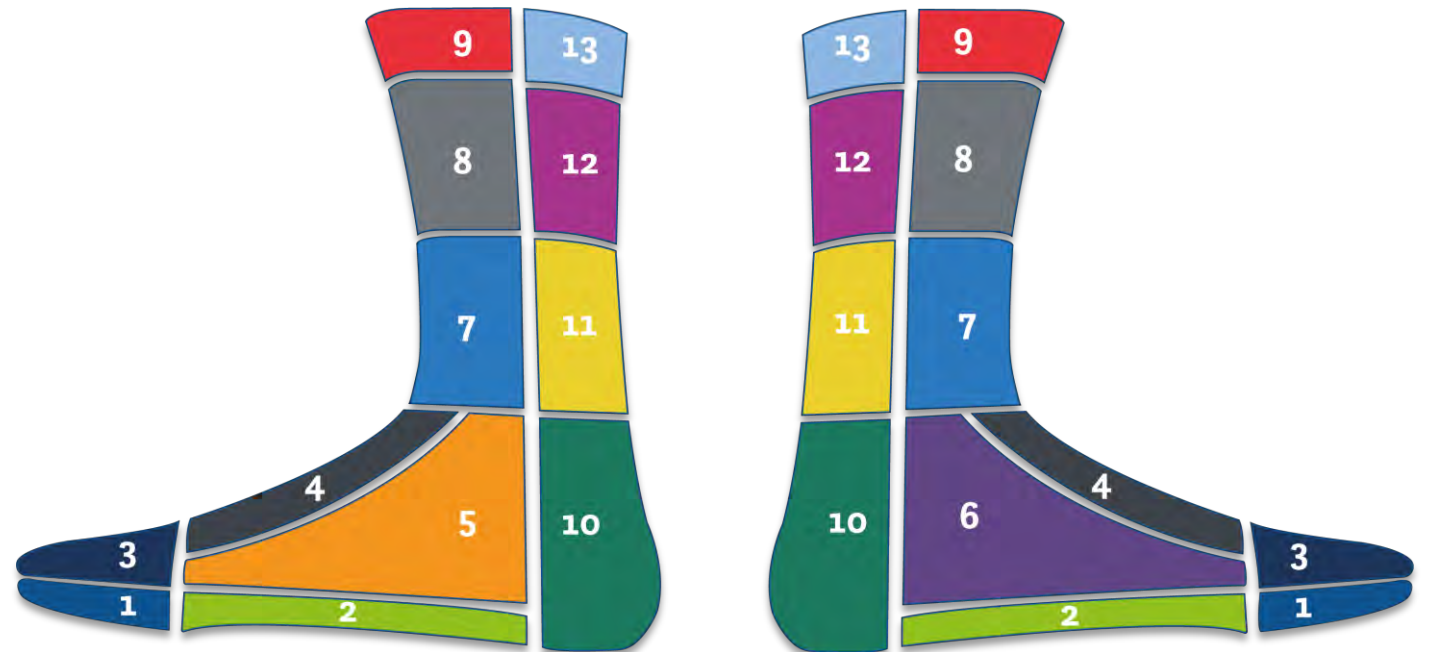
- Thermal - simulation of human heat emission
- Sweating thermal - simulation of human heat & moisture release
- Standing
- Moving - simulation of movements in the real life, ventilation influence



Sweating Foot

Thermal Insulation & Breathability

- $T_s = 34\text{ }^\circ\text{C}$
- 13 heated sections
- 32 water outlet openings
0.8 - 211 g water / h
- Loading weight 25 - 60
kg, max. 45 steps / min



Sherlock

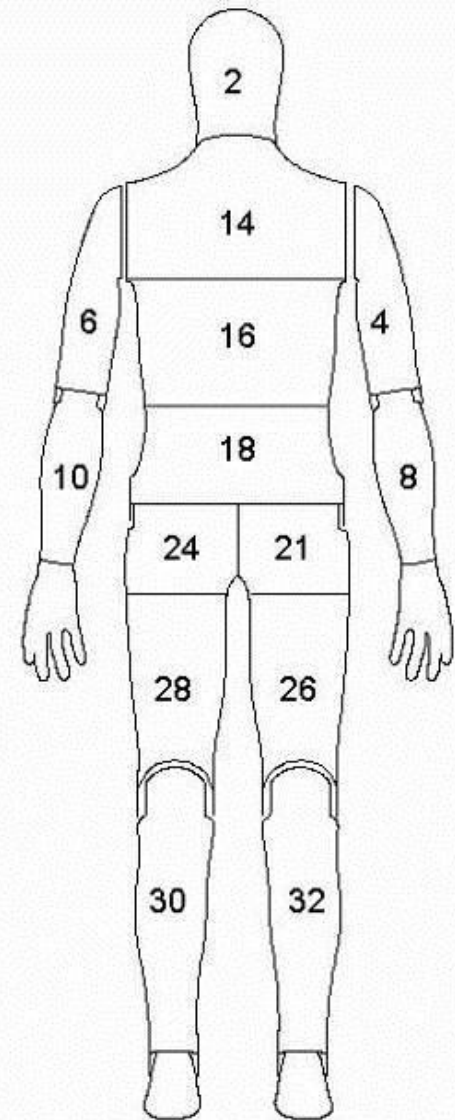
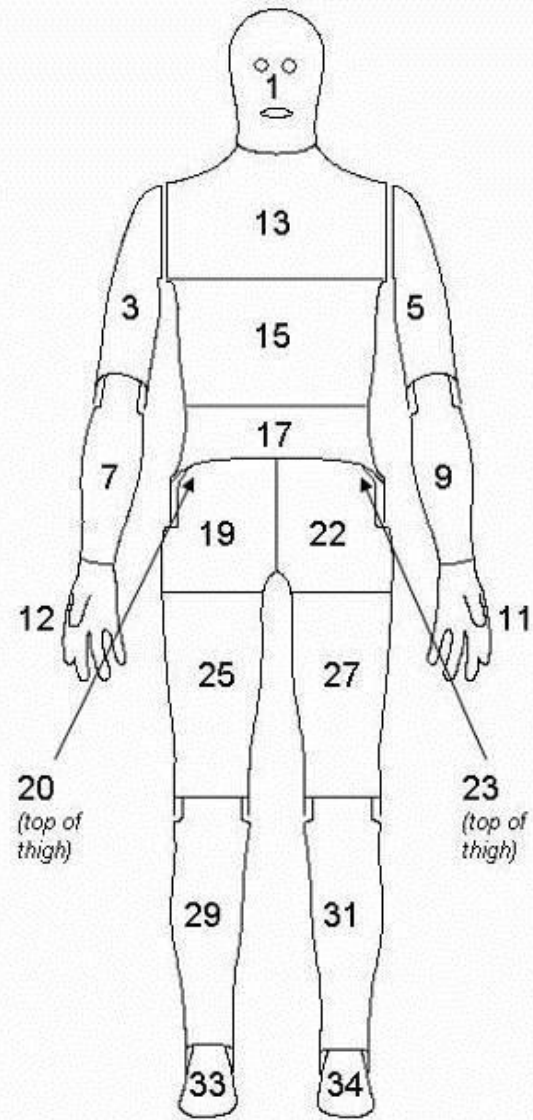
Sweating Thermal Manikin

Moisture & heat transport in apparel, workwear, PPE, car seats, office chairs, mattresses, duvets, etc.

- Standing, walking, sitting, lying
- Anatomical shape & size (standard man)
- Weight: 30 kg (66.14 lbs)
- 32 - 34 segments
- Simulation of sweating with sweat glands distributed over body
- Distributed heat & humidity sensors



Sherlock



Thermal / Sweating Manikins

Ready-made garments / clothing systems

- Thermal insulation
- “Breathability”
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- Range of utility



Charlie
(thermal)



Sherlock
(sweating)

Wear Tests

Weather Conditions in Climate Chamber

Wind



Rain



Heat



Wear Tests

Realistic Scenarios & Environmental Conditions



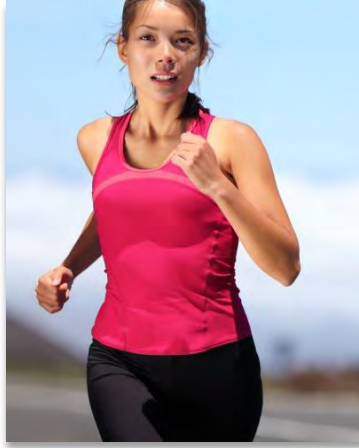
Thermo-physiological Validation Monitored Wear Trials



- Simulation of various weather conditions & activities in a climatic chamber
- Skin temperature & humidity measurements via sensors
- Subjective comfort judgement by the subjects
- Suitable for subjective evaluation of heating and cooling effects but even greater deal of time & effort
- Human testers & numerous ready-made garments needed

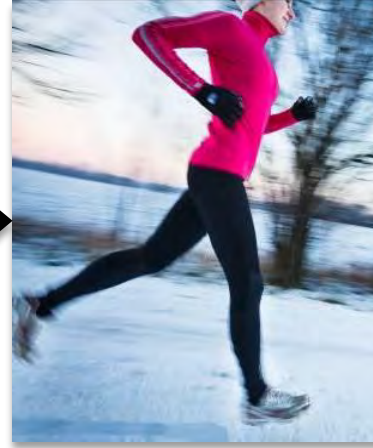


Prediction Model



Wearer

- Weight
- Surface Area



Activity

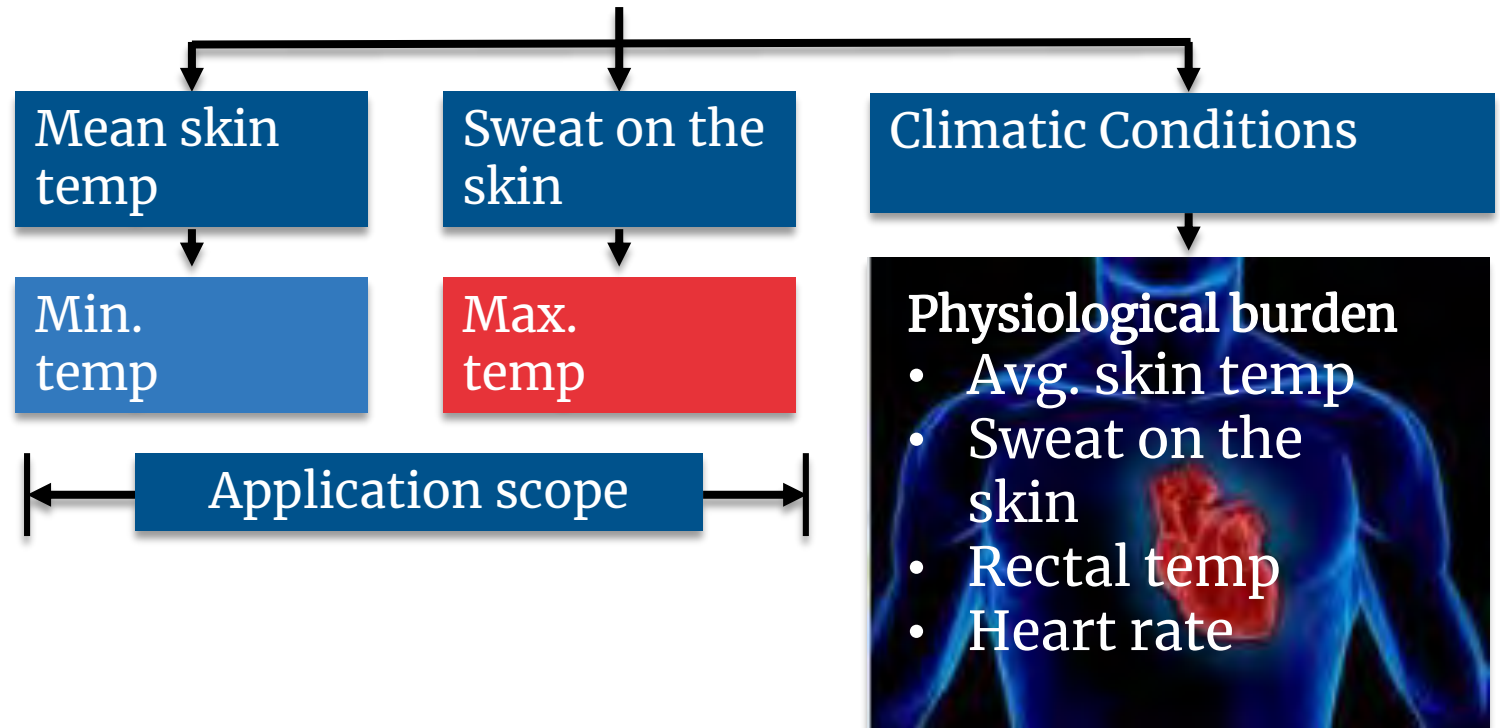
- Metabolic rate



Clothing

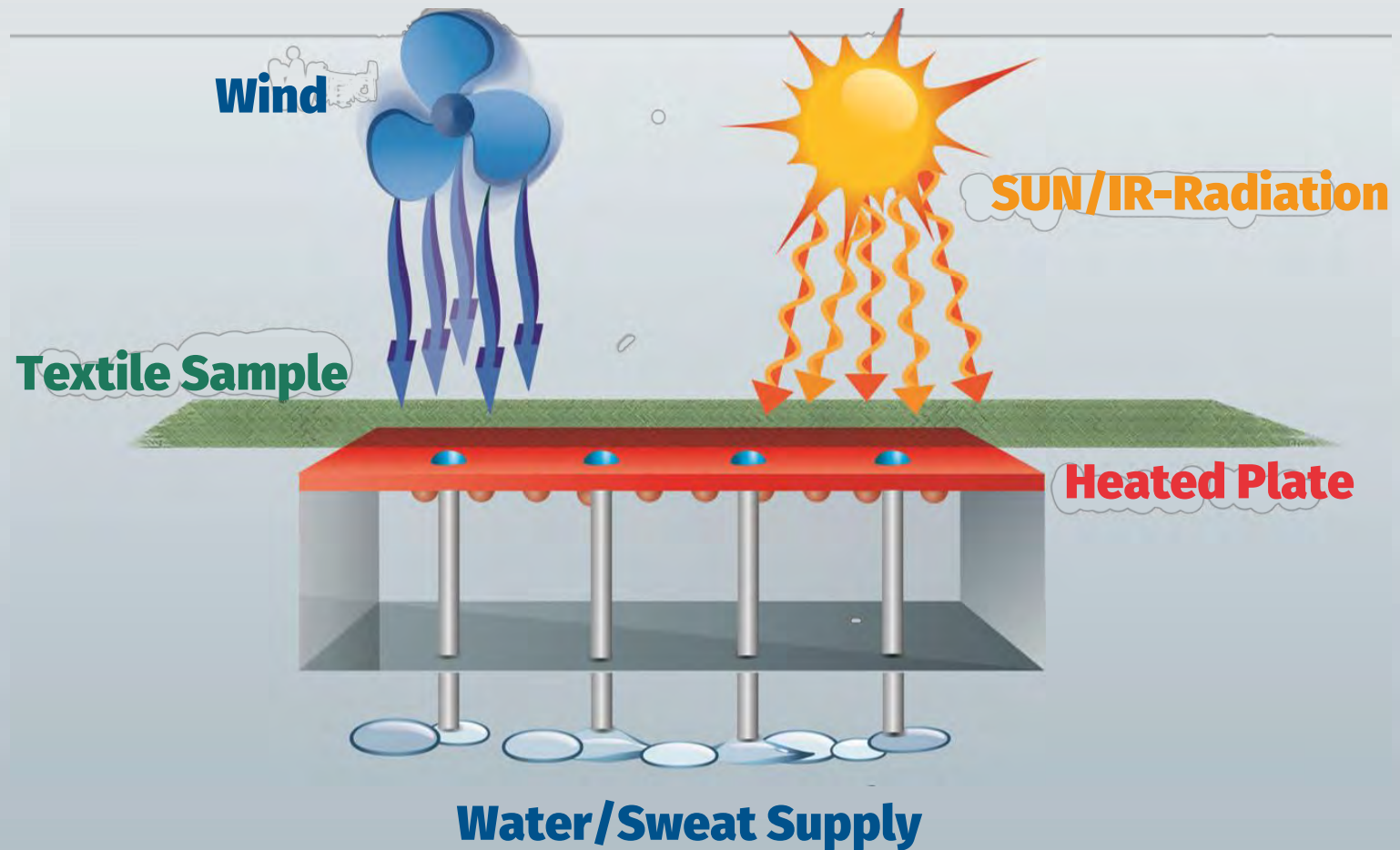
- Thermal insulation
- Water-vapor transmission resistance

Determination of Clothing Scope & Comfort



WATson

Controlled Ambient Climate



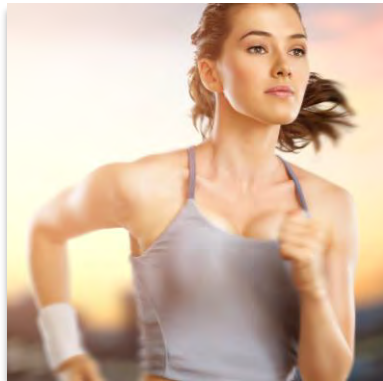
WATson = Wärme Abgabe Tester (Heat Release Tester)



WATson

Quantifying Heat Loss or Gain

- Versatile thermal testing device for special conditions
- Measuring head: fast response time to simulate the thermoregulation of human skin
- Various ambient climates (hot/humid - cold/dry)
- Numerous conditions (sweat, wind, “sun”)
- Results: cooling (heating) power/area in Watts, temperatures under & above the sample

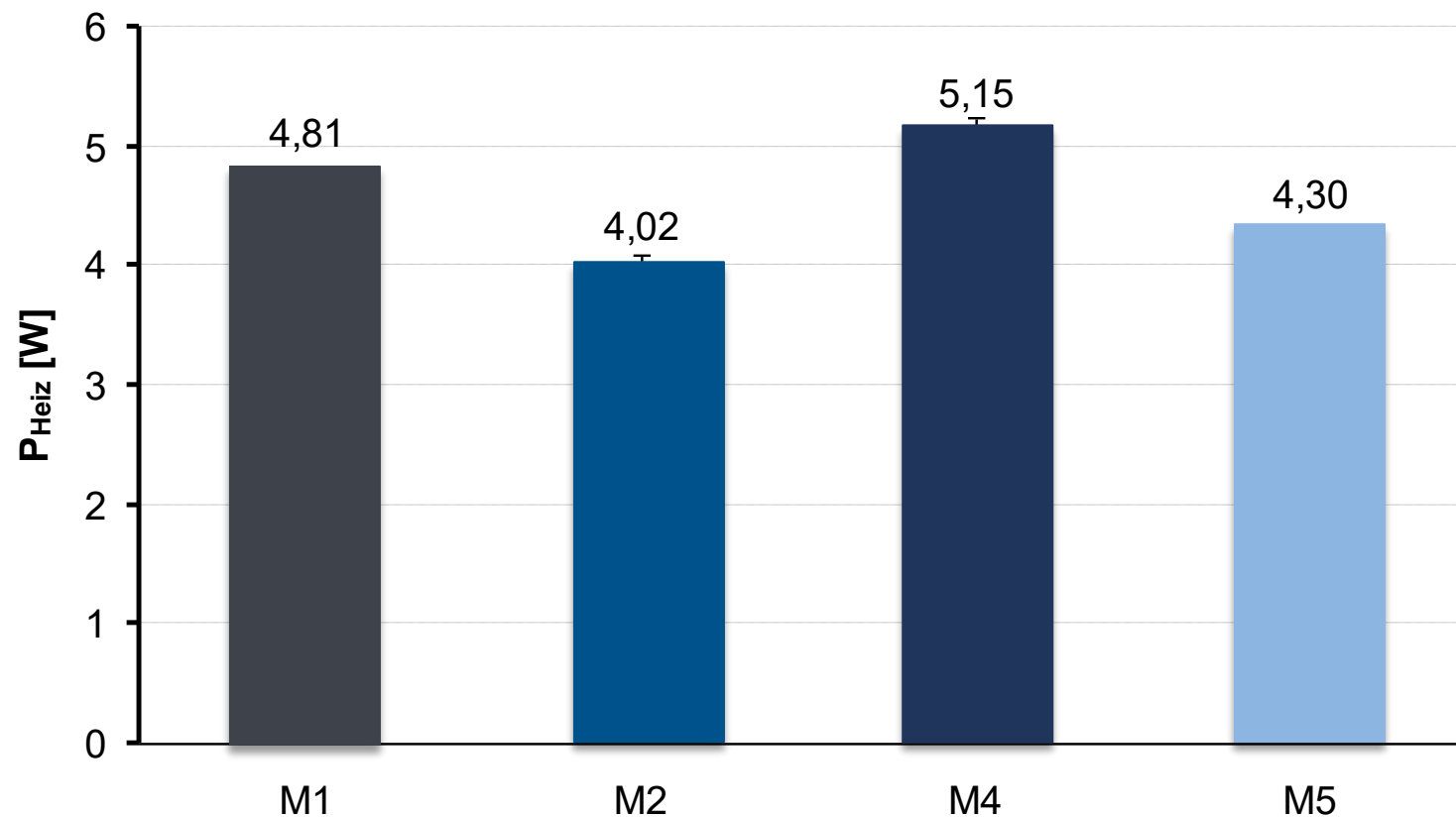


***Heating
Effect***

***Heat Gain by
Solar
Radiation***



Average Heating Power by Solar Heat Gain

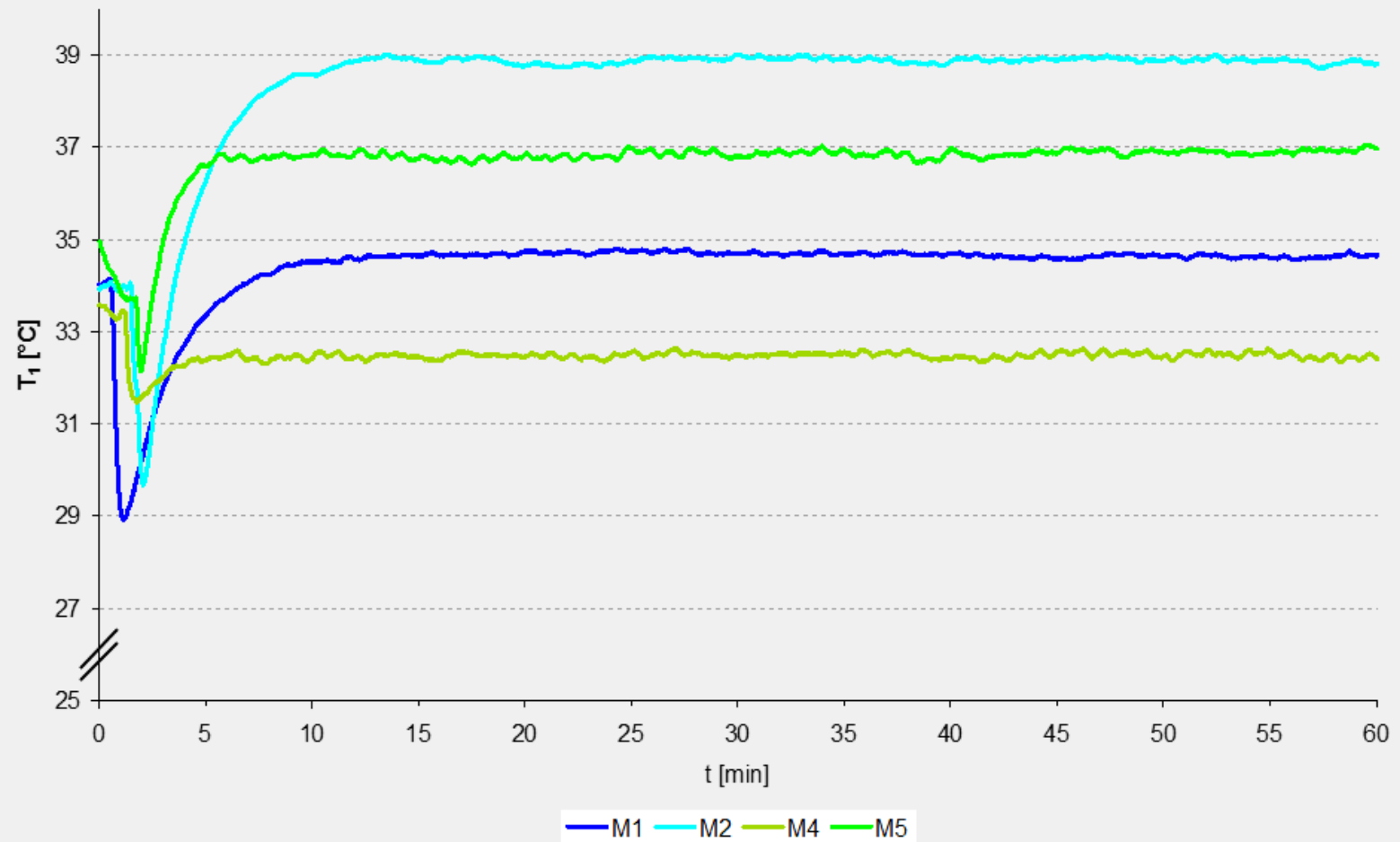


No heating



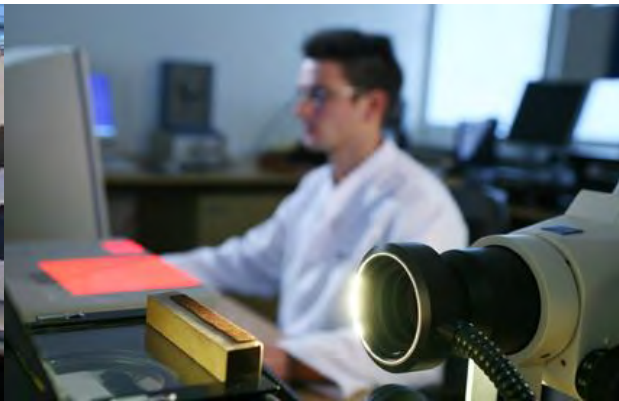
**Increasing
heating
power**

Temperature between Measuring Head & Sample over Time

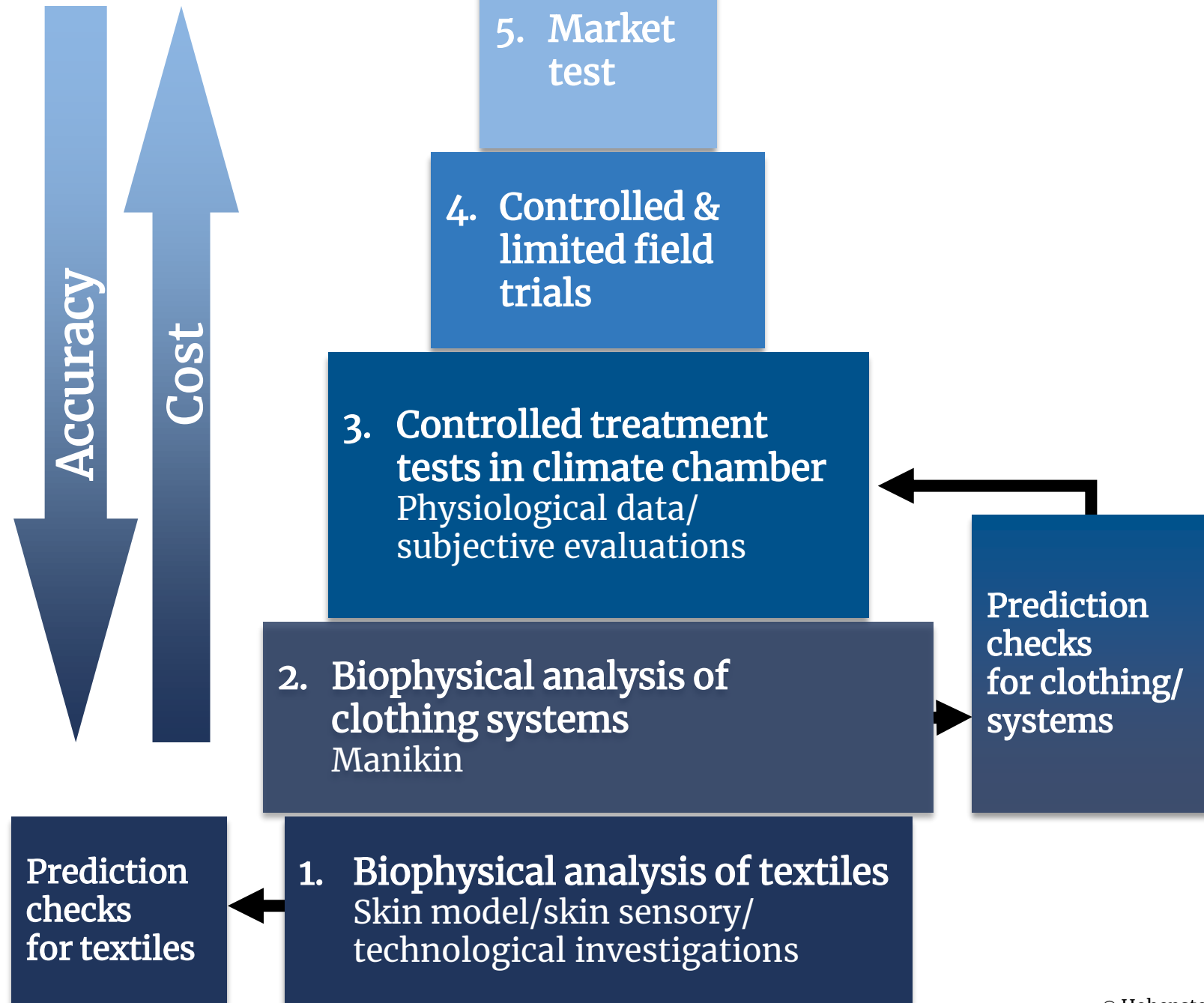


Clothing Physiology

- Assessment of comfort of textiles, clothing, home textiles
- Climatic comfort of car seats
- Determination of physiological stress as a function of clothing, climate & activity
- Development of design guidelines for optimized textiles



Clothing Physiology Methods



Thank you

Ben Mead

Managing Director

Hohenstein Institute America

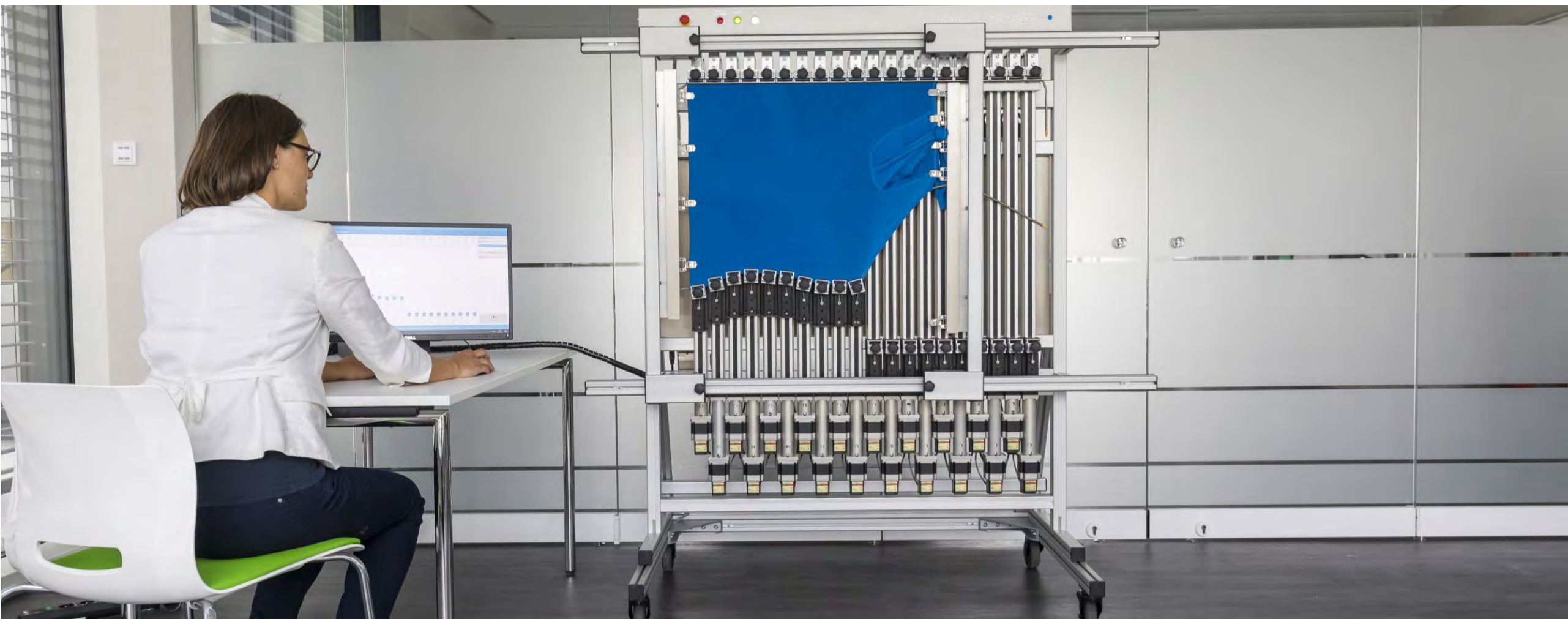
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Hohenstein.US

HOHENSTEIN ●

Compression and Fit for Sportswear



Hohenstein Testing & Product Development Services

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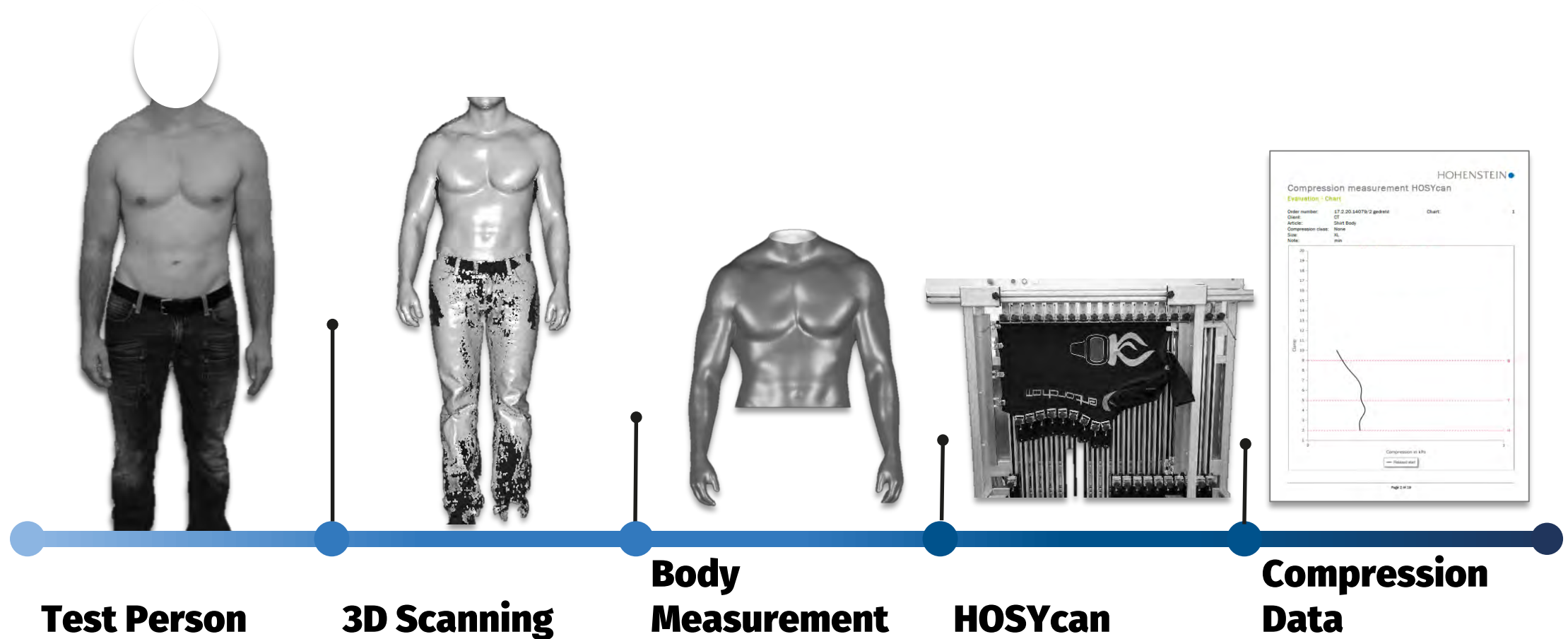


Hohenstein Compression Testing Device

HOSYcan measures

- Accurate compression & compression behavior during movement for
 - Defined standards (e.g. RAL)
 - Individual requirements & specifications
- Interaction between materials
- Combined with data from 3D scanning, simulated movement profiles provide increased accuracy for specific applications





Compression Analysis Process

Correlation Between Compression & Shape



Compression force & gradient can be quantified by HOSY

Resulting body shaping effect can be quantified & visualized via 3D-analysis



Compression Products

Product Development

Medical Products

Compression stockings for varicose veins or high risk of thrombosis (blood clotting)



Non-Medical Garments

Performance or shaping effect in sportswear, shapewear, wellness textiles



Compression Products

Compliance & Consumer Communication

Medical

Tested for compliance with

- RAL-GZ 387/1 (hosiery, bandages)
- RAL-GZ 387/2 (compression sleeves)
- DIN 58133 (hosiery)

Medical product recognition

Non-Medical

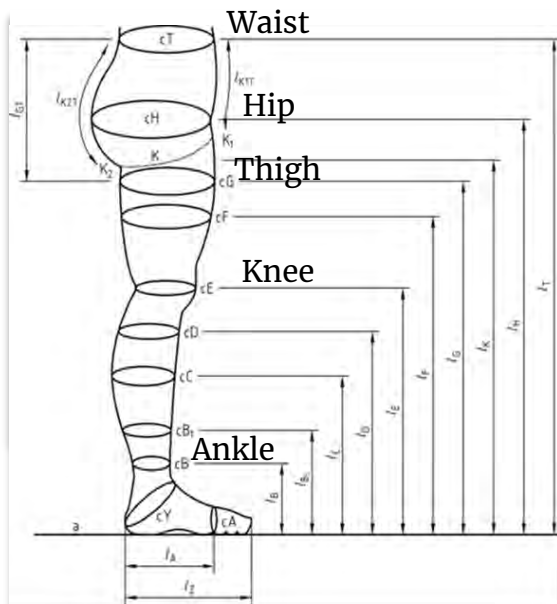
Quality label

Consumer communication of independently verified compression properties



HOSY Test Prep

1. Define heights & circumferences



2. Mark measuring points on textile



3. Insert sample in required length



4. Move lower clamps to variable positions



HOSY Test

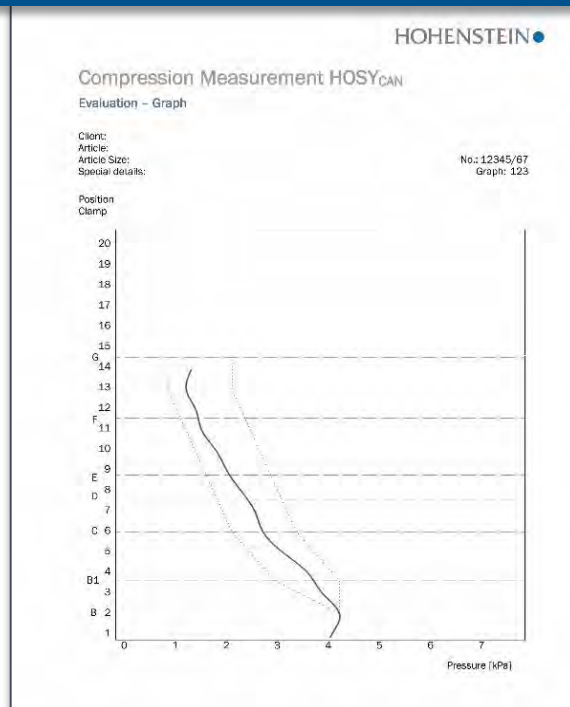
5. Stretch compression garment to specific girth

20 points moving at
individual velocities to
preset dimensions



HOSY Test Results

6. Graph – compression characteristics along body part



7. Data length & circumferences, pressure, residual pressure & practical elongation

HOHENSTEIN

Compression Measurement HOSY_{CAN}
Evaluation – Table

Client:
Article:
Article Size:
Special details:

Order No: 12345/67
Table: 123

Position	Circ. [cm]	Height [cm]	Messstellen				
			Practical elongation [%]	Tension [N/cm]	Pressure [kPa]	Pressure [mmHg]	
B	21.0	12.0	19.3	1.41	4.21	31.6	100.0
B1	28.0	20.0	29.4	1.66	3.71	27.8	88.1
C	37.0	32.0	30.5	1.60	2.71	20.3	64.5
D	32.0	40.0	13.3	1.24	2.41	18.1	57.2
E	35.5	46.0	13.3	1.16	2.06	15.5	48.9
F	47.0	60.0	12.5	1.08	1.44	10.8	34.3
G	53.1	67.0	10.5	1.02	1.21	9.1	28.7

No.	Circ. [cm]	Height [cm]	Messstellen				
			Practical elongation [%]	Tension [N/cm]	Pressure [kPa]	Pressure [mmHg]	
1	21.4	7.0	18.2	1.38	4.06	30.5	95.5
2	21.0	12.0	19.3	1.41	4.21	31.6	100.0
3	24.5	17.0	23.9	1.51	3.87	29.0	92.0
4	30.5	22.0	32.4	1.74	3.59	26.9	85.2
5	35.7	27.0	33.6	1.76	3.10	23.3	73.6
6	37.0	32.0	30.5	1.60	2.71	20.3	64.5
7	33.4	37.0	16.6	1.36	2.55	19.1	60.7
8	32.4	42.0	13.0	1.18	2.29	17.2	54.4
9	36.4	47.0	13.5	1.16	2.01	15.1	47.7
10	40.5	52.0	14.6	1.15	1.79	13.4	42.6
11	44.5	57.0	13.1	1.07	1.51	11.3	35.9
12	48.8	62.0	11.9	1.08	1.40	10.5	33.2
13	53.1	67.0	10.5	1.02	1.21	9.1	28.7
14	56.2	72.0	16.0	1.17	1.31	9.8	31.0

The results show the average of 1x measurements.

8. Test report

HOHENSTEIN

Hohenstein Laboratories
GmbH & Co. KG

Schloss Hohenstein
7367 Hohenstein - Germany

Customer Tests
Phone: +49 7143 271 201
Fax: +49 7145 271 34 201
sales@hohenstein.de

Client: C. Deigo
Order No: CD
Date: 29. July 2018

Report No. 123 456

Client: See address

Test sample: 5 compression stockings with adhesive waist, compressed on class F, made to measure, NG

Aim of test: Quality confirmation test (made to measure 2016) according to IXL 42: 387/1.2008-01, section 3

Date of order: 15.04.2018

Receipt of order: 15.04.2018

Receipt of test samples: 15.04.2018

Period of testing: 30.06. to 19.07.2018

Preliminary results: 27.07.2018

Sampling: The test sample has been delivered to us by the client.

The Report comprises 4 pages and a set of tables of 2 pages.

Product Improvement

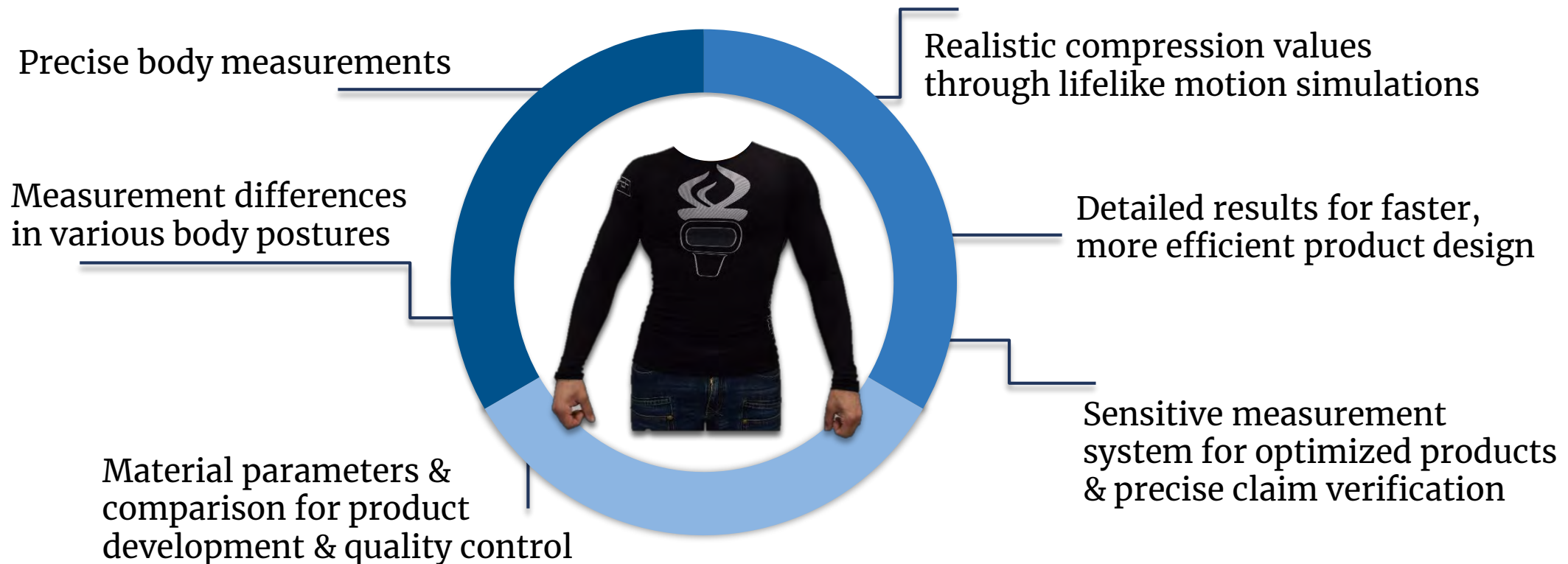
Change of knit

- On front at the chest area
- On back from neck to waist

Change of knit has a significant influence on the compression. The combination at front & back leads to relative moderate increase of compression in the chest area, comparable to waist area.



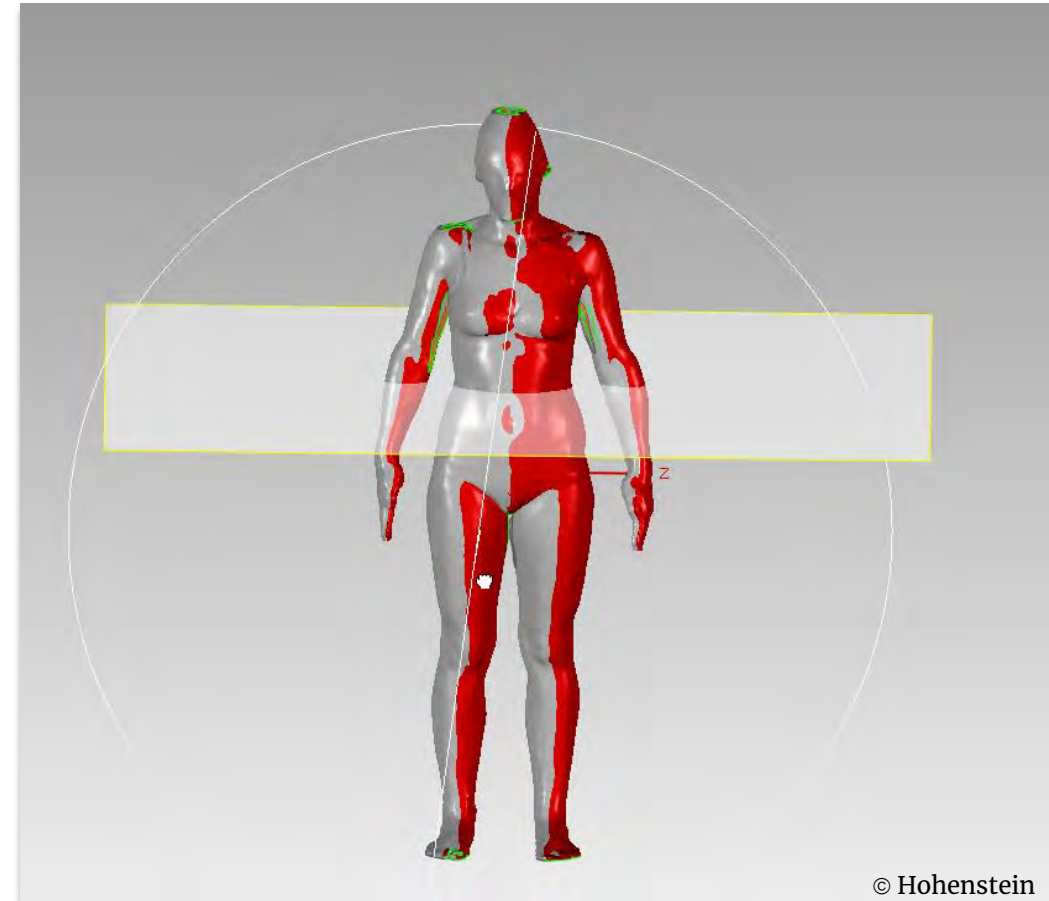
Compression Testing Benefits



Product Effectiveness - 3D Scan Combined with Fitting



1. Scan in underwear
2. Scan in compression wear/shapewear
3. Merge the scans



3D Analysis of Shaping Effects

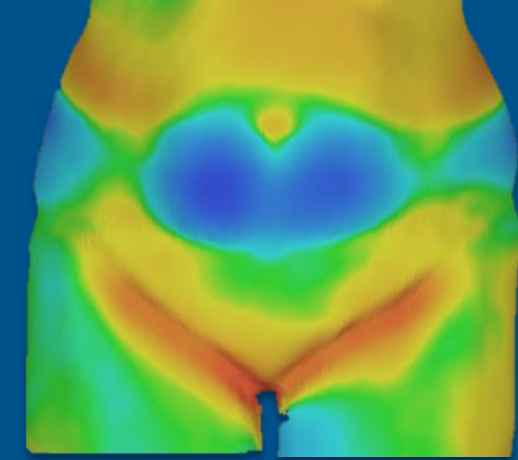
**3D Scan without
Compression/Shapewear**



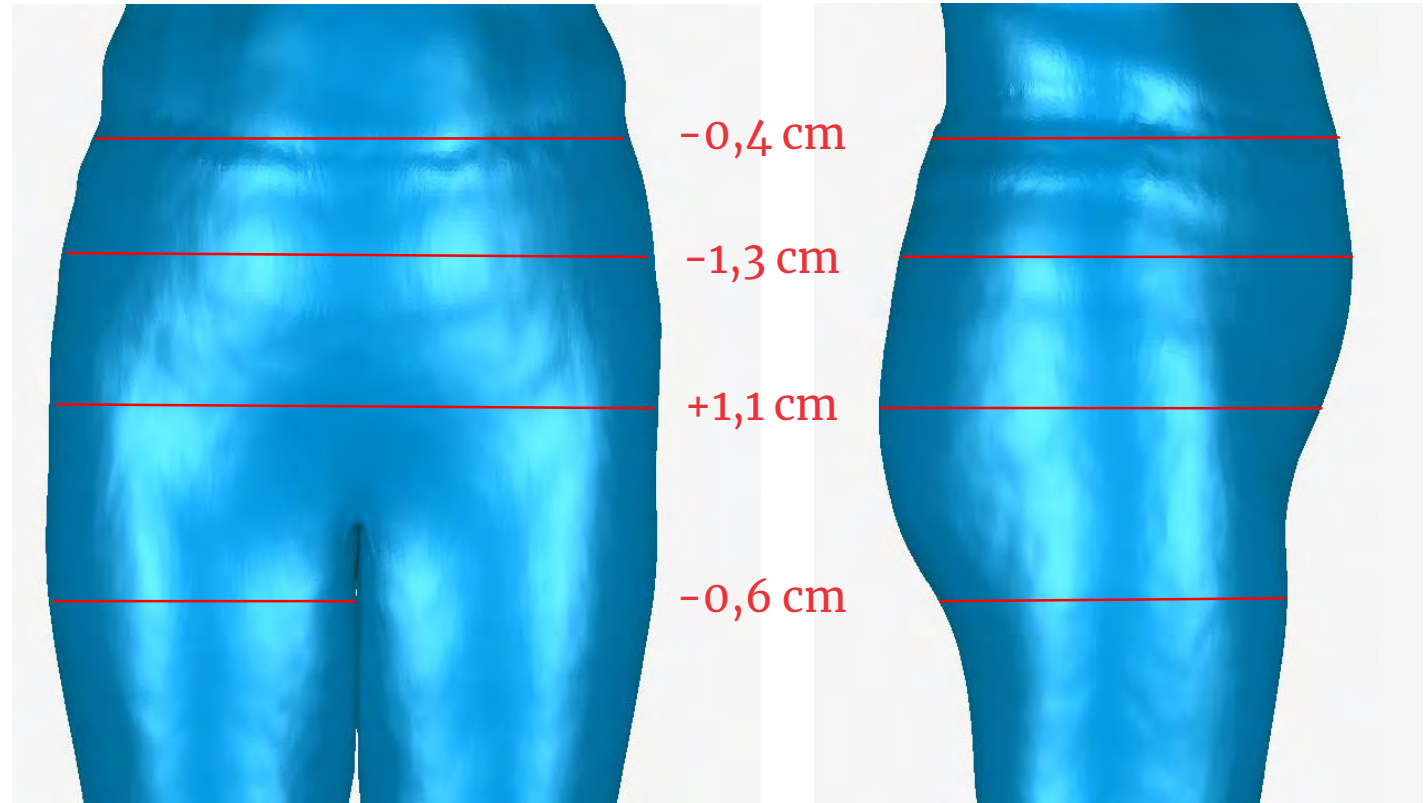
**3D Scan with
Compression/Shapewear**



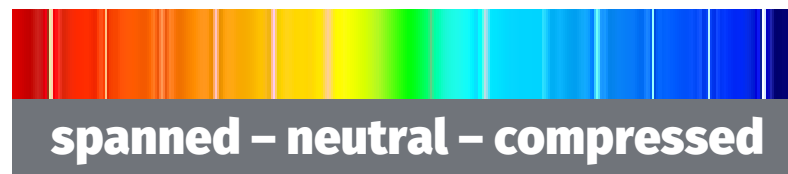
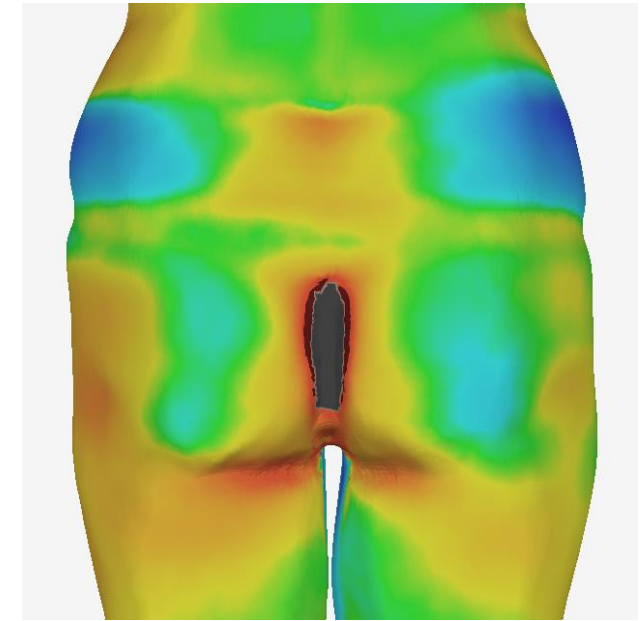
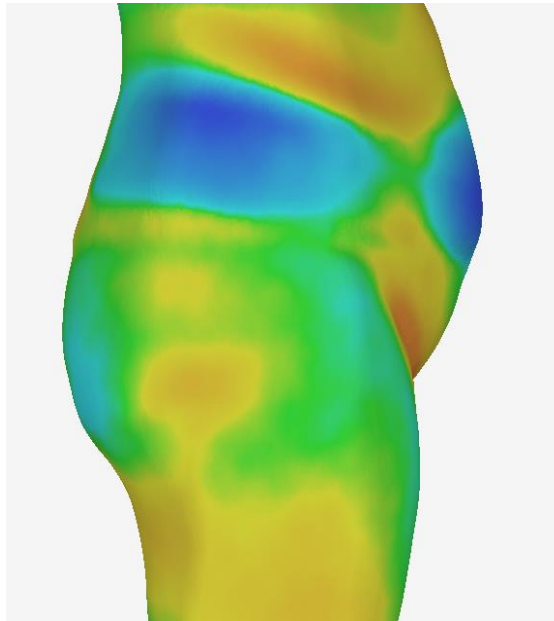
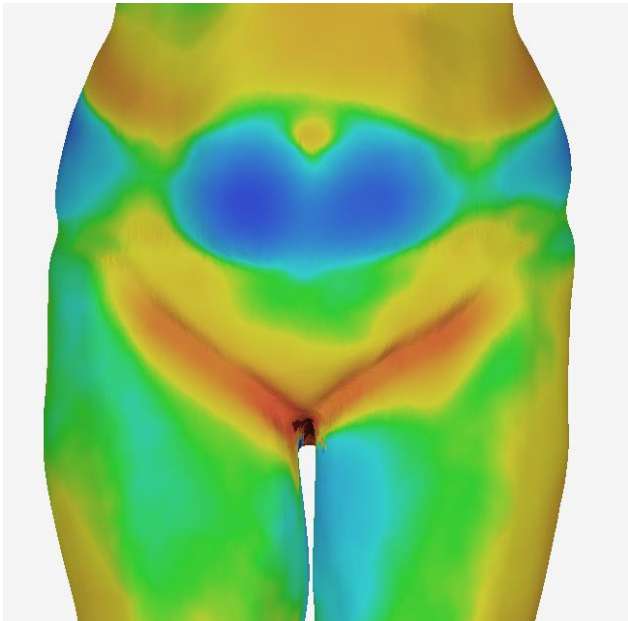
**Scan Comparison
(3D Analysis)**



Scan: Body Measurement Changes



3D-Analysis: Changes in Geometry



Shapewear Scan - Cross Section Silhouettes

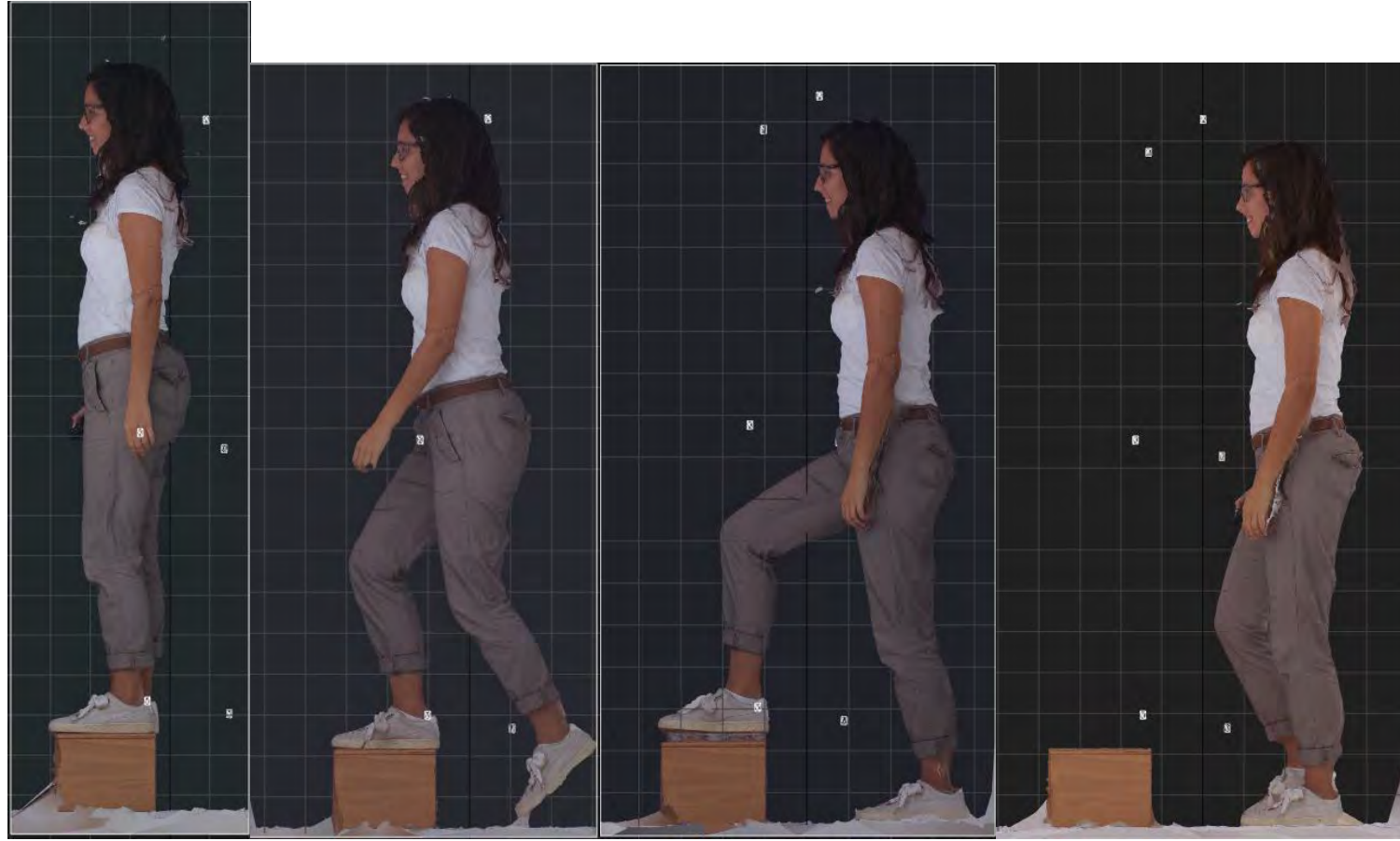


4D Scanning

HOHENSTEIN ●



Scanning in motion



Scanning in motion

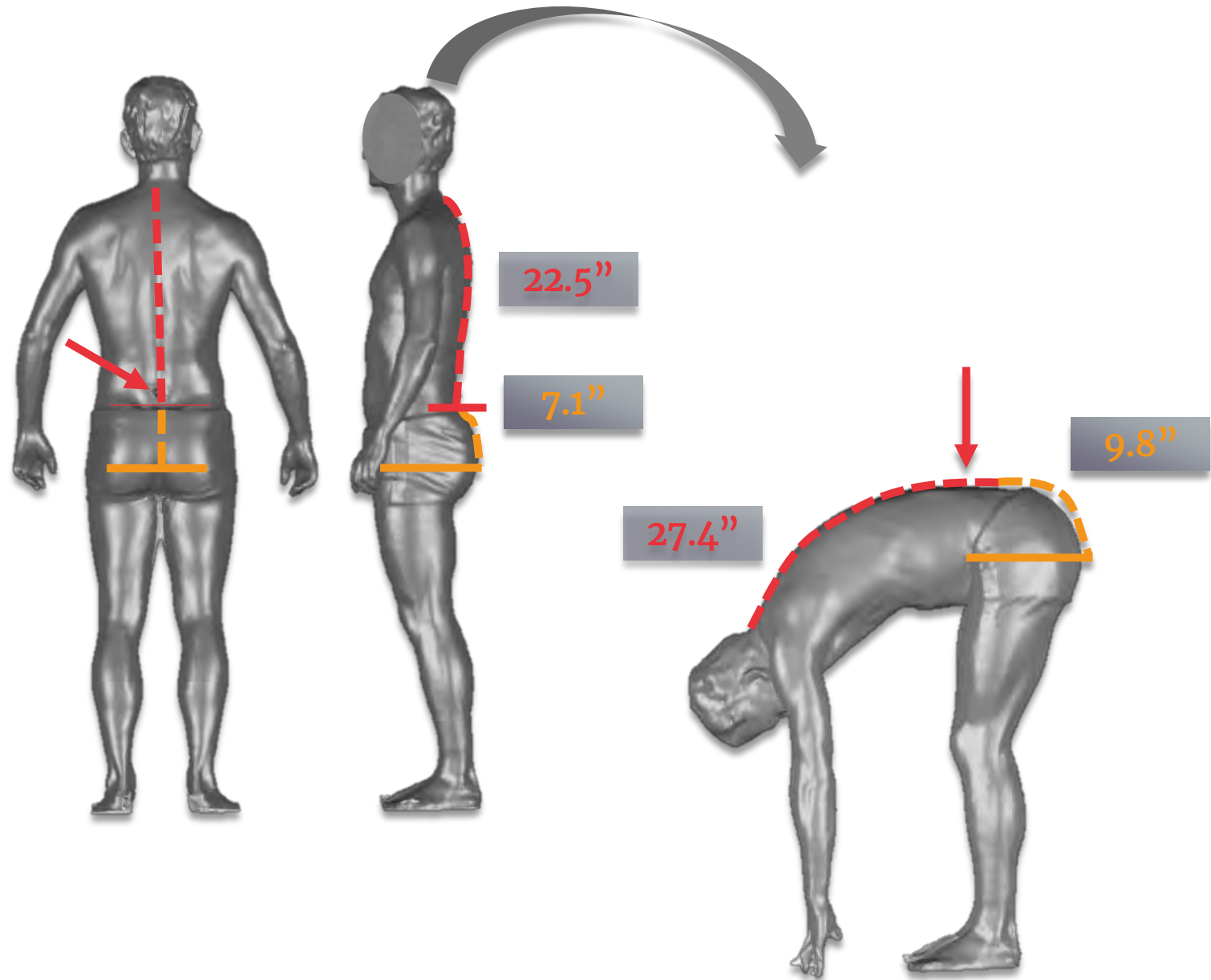




***How do body
measurements
change in
motion?***

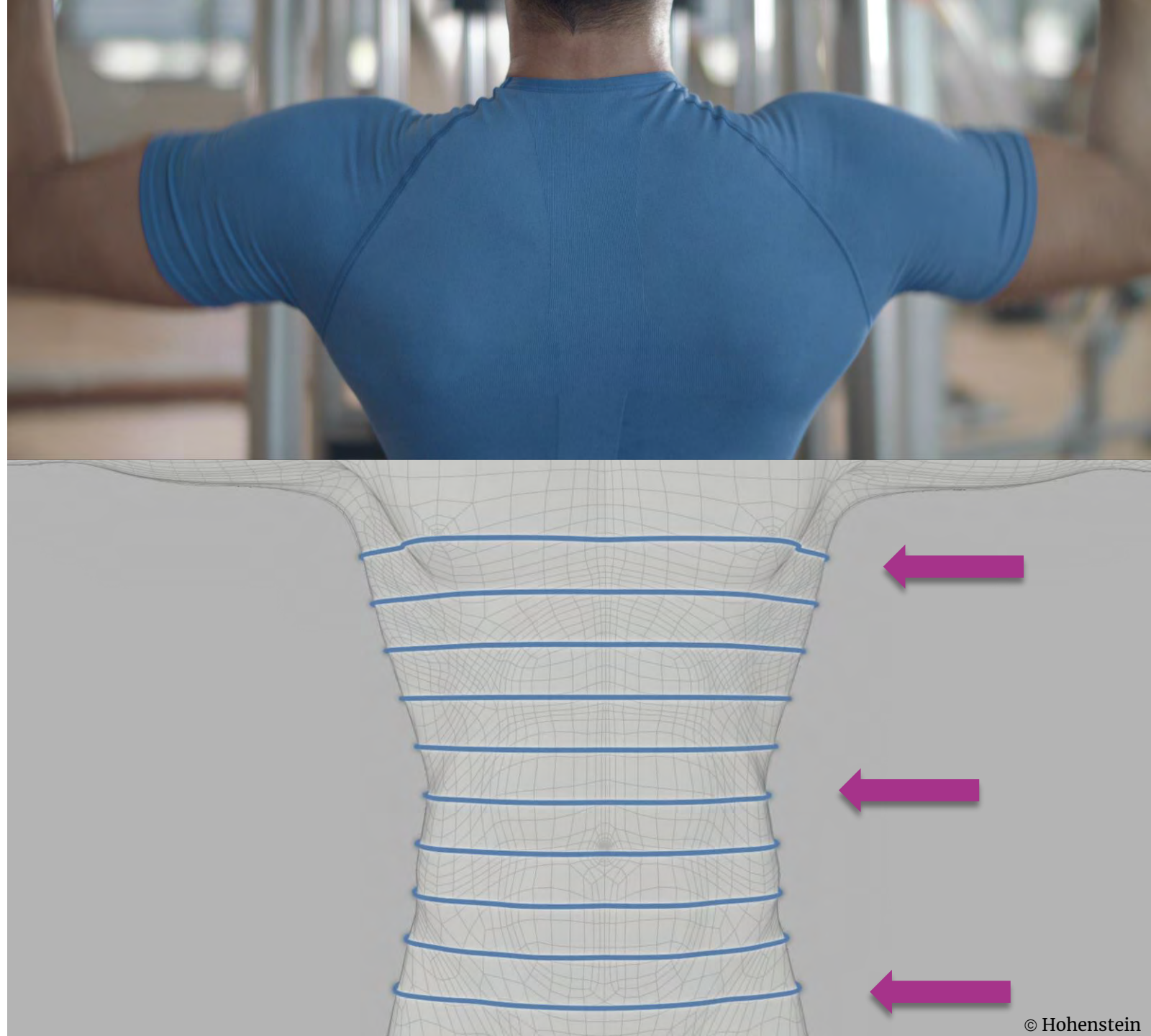
Opportunities for 4D Scanning

- 3D/4D capture of body movement measurements
- Restriction of mobility by ill-fitting clothing

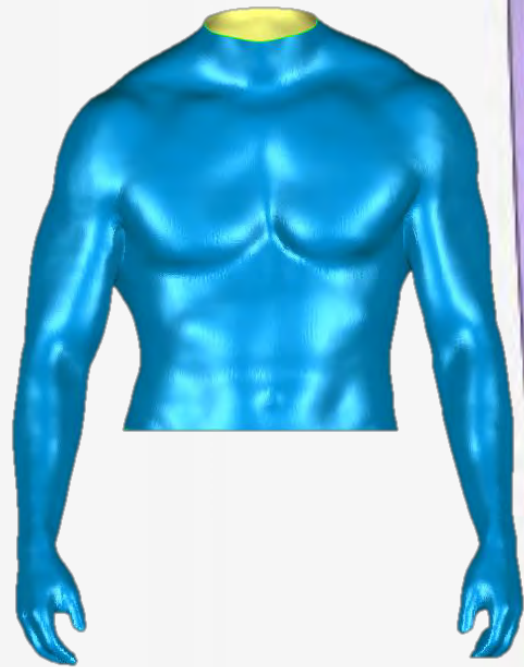


What happens during exercise?

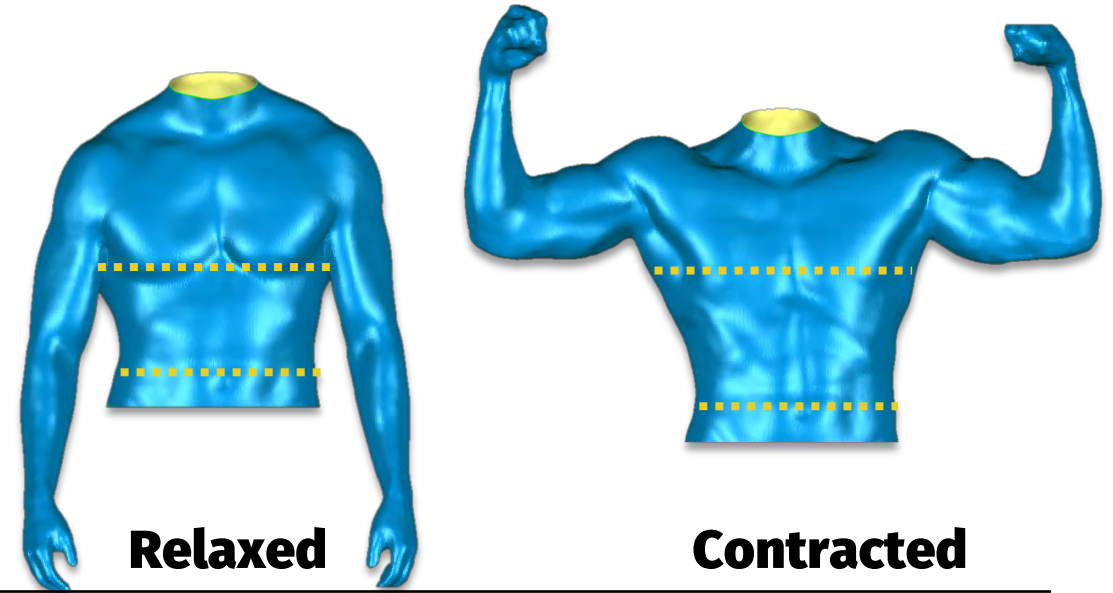
Depending on length of the shirt, at least 3 positions should be known – chest, waist, hip



Differences in body geometry



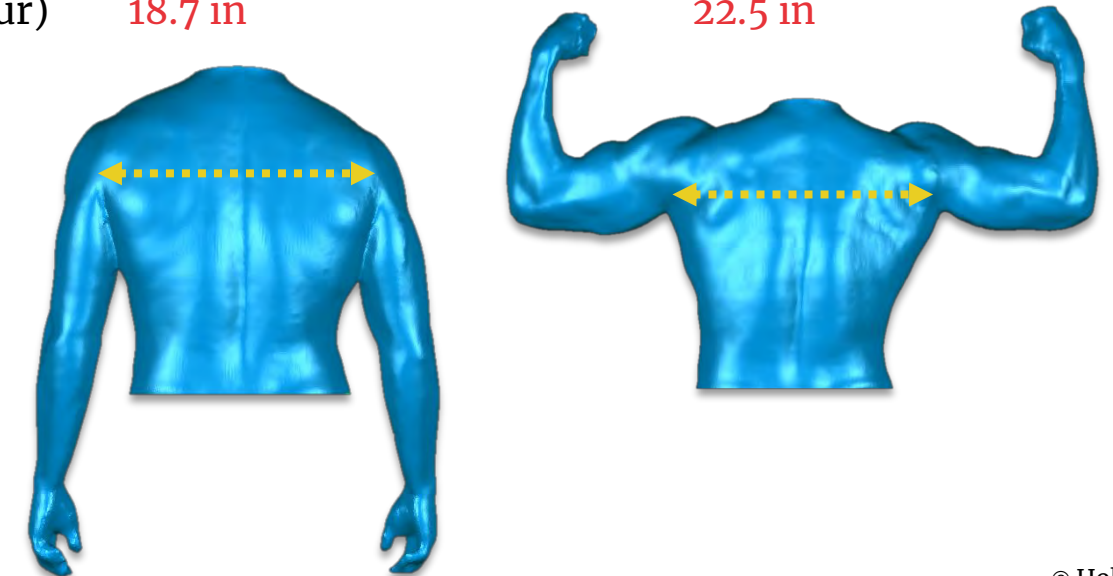
Movement Influences Body Measurement & Geometry



Relaxed

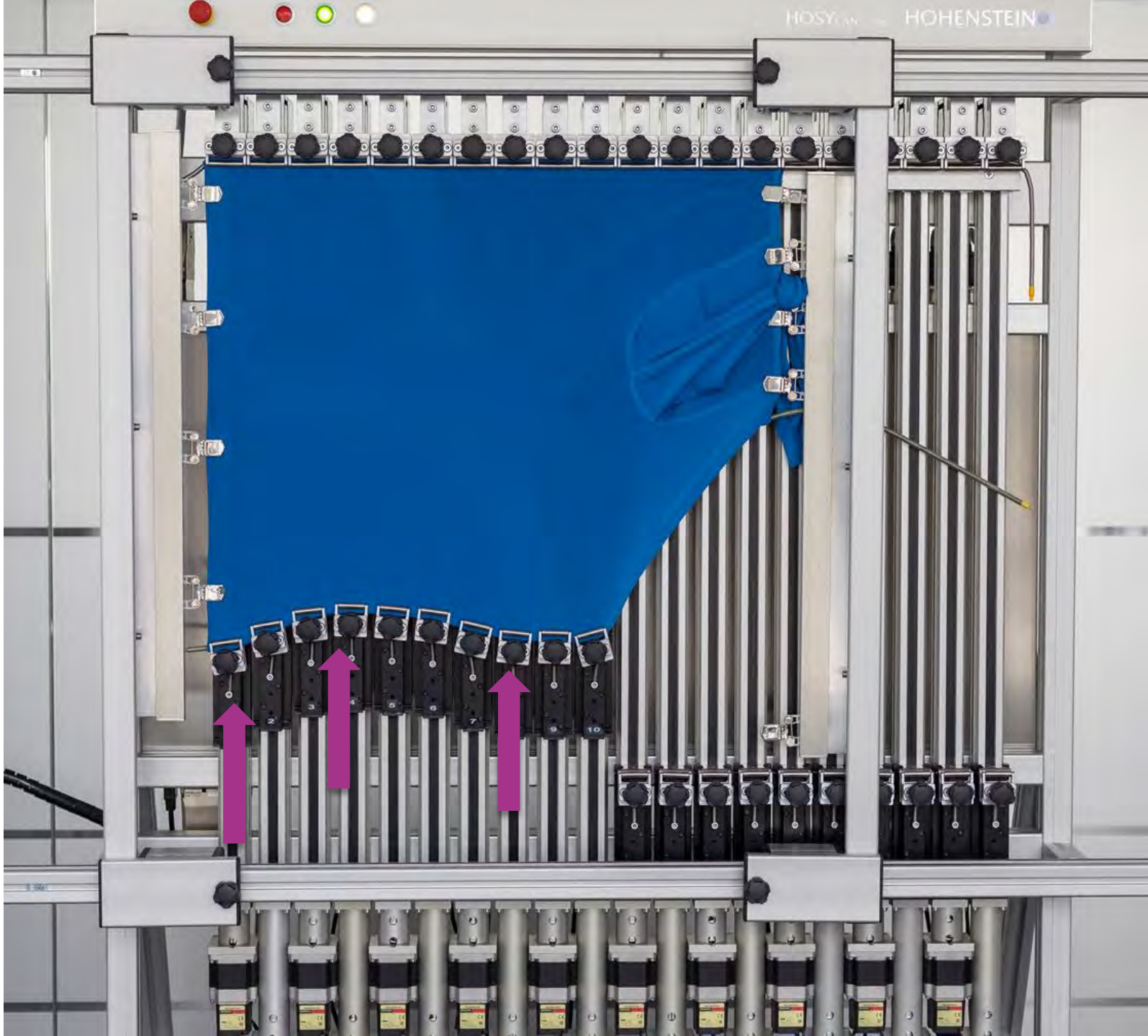
Contracted

Chest girth	45.7 in	47.8 in
Waist girth	35.7 in	35.9 in
Chest width (contour)	17.5 in	17.6 in
Back width (contour)	18.7 in	22.5 in

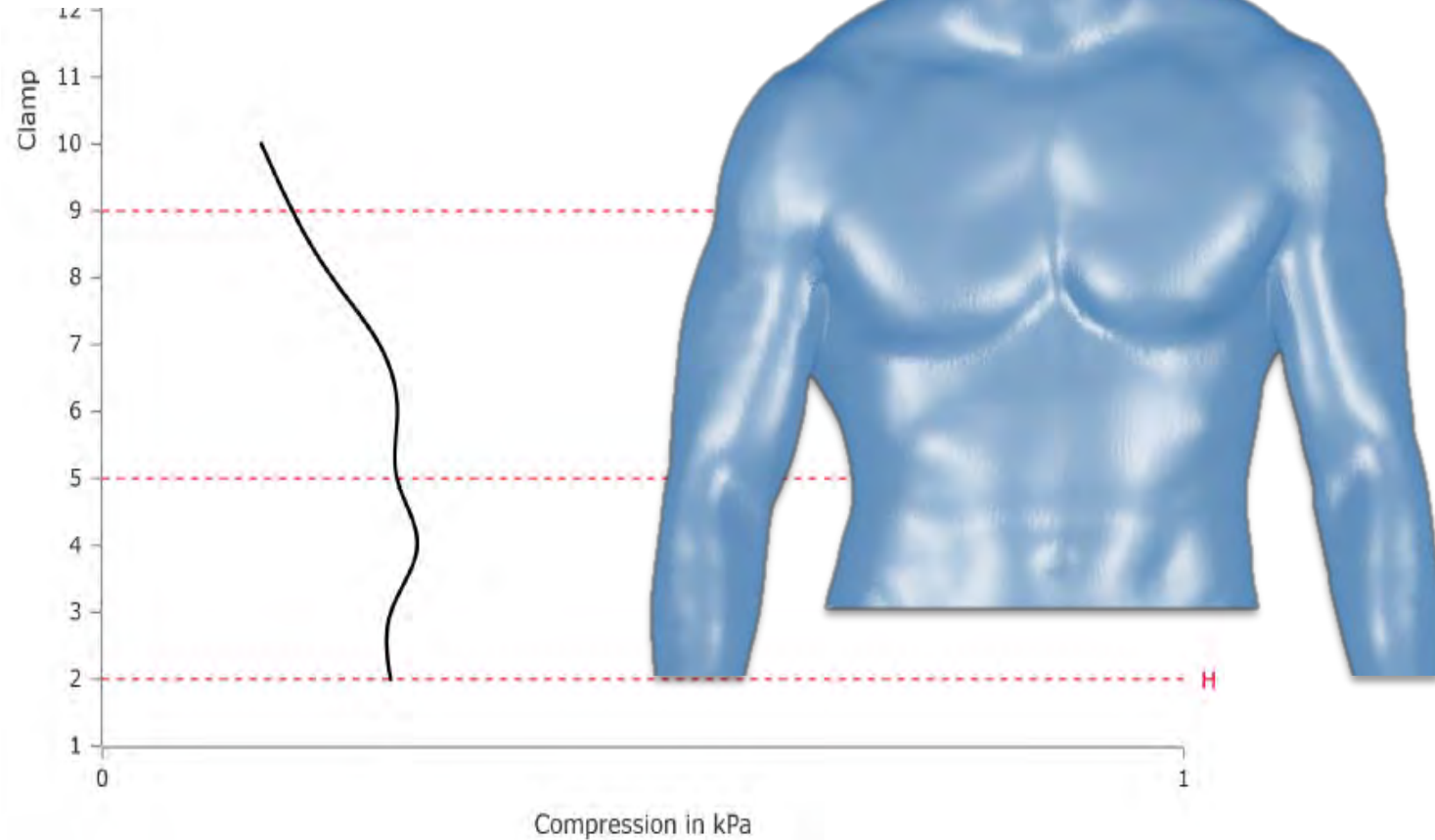


Hohenstein Database

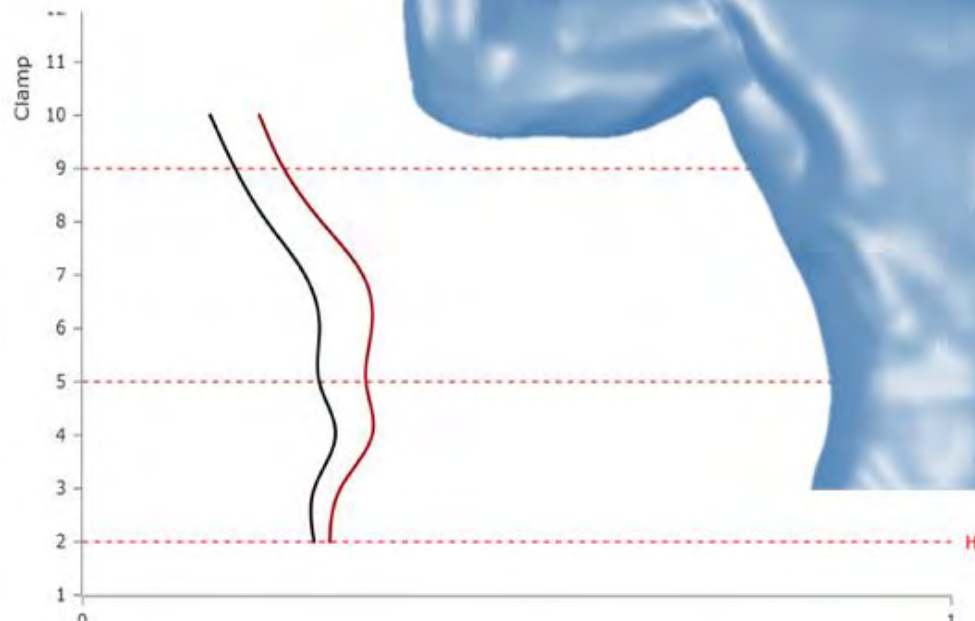
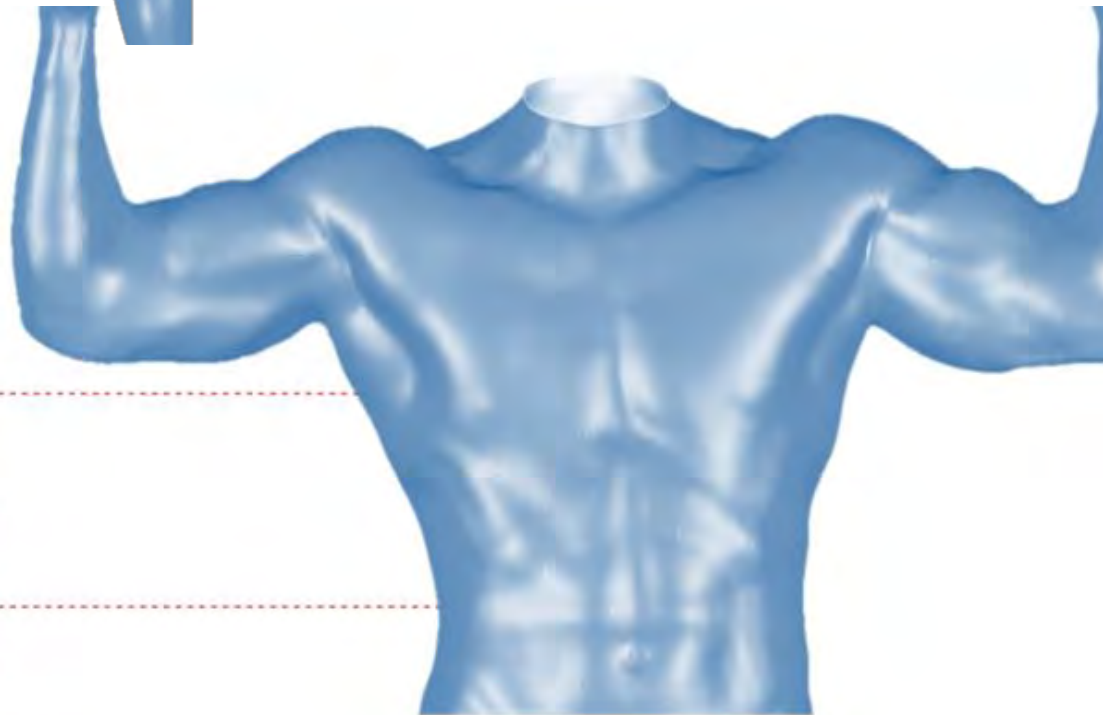
HOSYcan Testing



Body Results



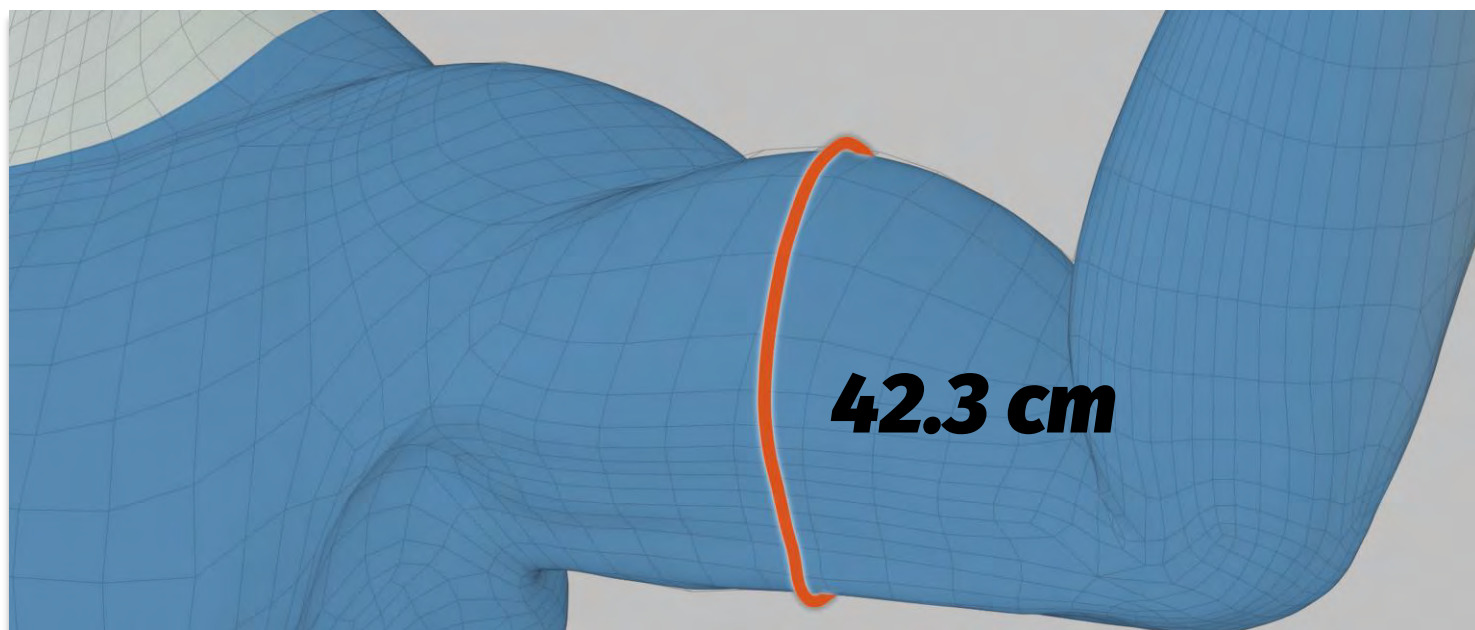
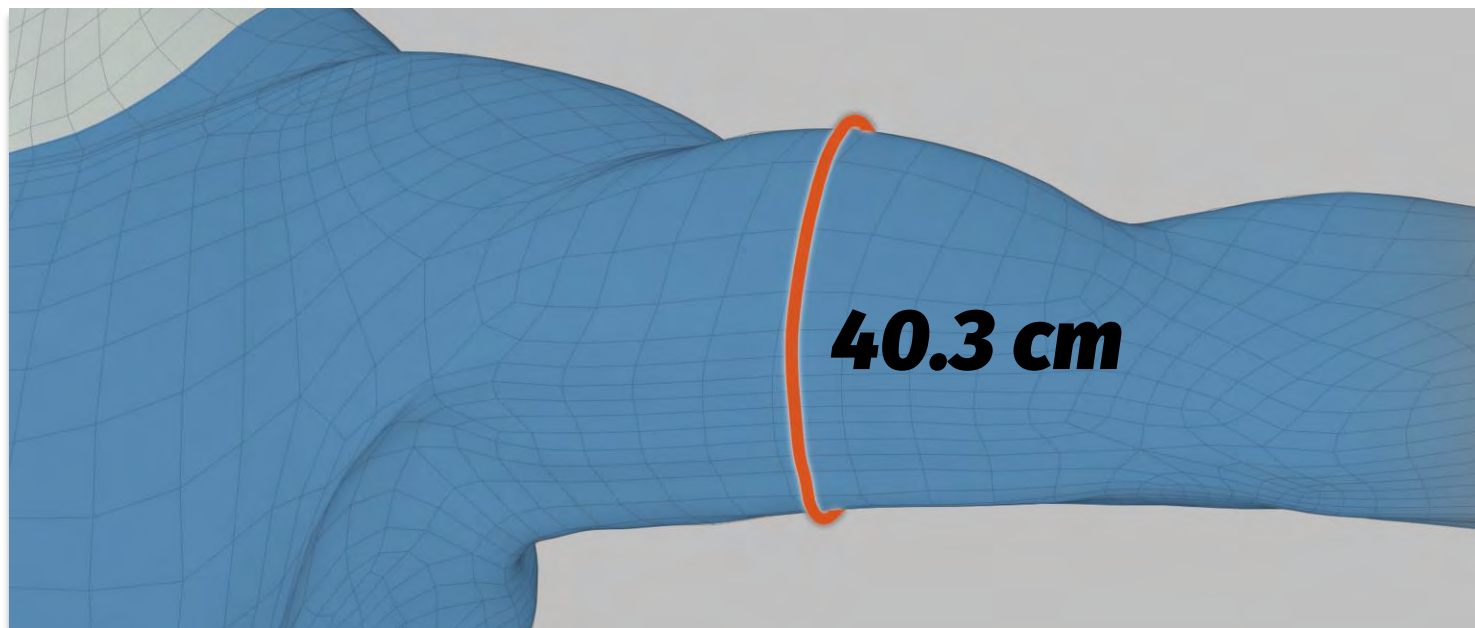
Chest	1.32 mmHg // 116.1 cm
Waist	2.04 mmHg // 89.9 cm
Hip	2.00 mmHg // 110.0 cm



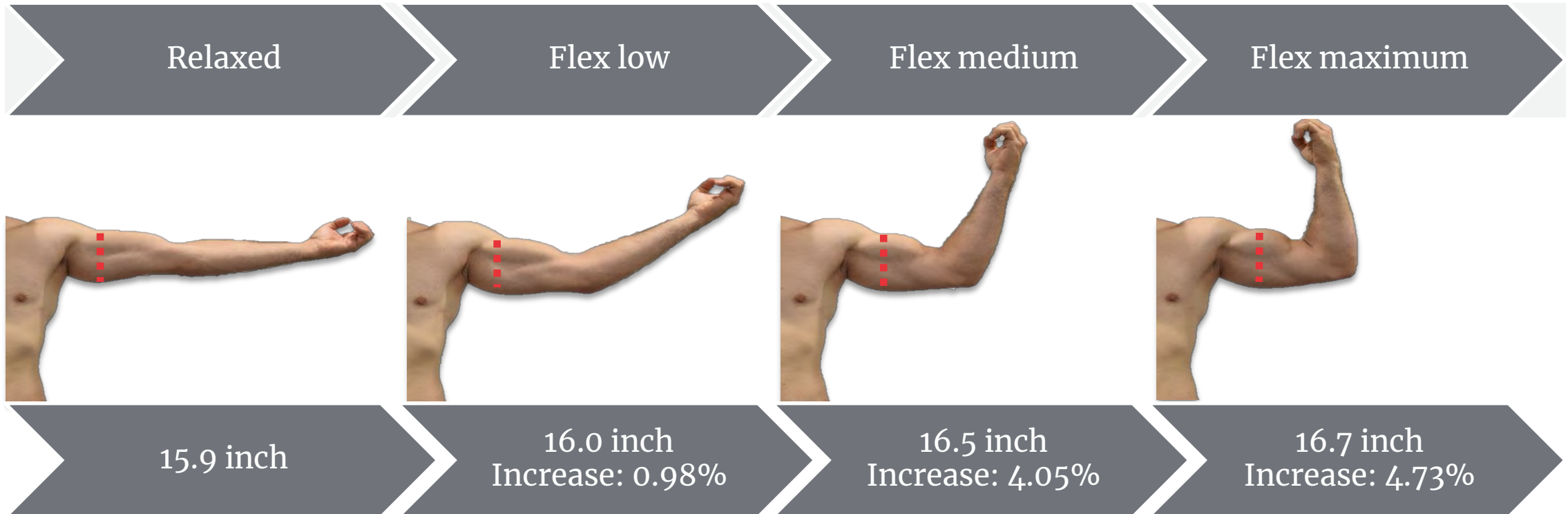
Body Results

Chest	1.74 mmHg // 120.9 cm 1.32 mmHg // 116.1 cm + 32 % // + 4%
Waist	2.45 mmHg // 91.9 cm 2.04 mmHg // 89.9 cm + 20% // + 2%
Hip	2.13 mmHg // 110.0 cm 2.00 mmHg // 110.0 cm + 7% // ± 0%

Arm Compression



Measurement Differences



HOSY Test

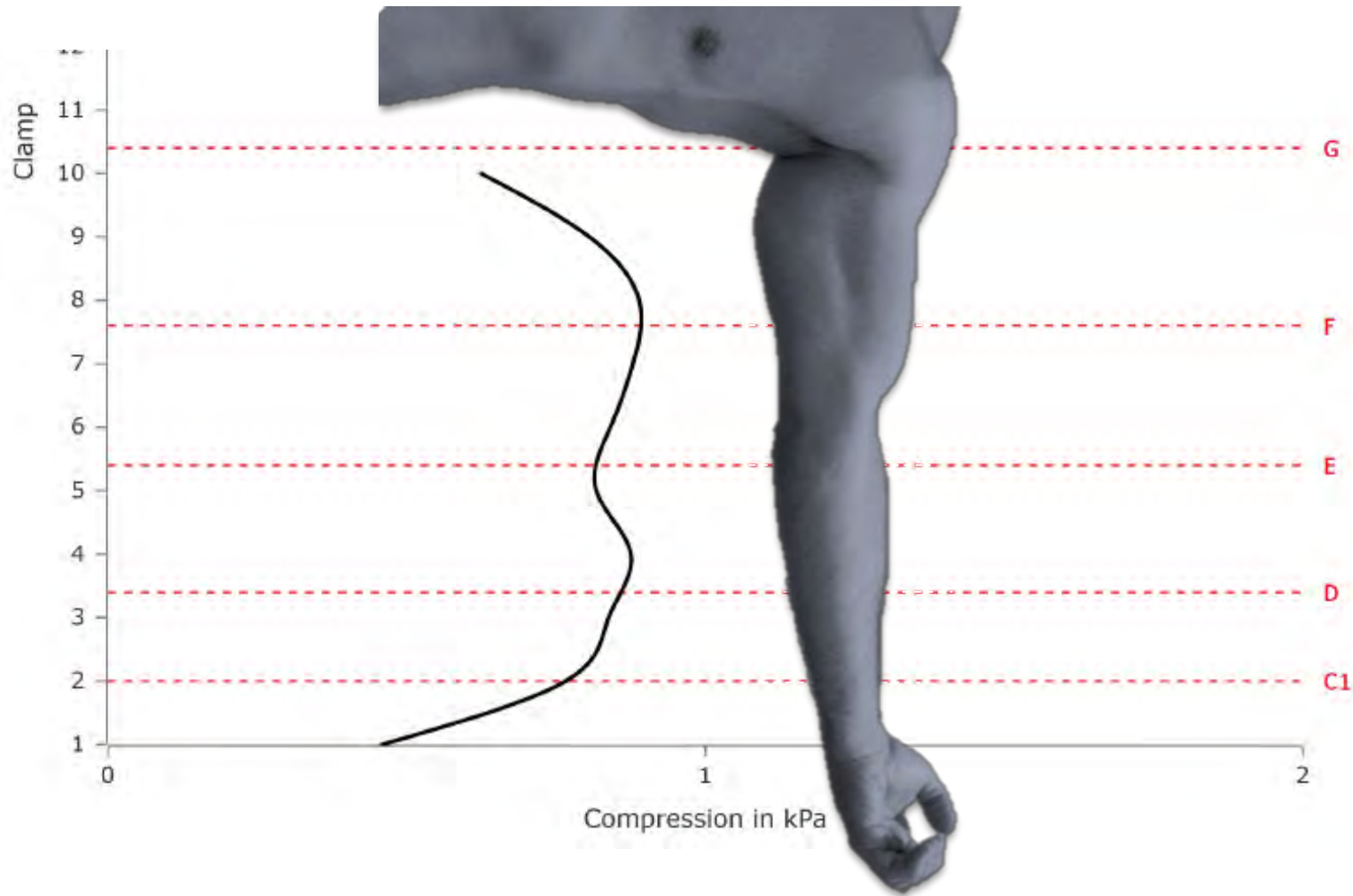
5. Stretch compression garment to specific girth

Simulating four flexes
& back again



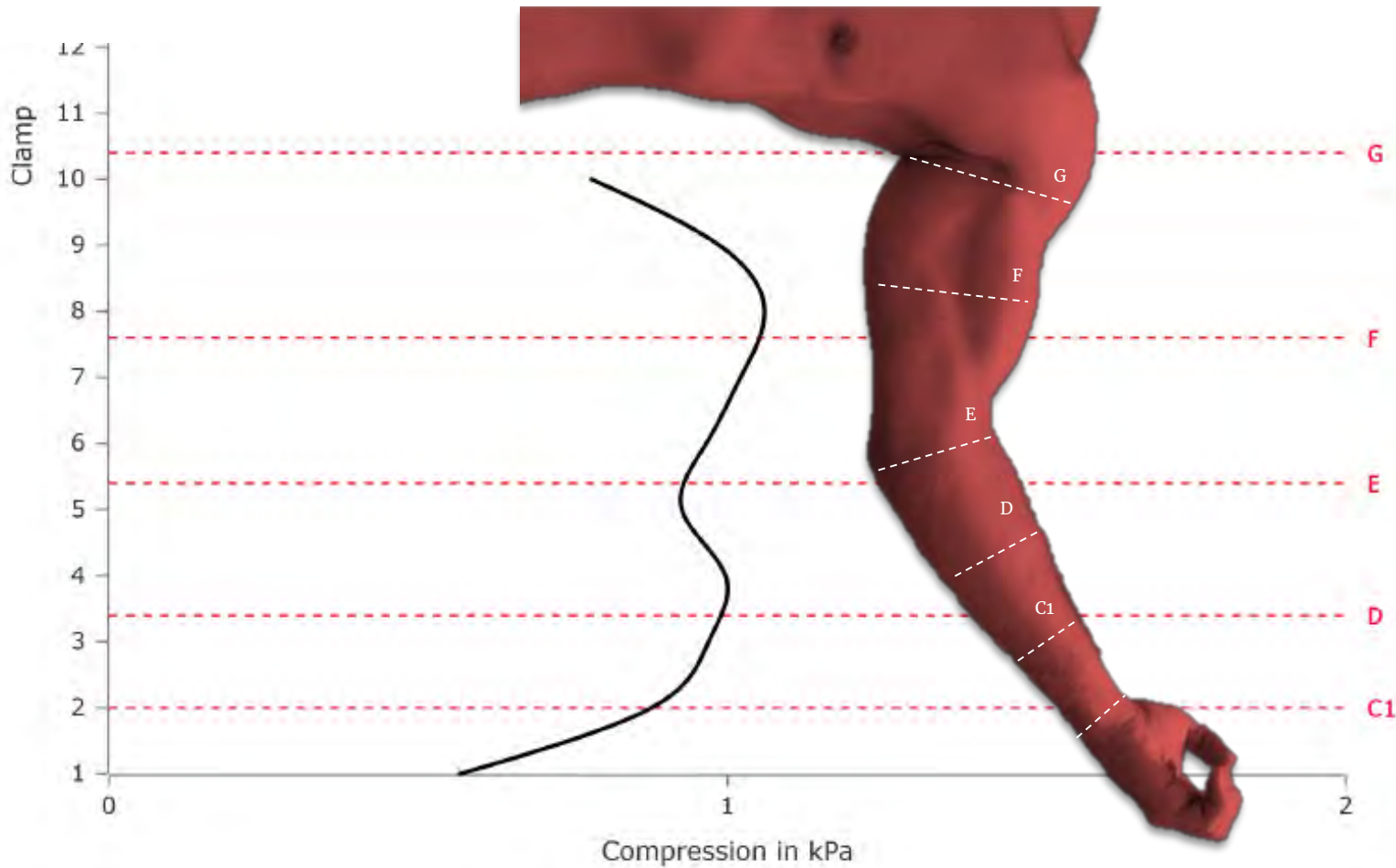
Arm Results

- Relaxed state, no muscle contraction
- Compression is due to practical stretch (difference between table measure & wear size)



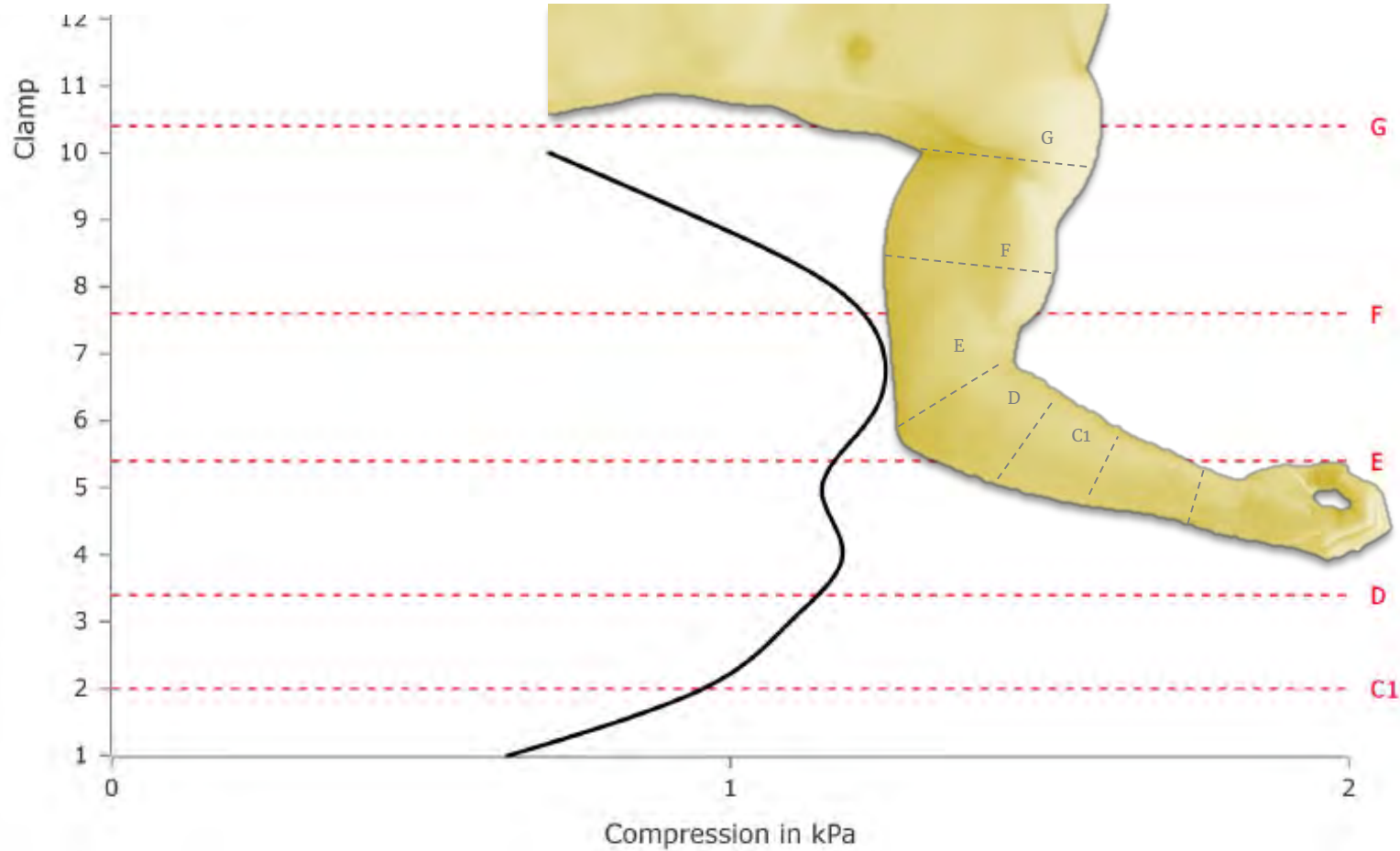
Arm Results

- 2nd posture – 1st movement
- Pressure curve changes

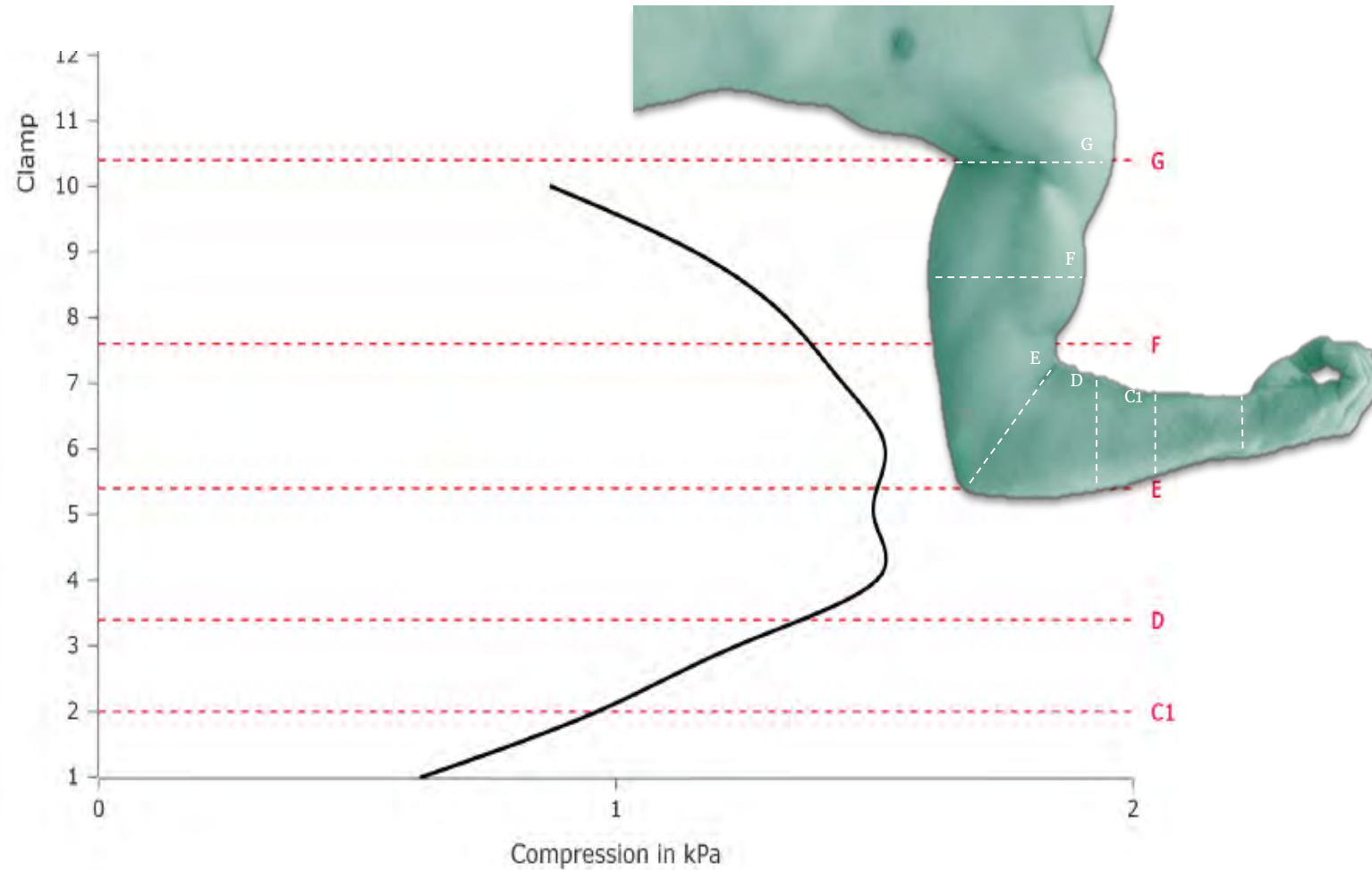


Arm Results

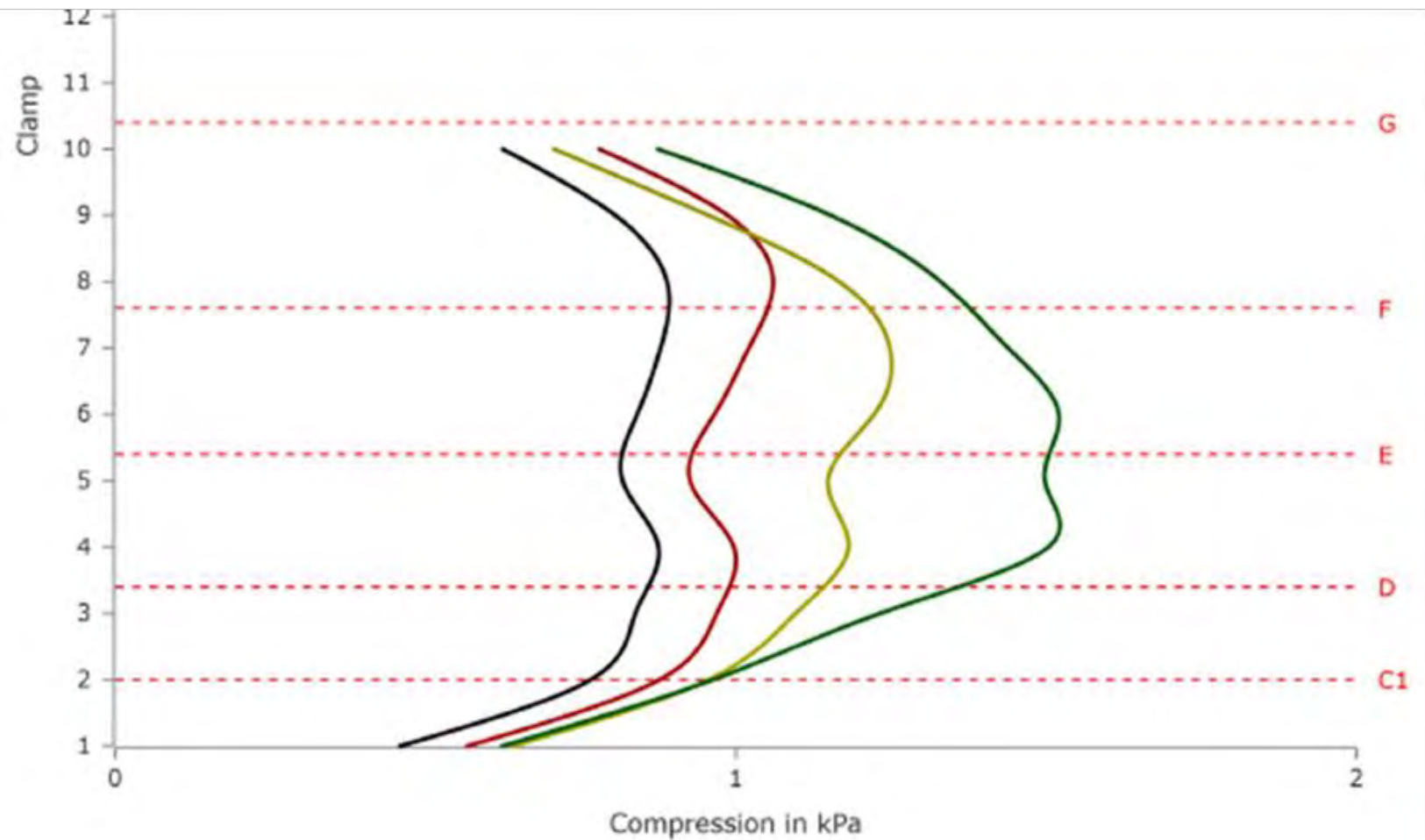
- 3rd posture
- New curve



Arm Results



- 4rd posture
- New curve



	1	2	3	4	
G	40,1	41,9	40,9	43,8	cm
	4,7	5,9	5,3	6,6	mmHg
F	40,3	40,7	42	42,3	cm
	6,7	7,9	9,1	10,3	mmHg
E	31,4	32,2	35,1	39,5	cm
	6,1	7	8,8	11,3	mmHg
D	30,2	30,4	30,9	33,2	cm
	6,4	7,4	8,6	10,2	mmHg
C1	24,2	24,8	25,2	24,3	cm
	5,8	6,6	7,2	7,2	mmHg

Arm Compression Results

Thank you

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