

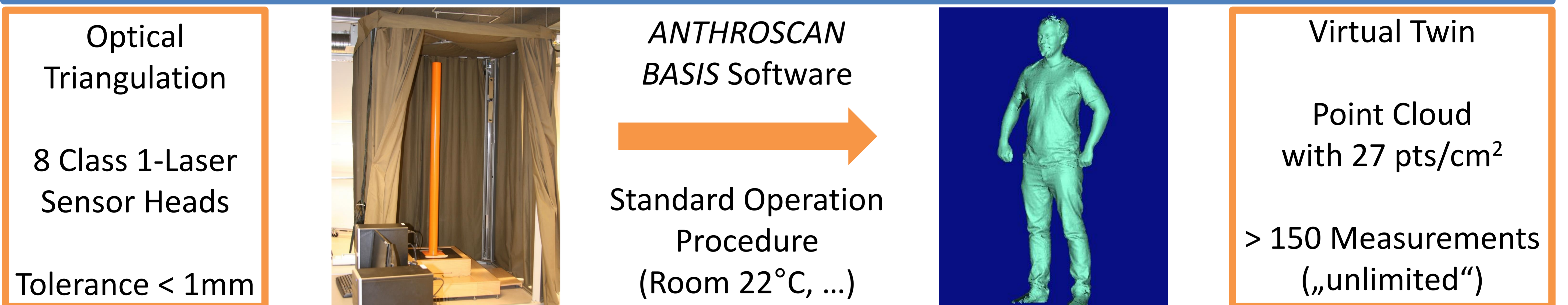
Laser-based 3D Anthropometry: Reliability, Comparison with Classical Anthropometry, and GWAS for more than 150 Body Phenotypes

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...explained in 100 words...

Anthropometric quantities are widely used in epidemiologic research as possible confounders, risk factors, or outcomes. 3D laser-based body scans allow calculation of dozens of quantities such as body height, body weight, length of extremities, and body circumferences in short time with minimal physical contact between observers and probands. Body surface area is also a physiological quantity relevant for many medical applications as it is believed that body surface area correlates with size and function of drug-metabolizing organs. Based on 3D body scanning, genome-wide association studies for dozens of quantities can be performed at once speeding up investigations in molecular genetics.

3D Body Scanner VITUS XXL



Reliability + Validity

Feasibility Study in Preparation
of LIFE-Adult Study (N = 108)

Measure of Agreement
*Overall Concordance Correlation
Coefficient*

$$OCCC = \frac{2 \sum_{j=1}^{J-1} \sum_{k=j+1}^J \text{Cov}(M_j, M_k)}{(J-1) \sum_{j=1}^J \text{Var}(M_j) + \sum_{j=1}^{J-1} \sum_{k=j+1}^J [\text{E}(M_j) - \text{E}(M_k)]^2}$$

Intra-Rater
Reliability

| Trait | OCCC | 95%-CI of OCCC |
|----------------------------------|-------|----------------|
| Calf girth | 0.999 | 0.998 0.999 |
| Neck height | 0.998 | 0.997 0.999 |
| Minimum leg girth | 0.997 | 0.993 0.998 |
| Body height | 0.997 | 0.990 0.999 |
| Scapula height | 0.997 | 0.989 0.999 |
| ... | ... | ... |
| Distance waistband high hip back | 0.683 | 0.462 0.825 |
| Across front width | 0.674 | 0.478 0.806 |
| Shoulder angle | 0.628 | 0.392 0.786 |
| Side upper torso length | 0.559 | 0.315 0.734 |
| Shoulder width | 0.353 | 0.035 0.605 |

Inter-Rater
Reliability

| Trait | OCCC | 95%-CI of OCCC |
|------------------------------|-------|----------------|
| Calf girth | 0.999 | 0.998 0.999 |
| Buttock girth | 0.999 | 0.997 0.999 |
| Neck height | 0.998 | 0.997 0.999 |
| Body height | 0.998 | 0.996 0.999 |
| Scapula height | 0.998 | 0.996 0.999 |
| ... | ... | ... |
| Upper torso torsion | 0.695 | 0.540 0.805 |
| Shoulder angle | 0.651 | 0.451 0.788 |
| Distance buttock to vertical | 0.643 | 0.365 0.816 |
| Shoulder width | 0.548 | 0.128 0.801 |
| Neck height front | 0.458 | -0.323 0.868 |

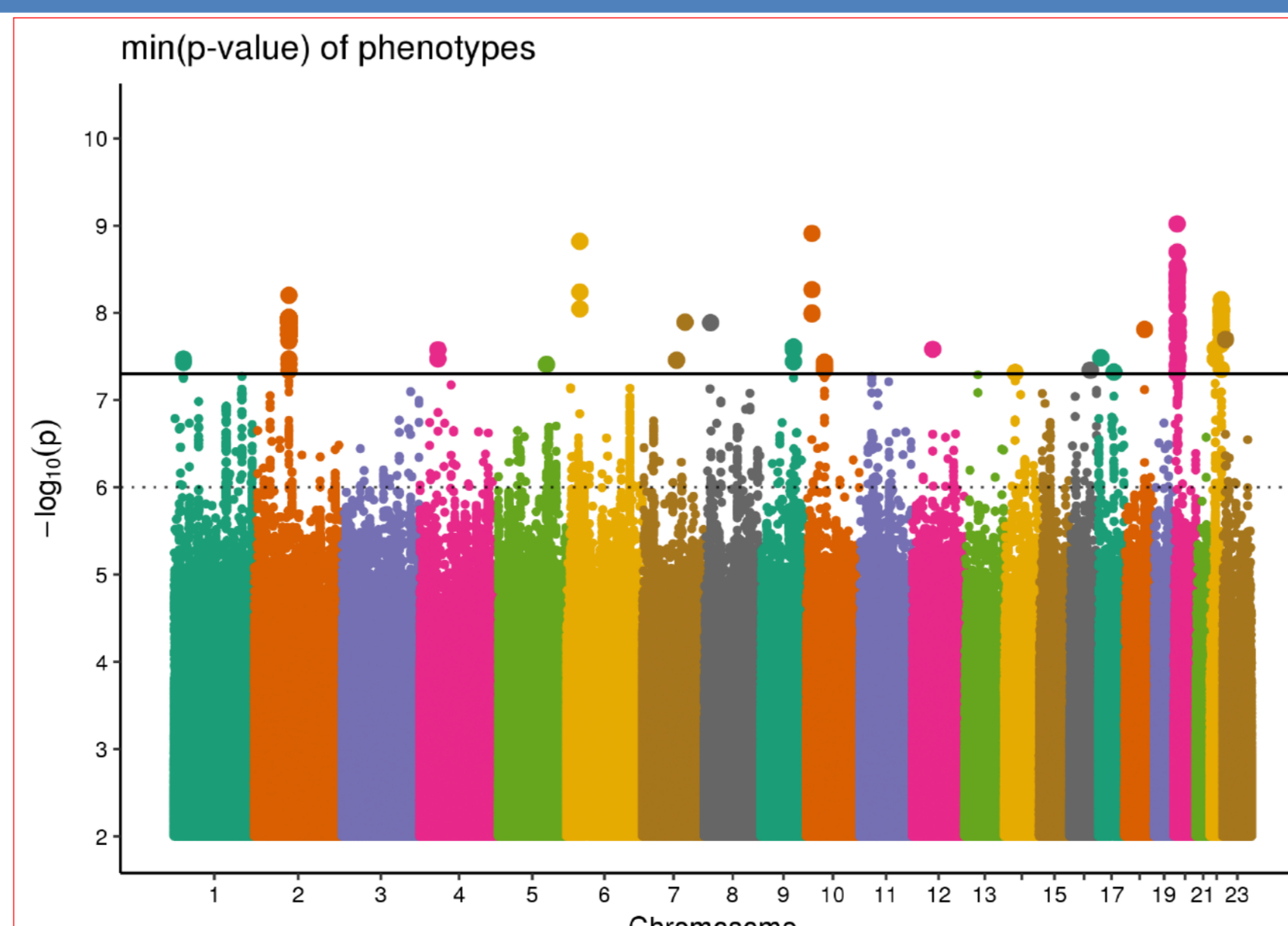
Validity

| Classical anthropometry | Body scanner | Uncorrected OCCC | Offset | OCCC | 95%-CI of OCCC |
|-----------------------------|-----------------------------|------------------|--------|-------------|----------------|
| Body height | Body height | 0.995 | -0.61 | 0.997 | 0.996 0.998 |
| Body weight | Body weight | 1.000 | -0.23 | 1.000 | 0.999 1.000 |
| Upper arm length | Upper arm length | 0.183 | +5.73 | 0.769 | 0.680 0.835 |
| Upper arm girth | Upper arm girth | 0.720 | +2.18 | 0.862 | 0.820 0.894 |
| Waist girth | Waist girth | 0.982 | -1.51 | 0.987 | 0.981 0.991 |
| | High waist girth | 0.984 | +1.09 | 0.986 | 0.980 0.991 |
| | Waist band | 0.924 | -2.17 | 0.935 | 0.907 0.956 |
| | 3D waist band | 0.924 | -2.16 | 0.936 | 0.907 0.956 |
| Belly circumference | Belly circumference | 0.929 | -4.39 | 0.973 | 0.961 0.981 |
| Maximum belly circumference | Maximum belly circumference | 0.894 | -5.66 | 0.963 | 0.944 0.975 |
| Hip girth | Middle hip girth | 0.910 | -0.28 | 0.910 | 0.850 0.947 |
| | High hip girth | 0.832 | +2.76 | 0.853 | 0.771 0.908 |
| | Buttock girth | 0.969 | -2.14 | 0.986 | 0.979 0.990 |
| Thigh length | Hip girth | 0.938 | -3.19 | 0.976 | 0.964 0.984 |
| | Hip/thigh girth | 0.510 | +7.22 | 0.659 | 0.557 0.742 |
| | TL1 | 0.311 | +4.70 | 0.778 | 0.678 0.849 |
| | TL2 | 0.156 | +6.26 | 0.407 | 0.252 0.541 |
| | TL3 | 0.031 | +17.77 | 0.606 | 0.481 0.706 |
| | TL4 | 0.035 | +16.47 | 0.580 | 0.446 0.689 |
| | TL5 | 0.079 | -8.30 | 0.381 | 0.218 0.523 |
| TL6 | 0.542 | -1.80 | 0.671 | 0.550 0.764 | |
| TL7 | 0.528 | -1.02 | 0.565 | 0.409 0.689 | |
| Thigh girth | Thigh girth | 0.557 | -6.30 | 0.928 | 0.894 0.951 |
| Calf girth | Calf girth | 0.984 | -0.30 | 0.988 | 0.981 0.992 |

What about the Genome?

LIFE-Adult Study
(N = 4.985)

GWAS-Pipeline of Project Group
*Genetical Statistics and Systems
Biology* (Prof. Dr. Markus Scholz)



- Traits with significant Associations**
- Several Height Measurements
 - BS_WAIST_GTH
 - BS_HIGHWAIST_GTH
 - BS_HIGH_HIP_GTH
 - BS_BUTTOCK_GTH
 - BS_BELLY_CIRC
 - BS_MAX_BELLY_CIRC
 - BS_UP_ARM_GTH_L
 - BS_IN_LEG_ANKLE_R
 - BS_SIDESEAM_ANKLE_L
 - BS_SIDESEAM_ANKLE_R
 - BS_KNEE_GTH_L
 - BS_CALF_GTH_R
 - BS_BUST_PT_WTH
 - BS_UNDERBUST_CIRC_HZ

Next
GWAS for
LIFE-Adult
Study with
N ≈ 8.000

Kuehnappel A, Ahnert P, Loeffler M, Broda A, Scholz M. Reliability of 3D laser-based anthropometry and comparison with classical anthropometry. *Sci Rep* 6, 26672 (2016).
Glock F, Vogel M, Naumann S, Kuehnappel A, Scholz M, Hiemisch A, Kirsten T, Rieger K, Koerner A, Loeffler M, Kiess W. Validity and intraobserver reliability of three-dimensional scanning compared with conventional anthropometry for children and adolescents from a population-based cohort study. *Pediatr Res* 81(5), 736-744 (2017).
Kuehnappel A, Ahnert P, Loeffler M, Scholz M. Body surface assessment with 3D laser-based anthropometry: reliability, validation, and improvement of empirical surface formulae. *Eur J Appl Physiol* 117(2), 371-380 (2017).