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Using 3D Scanning for Improved Helmet Design

Dr. Jan Beringer | Hohenstein Institute

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COMPETENCE IN TEXTILES

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Introduction




Increasing number of users

- Growing markets in job, leisure and sports
- From children to seniors
- Skiing: 16 million skiers in GERmany
- Biking: 68 million bikes in GER, not all bikers wear helmets
- Industry: 10 million workers in GER with need for head protection
- Furthermore: Forest operation, fire dept, police, military, inline skating, rock climbing, horse riding, motorcycling, canoeing and rafting …
- **Growing safety demands by awareness**
  both legal regulation and voluntary motivation

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Introduction

The Facts / Findings

- Helmets avoid or reduce the risk of head injuries
- 2011: 79.000 notifiable accidents at work with head injuries were (according to German statutory accident insurance)
- Head injuries often lead to secondary damage like paralysis and / or speech disorder
- Economic benefit: Reduction of insurance expenses, patient care and rehabilitation
- **Consumer acceptance is needed**
  Only wearing a helmet can prevent from severe head injuries !
- **Fit (and wearing comfort) optimized helmets are needed !**

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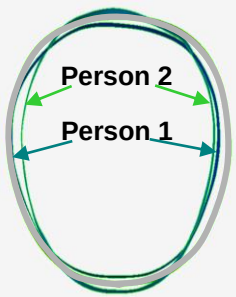
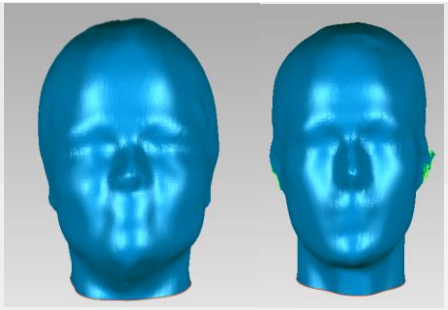
Introduction





The Challenge

- “SizeGERMANY” sizing survey showed remarkable variations in head shapes within the same head circumference
- Additional high-resolution anthropometric head data is needed, in particular shape information
- Market shares in head shape are needed for best market coverage
- Industry standards do not comply with the state of technology anymore, head shape information is missing totally
- Influence of hair on the size measurements and helmet fit is unclear

⟹ **Important basic information for optimized helmet development is not available**

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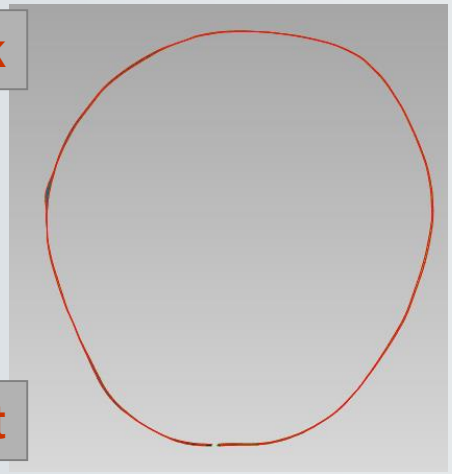
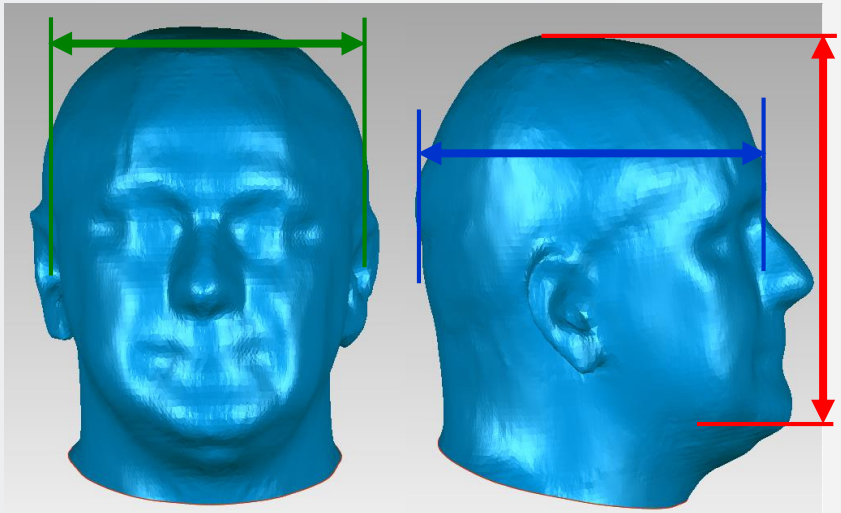
Visual comparison – male subject (view from top)

back

front

male 1



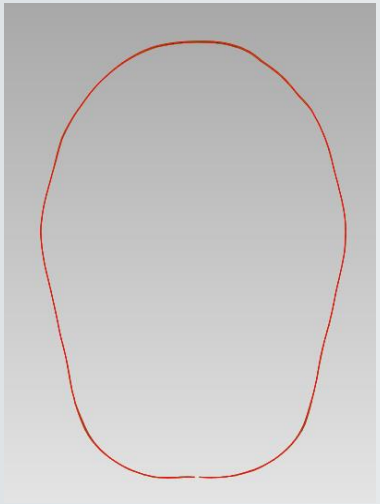


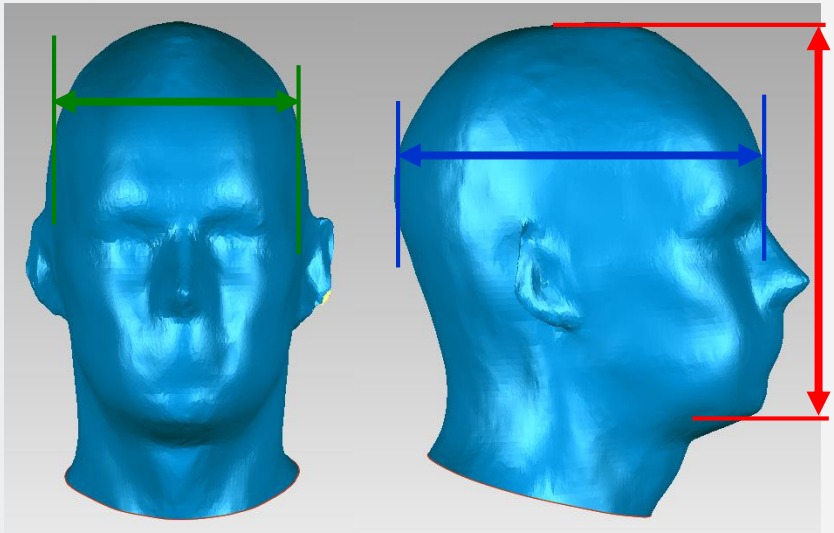
Circum-
ference
58 cm

back

front

male 2





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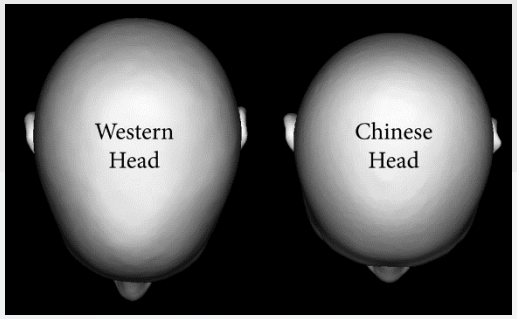
State of technology



Head shape comparison - Size China

Worldwide head-sizing related activities:

- CAESAR-project, 1997-2001 (NL/US)
- NIOSH Anthropometric Survey of Respirator Users, 2001-2004 (US)
- SizeChina (2006): Anthropometric head survey and digital database of Asian heads and faces for use by manufacturers (about 1600 Scans)
- 3D Facial Norms Database (https://www.facebase.org)
  3500 healthy Caucasian individuals age 5-40 (US)
- Various papers (US & CAN):
  - Head-and-face shape variations of U.S. civilian workers (2013)
  - A simple and standardized method for analyzing head and face morphology of a population sample (2010)
  - Sizing trials of a prototype aircrew helmet (2009)
  - Principles of Fit to Optimize Helmet Sizing (2006)
  - Helmet accommodation analysis using 3D laser scanning (2000) etc.

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Aim of the Hohenstein study

The Aim is the improvement of head gear systems considering fitting plus comfort and function

Results:

- Up-to-date face and 3D head measurements and head shapes of men, women and children in Germany
- German market share tables of sex, age and head shape types
- Head specific grading guidelines
- Virtual 3D-head shape models
- Guidelines and design characteristics for optimized development considering fit, ergonomic comfort, thermophysiological comfort and hygiene

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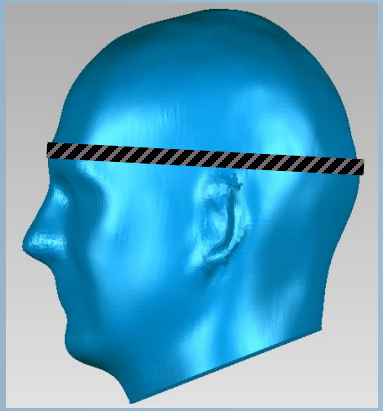
Step 1 of the Hohenstein study and results

- Detailed analysis of existing 3D Scan data of Hohenstein's own database (17,000+ scans)
- Acquisition of additional high resolution 3D Scan data from typical head shapes
- Definition of measurements and methods according to established standards like (ISO 7250, SizeGERMANY etc. plus new additional head and face measurements)



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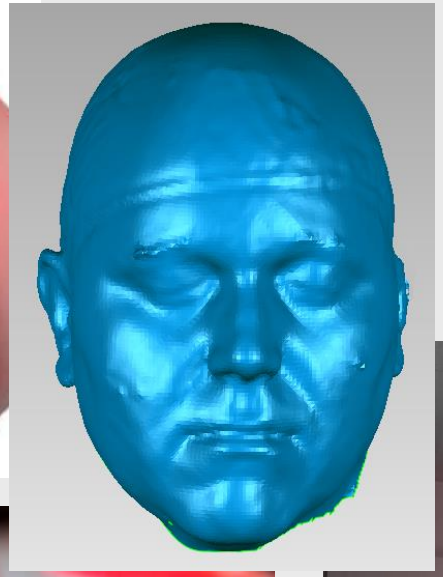
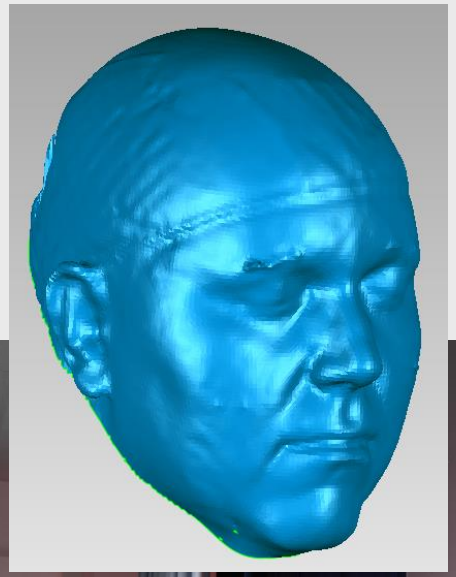
Available 3D Scanner Systems





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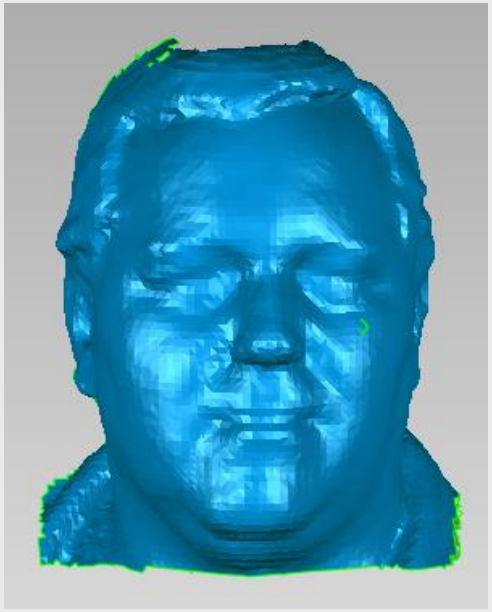
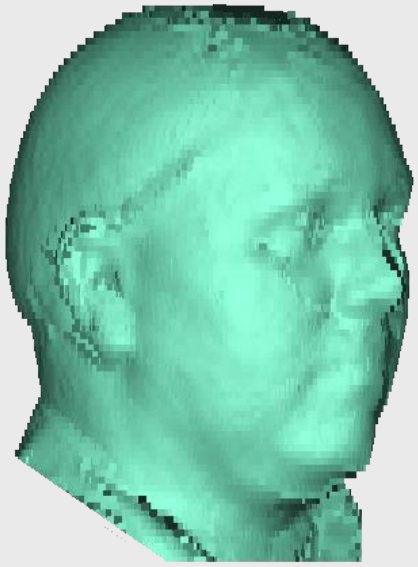
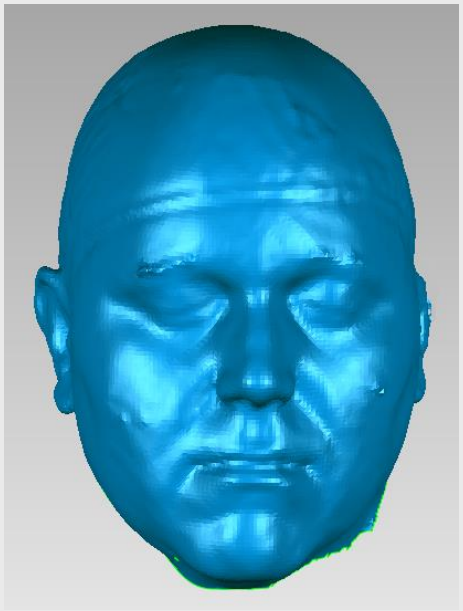
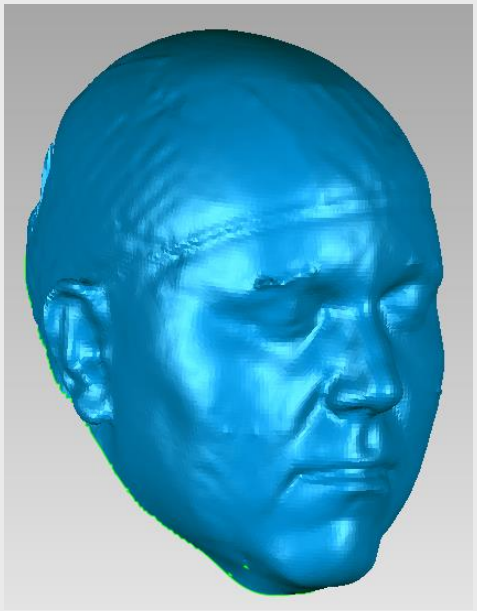
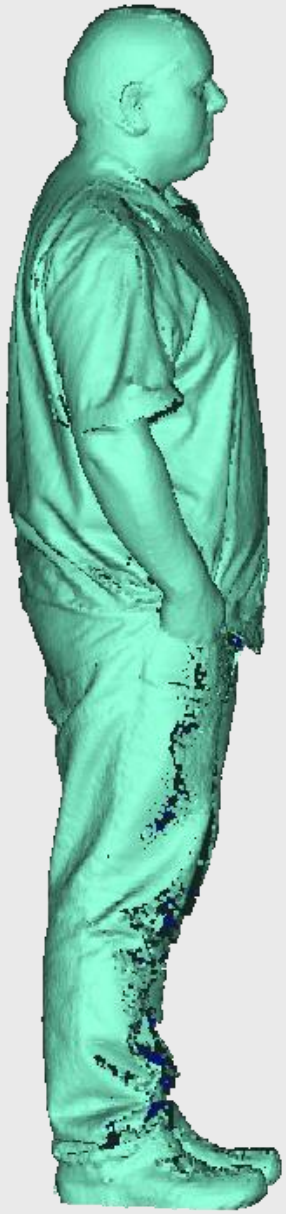
3D Scan-Quality











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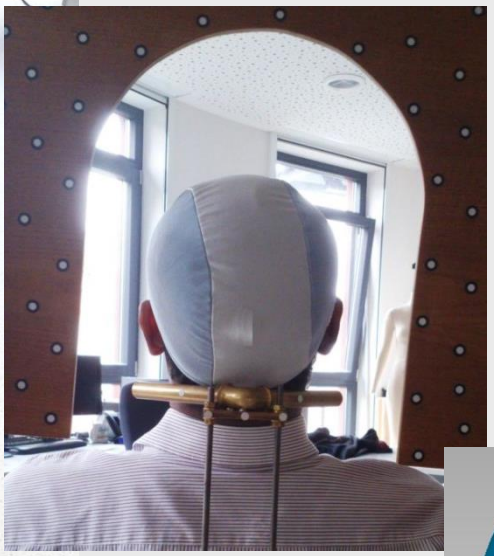
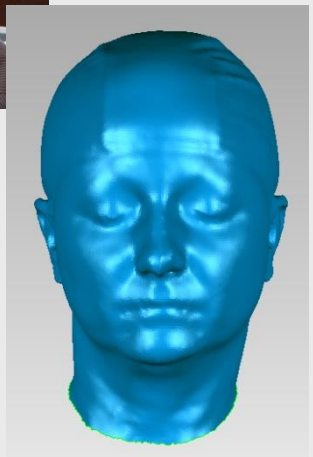
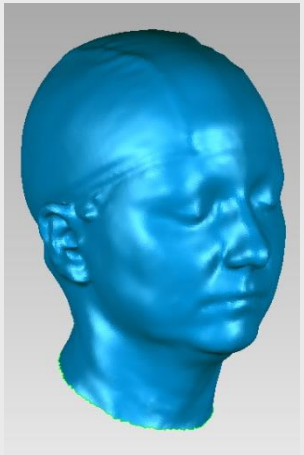
3D Scan experimental setup







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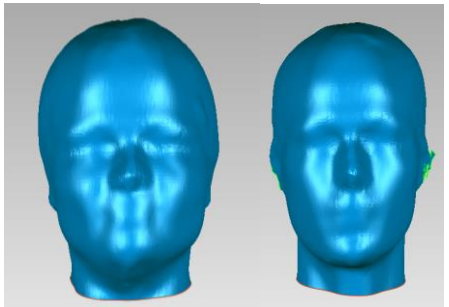
Step 2 of the Hohenstein study and results

- Analysis und statistical evaluation of 3D-scandata of men, women and children
- 3D-head shape analysis
- Definition of basic 3D head shapes
- Definition of size ranges according to sex, age and head shape types based on percentage shares



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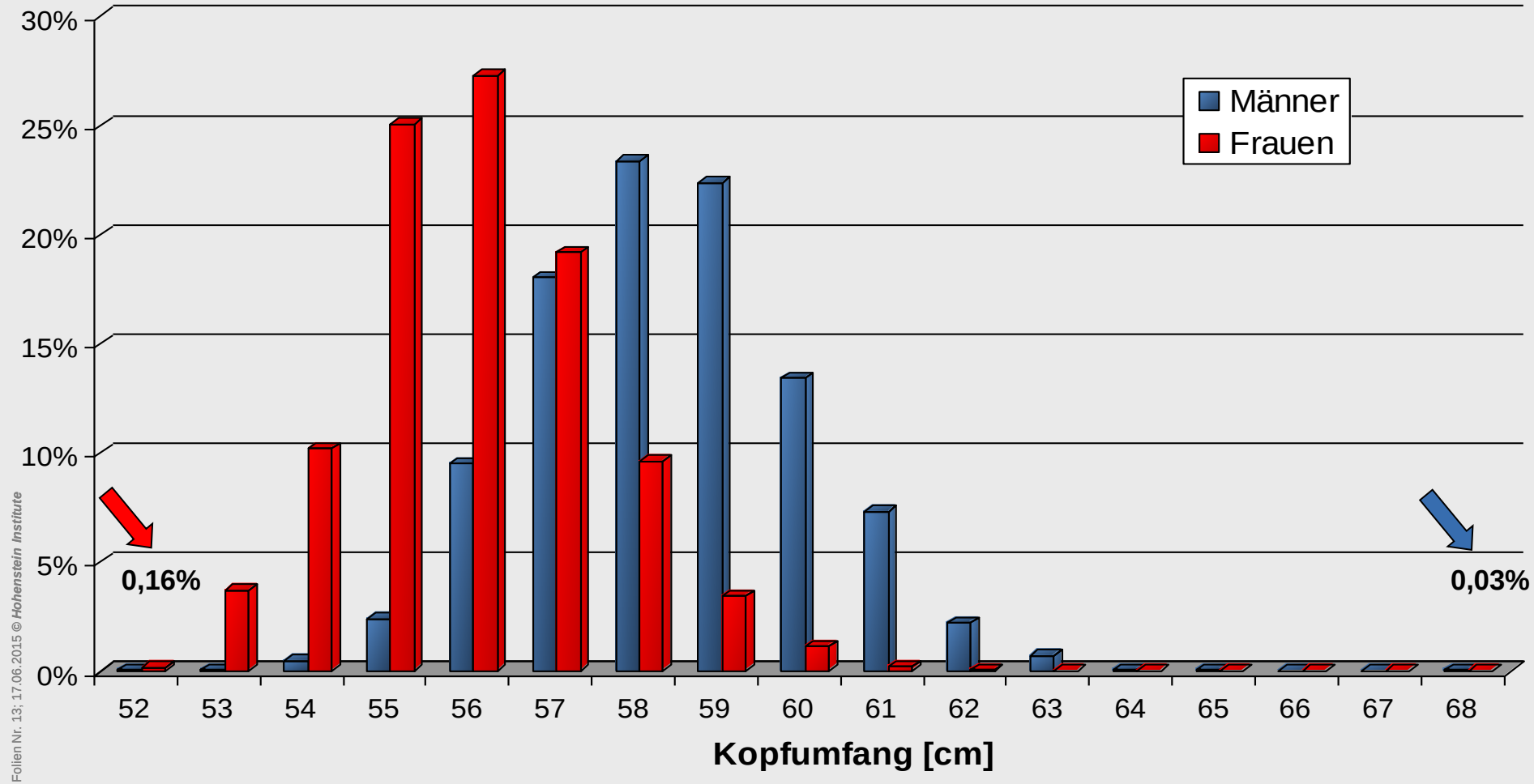
Men & Women:
Head circumference - percental distribution



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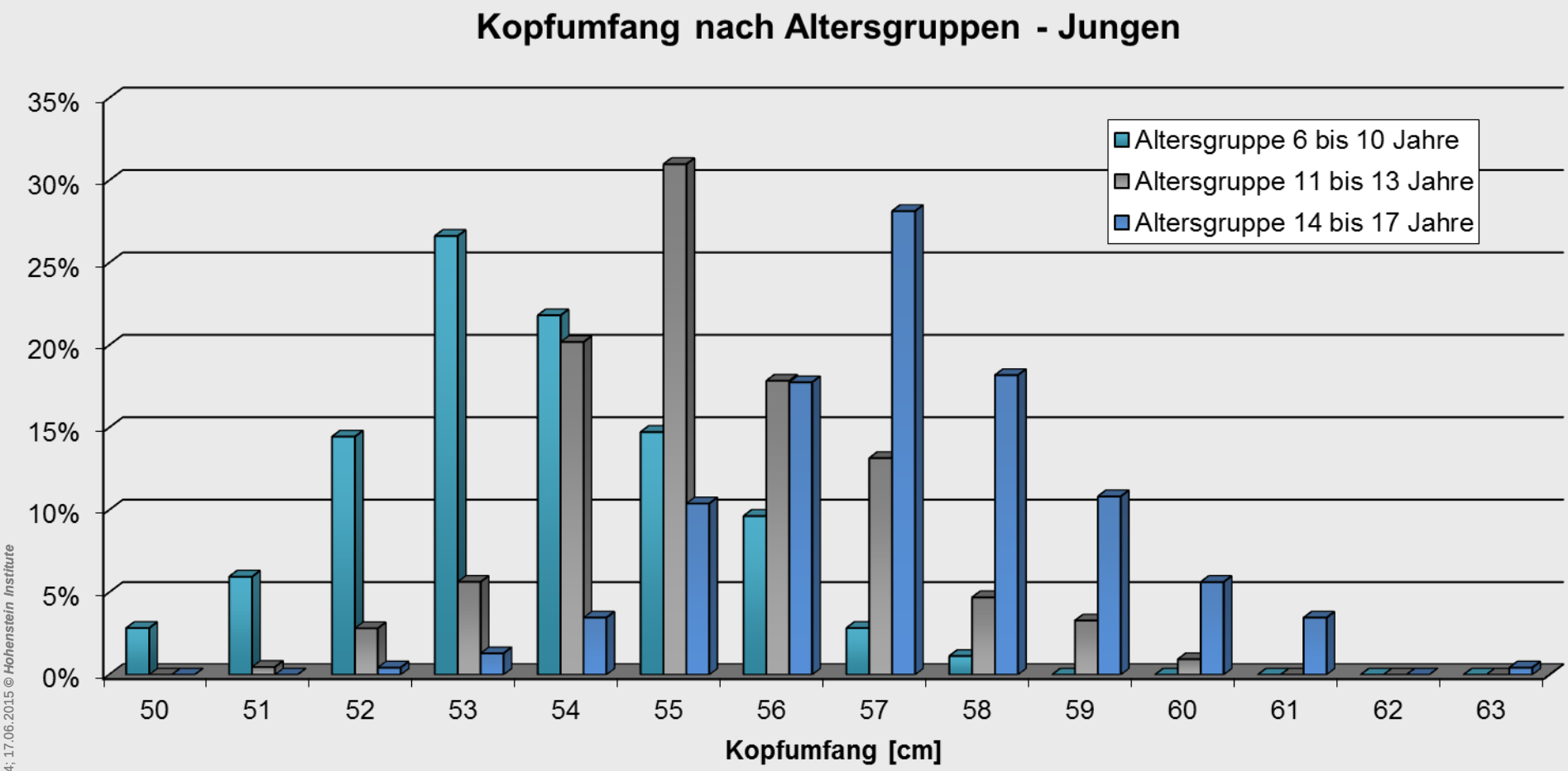
Boys: Head circumference over age groups



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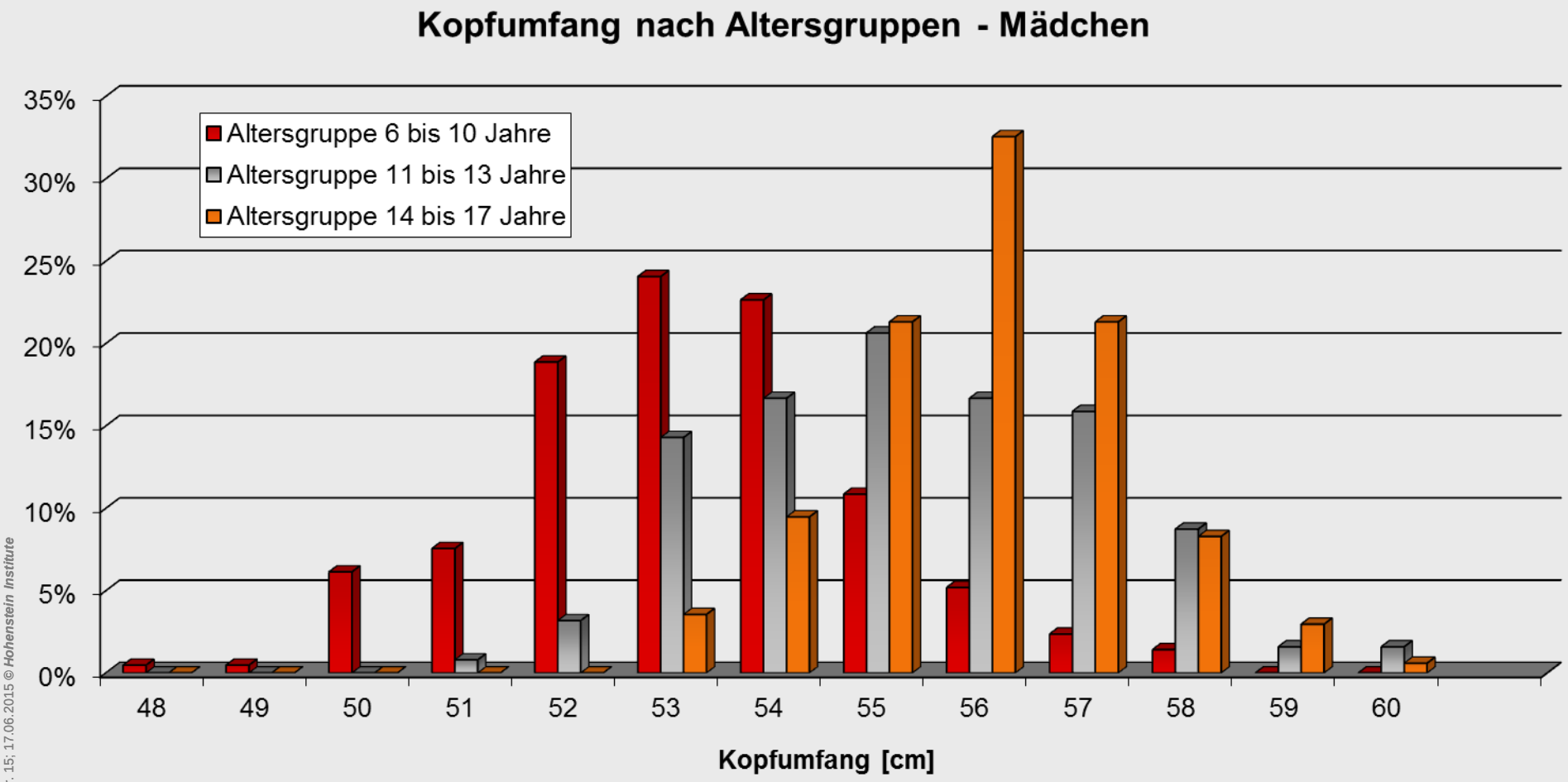
Girls: Head circumference over age groups



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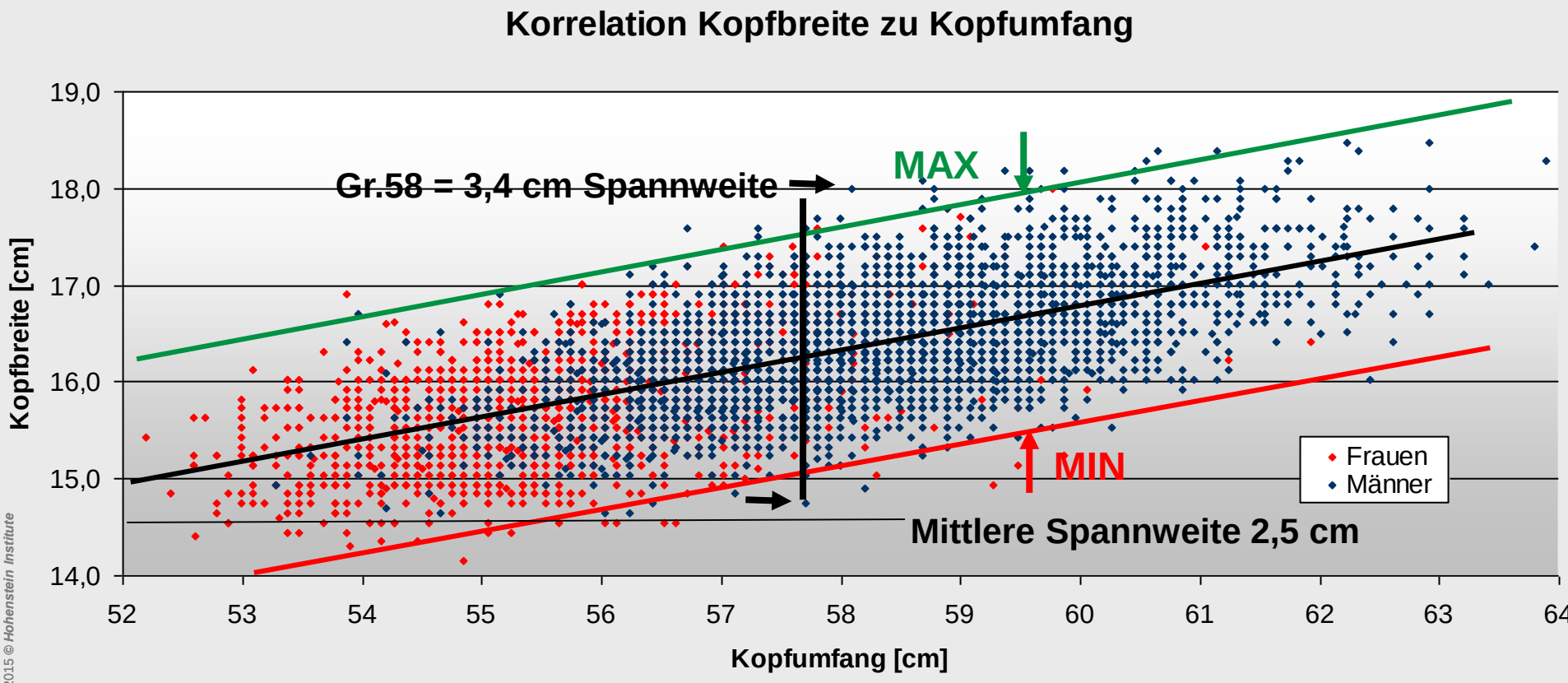
Men & Women: Rage of head width (correlation head width vs. head circumference)



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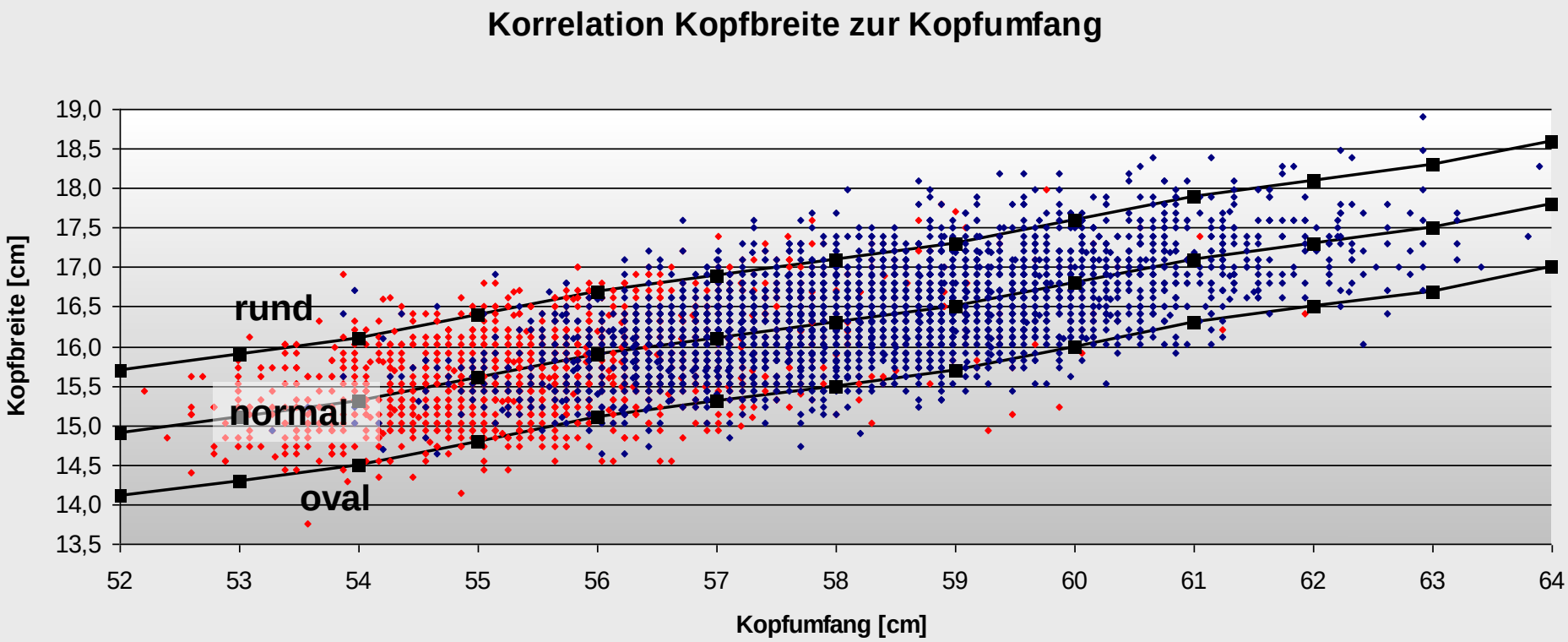
Men & Women: Definition of head shapes and types (correlation head width vs. head circumference)



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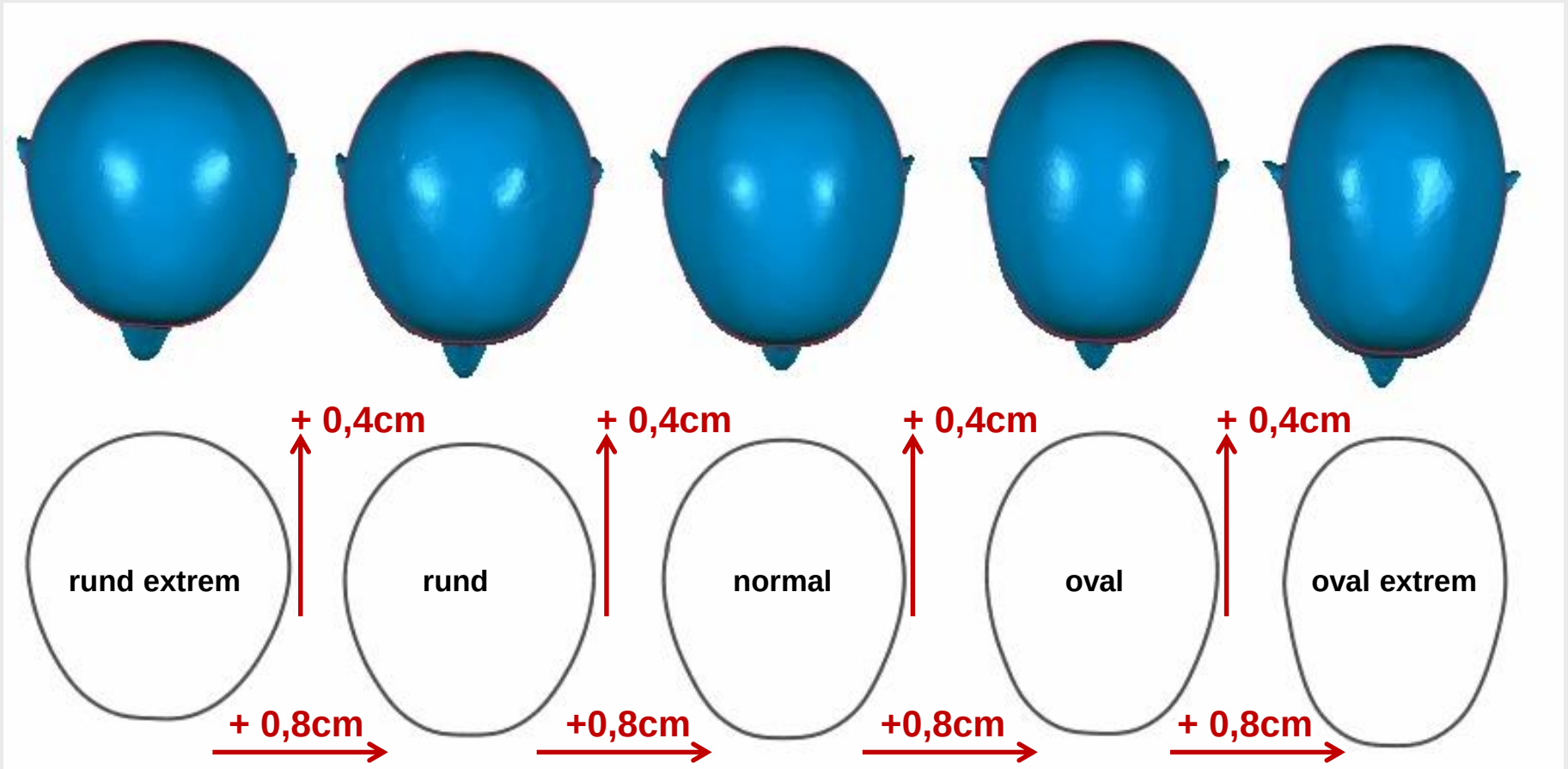
The 5 defined/extracted average head types



X round round normal oval X oval

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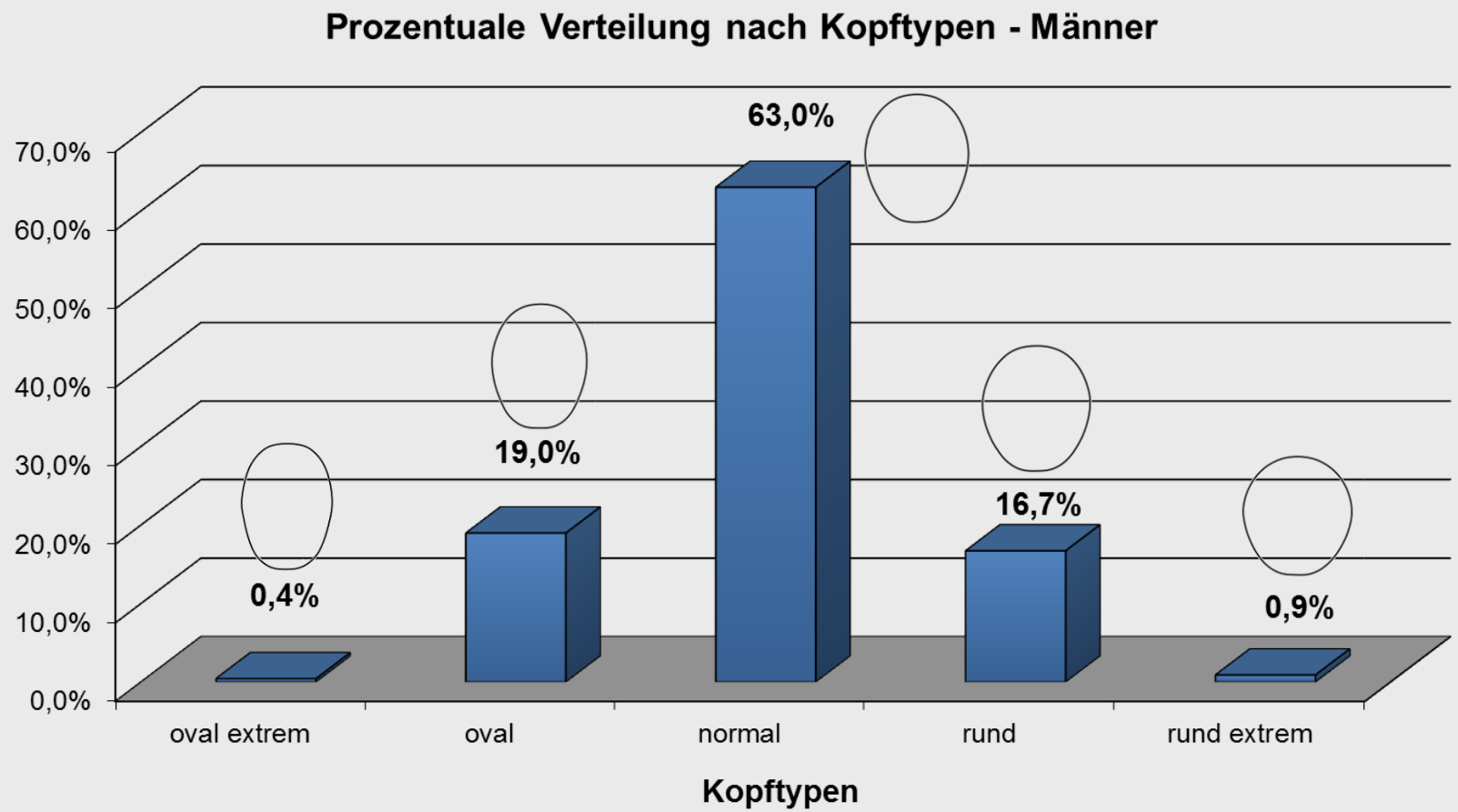
Men: percental distribution head types



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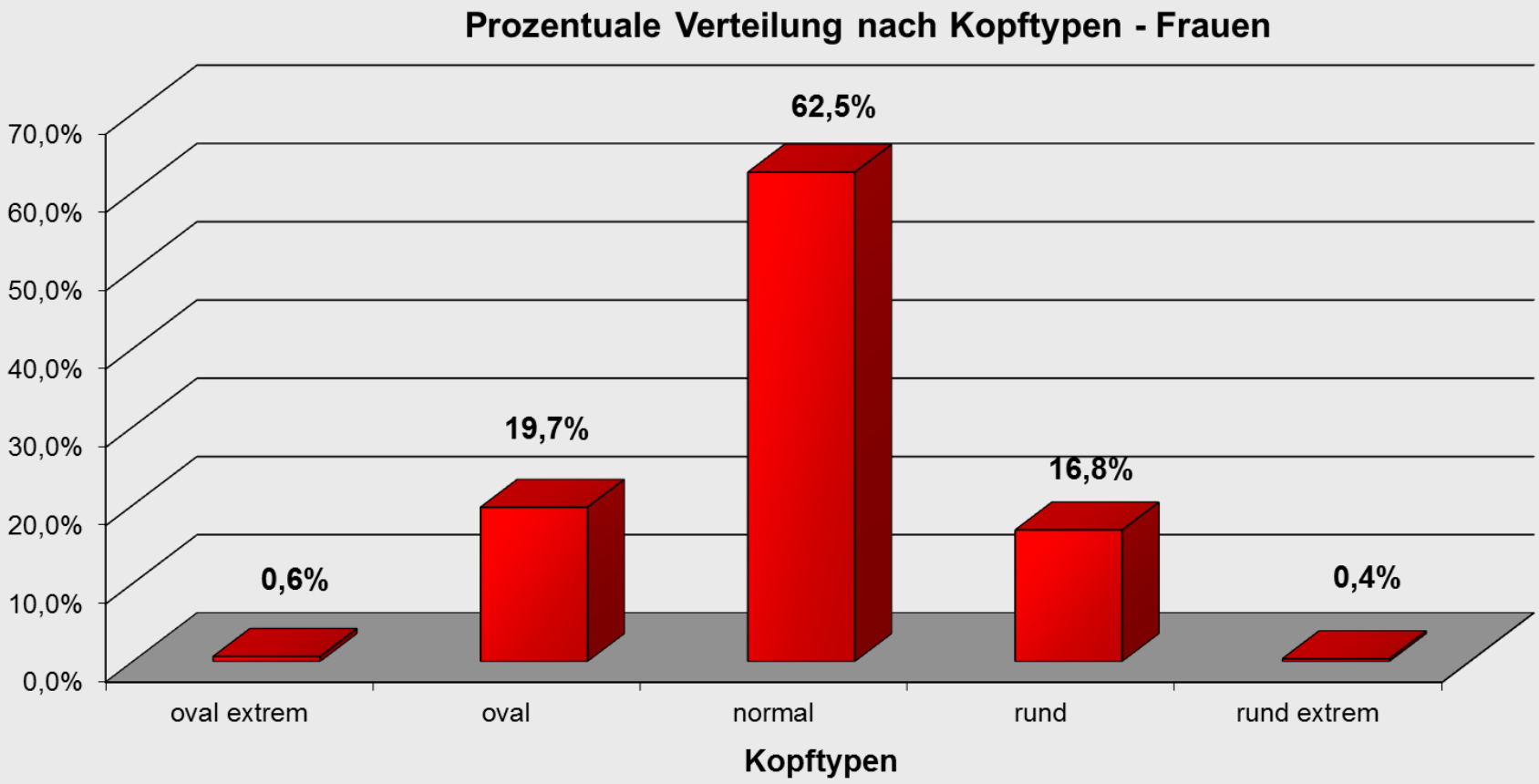
Women: percental distribution head types



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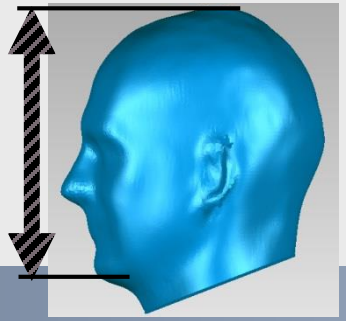
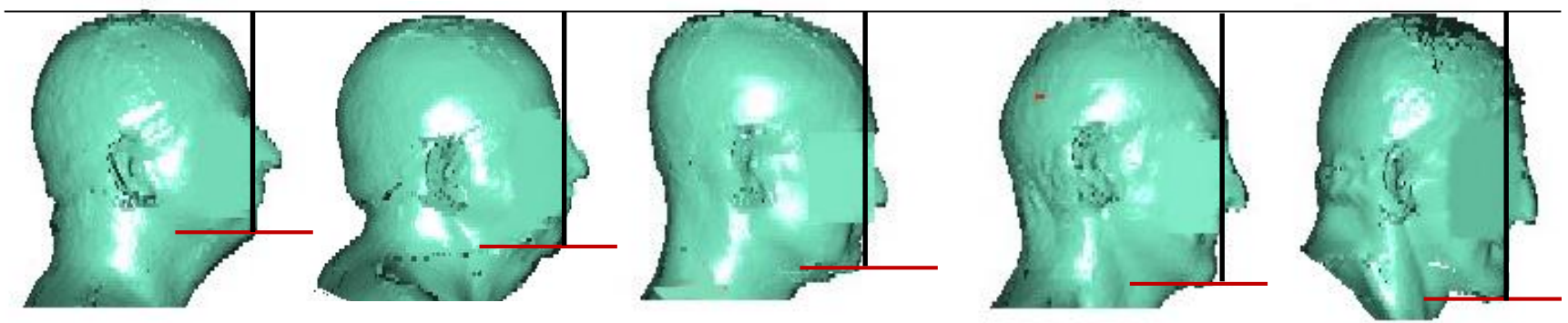
Head height types (…helmet belt)



⇨ Definition of 5 head hight types



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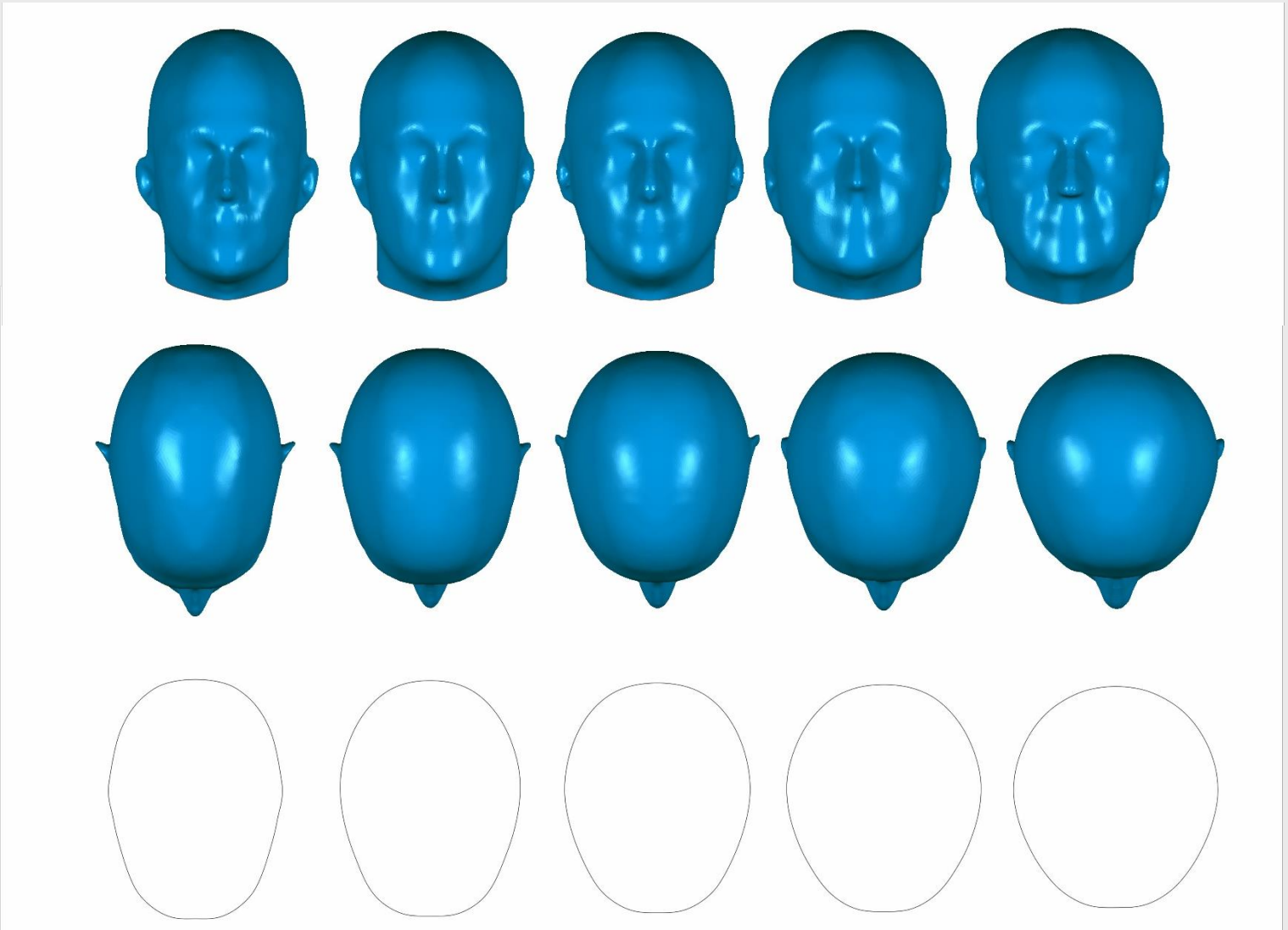
Average head shapes as 3D data available



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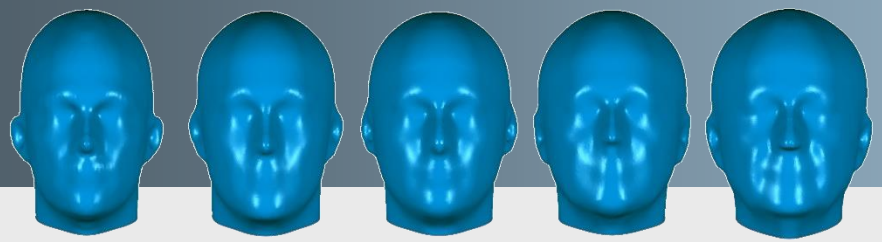
Summary

- 3D Scan system and experimental setup defined
- 3D-scandata of men, women and children analyzed and statistically evaluated
- 3D-head shapes analyzed and 5 basic types defined
- Size ranges according to sex, age and head shape types based on percentage shares defined
- Average head shapes in various sizes available as 3D data



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Thank you for your kind attention

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