Leipziger Forschungszentrum
für Zivilisationserkrankungen

imise.

UNIVERSITÄT LEIPZIG
Medizinische Fakultät

Bodyscanner-Feasibility und Formeln der Körperoberfläche

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AG Genetische Statistik

16.5.2017

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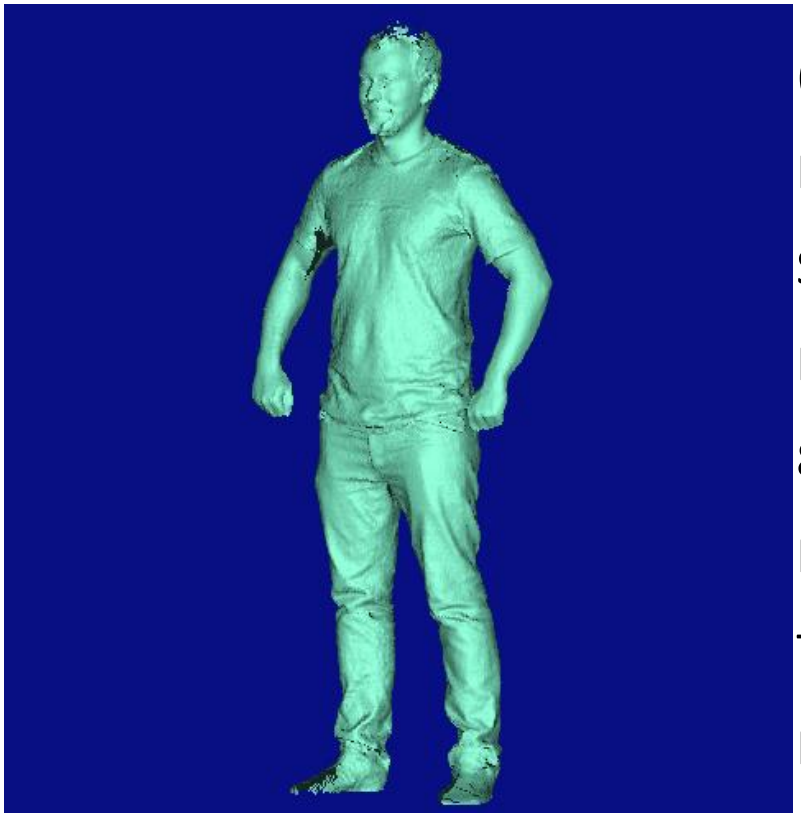
Bodyscanner



Vitus Smart XXL

(Human Solutions, Kaiserslautern)

Messbereich: 2100 mm H, 1000 mm B, 1200 mm T

Scanzeit: ca. 10 sec

Messprinzip: optische Triangulation

8 Laser-Sensorköpfe (Klasse 1)

Punktedichte: 27 Punkte/cm^2

Toleranz: < 1 mm

Flächenbedarf: ca. 5 m^2

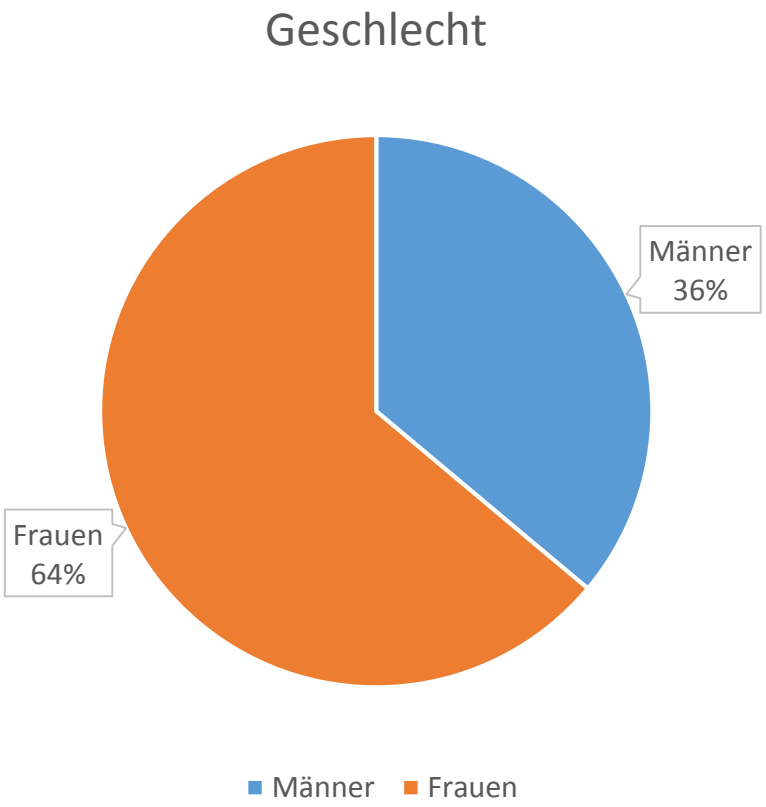
Gesamtgewicht: ca. 250 kg

Machbarkeit

Machbarkeit: Zielsetzung

- benötigte **Zeit** und **Zufriedenheit** der Probanden
- **Intra-/Interrater-Reliabilität** CA
- **Intra-/Interrater-Reliabilität** BS
- Vergleich der Reliabilitäten zwischen CA und BS
- **Vergleich CA- und** korrespondierende **BS-Maße**
- **Effekt von Adipositas** auf Validität BS und Reliabilität von CA und BS

Machbarkeit: Kollektiv



Body Mass Index

- **34,3% BMI ≥ 30** kg / m^2
- 65,7% BMI < 30 kg / m^2

Alter

- 31,5% < 60 Jahre
- 68,5% ≥ 60 Jahre

108 Probanden in Vorbereitung von LIFE-Adult (Convenience Sample)

Machbarkeit: Material & Methoden

- **CA: 9** Maße **vs. BS: 154** Maße
- Äquivalente Maße über
  - Name und Scanbild
  - Auswahl unter mehreren Alternativen (*Waist girth*, *Hip girth*)
  - Derivat aus bestehenden Maßen (*Thigh length*)
- Maß der Übereinstimmung für *J* Untersucher:

Overall Concordance Correlation Coefficient

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

Machbarkeit: Ergebnisse (1/2)

Zeit

- Ø(**CA**) = **3,1** ± 0,97 **Minuten**
- Ø(**BS**) = **4,1** ± 1,43 **Minuten**

Reliabilität **CA**

- **Intra**: Median = **0,995** (IQR = 0,991 – 0,997)
- **Inter**: Median = **0,992** (IQR = 0,974 – 0,996)

Zufriedenheit

- ☺(CA) = 86,5%
- ☺(BS) = 92,3%

Reliabilität **BS**

- **Intra**: Median = **0,954** (IQR = 0,867 – 0,984)
- **Inter**: Median = **0,960** (IQR = 0,904 – 0,988)

Machbarkeit: Ergebnisse (2/2)

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	0.929	−4.39	0.973	0.961	0.981
	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
	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
Thigh length	*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

CA vs. BS

- Reliabilitäten vergleichbar
- Validität: Offset-Korrektur

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Reliability of 3D laser-based anthropometry and comparison with classical anthropometry

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Andreas Kuehnapfel[1,2], Peter Ahnert[1,2], Markus Loeffler[1,2], Anja Broda[1,2] & Markus Scholz[1,2]

Anthropometric quantities are widely used in epidemiologic research as possible confounders, risk factors, or outcomes. 3D laser-based body scans (BS) allow evaluation of dozens of quantities in short time with minimal physical contact between observers and probands. The aim of this study was to compare BS with classical manual anthropometric (CA) assessments with respect to feasibility, reliability, and validity. We performed a study on 108 individuals with multiple measurements of BS and CA to estimate intra- and inter-rater reliabilities for both. We suggested BS equivalents of CA measurements and determined validity of BS considering CA the gold standard. Throughout the study, the overall concordance correlation coefficient (OCCC) was chosen as indicator of agreement. BS was slightly more time consuming but better accepted than CA. For CA, OCCCs for intra- and inter-rater reliability were greater than 0.8 for all nine quantities studied. For BS, 9 of 154 quantities showed reliabilities below 0.7. BS proxies for CA measurements showed good agreement (minimum OCCC $>$ 0.77) after offset correction. Thigh length showed higher reliability in BS while upper arm length showed higher reliability in CA. Except for these issues, reliabilities of CA measurements and their BS equivalents were comparable.

Pediatr Res. 2017 May;81(5):736-744. doi: 10.1038/pr.2016.274. Epub 2017 Jan 4.

Validity and intraobserver reliability of three-dimensional scanning compared with conventional anthropometry for children and adolescents from a population-based cohort study.

Glock F[1,2], Vogel M[1], Naumann S[1], Kuehnapfel A[1,3], Scholz M[1,3], Hiemisch A[1,2], Kirsten T[1], Rieger K[1,2], Koerner A[1,2], Loeffler M[1,3], Kiess W[1,2].

Author information

Abstract

BACKGROUND: Conventional anthropometric measurements are time consuming and require well trained medical staff. To use three-dimensional whole body laser scanning in daily clinical work, validity, and reliability have to be confirmed.

METHODS: We compared a whole body laser scanner with conventional anthropometry in a group of 473 children and adolescents from the Leipzig Research Centre for Civilization Diseases (LIFE-Child). Concordance correlation coefficients (CCC) were calculated separately for sex, weight, and age to assess validity. Overall CCC (OCCC) was used to analyze intraobserver reliability.

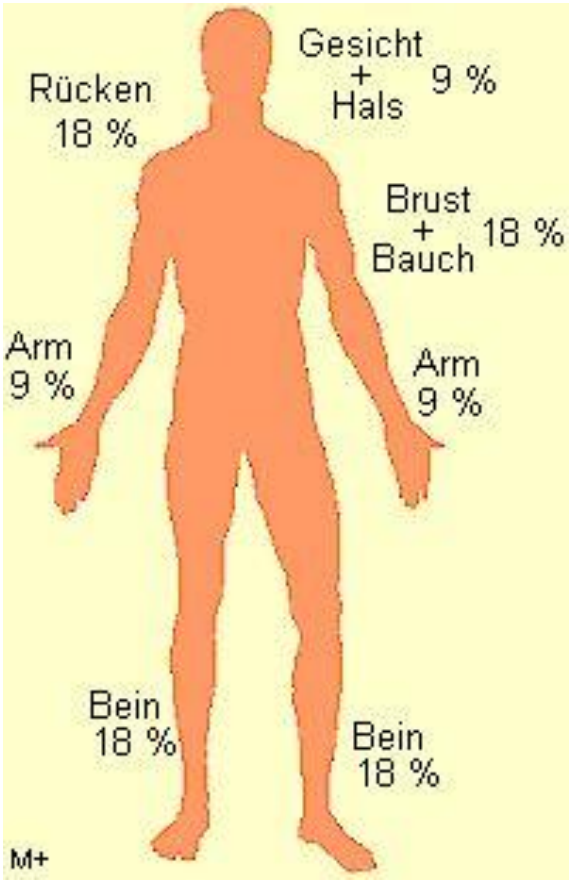
RESULTS: Body height and the circumferences of waist, hip, upper arm, and calf had an "excellent" (CCC ≥ 0.9); neck and thigh circumference, a "good" (CCC ≥ 0.7); and head circumference, a "low" (CCC < 0.5) degree of concordance over the complete study population. We observed dependencies of validity on sex, weight, and age. Intraobserver reliability of both techniques is "excellent" (OCCC ≥ 0.9).

CONCLUSION: Scanning is faster, requires less intensive staff training and provides more information. It can be used in an epidemiologic setting with children and adolescents but some measurements should be considered with caution due to reduced agreement with conventional anthropometry.

PMID: 28052064 DOI: 10.1038/pr.2016.274

Oberfläche

Oberfläche: Zielsetzung



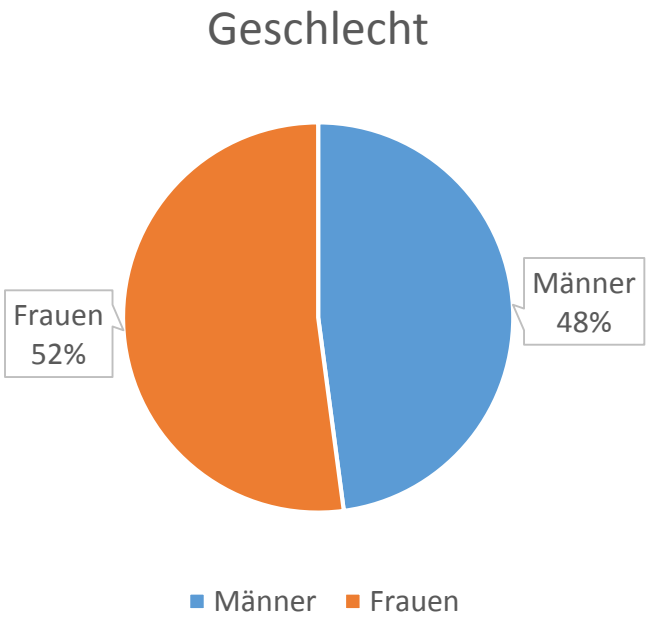
http://jucknix.de

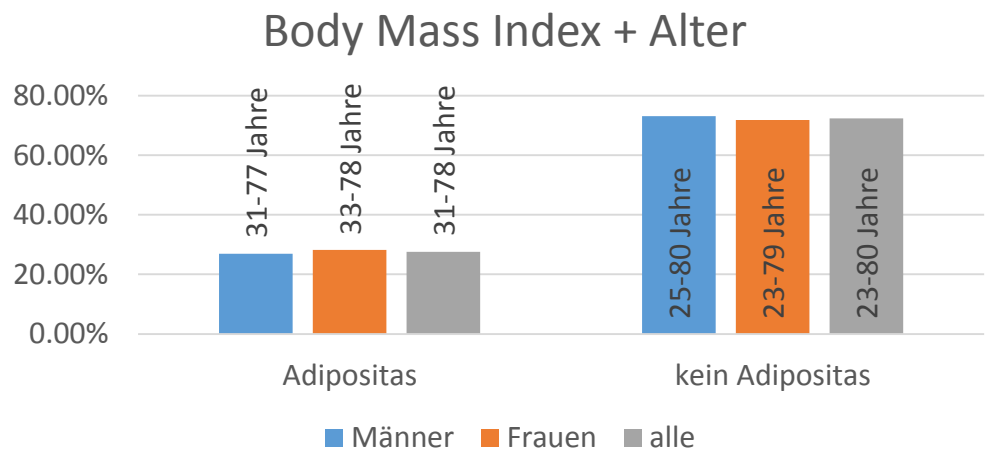
- **Intra-/Interrater-Reliabilität** BS
- **Bewertung** von bereits existierenden Oberflächenformeln
- **Reparametrisierung** von empirischen Oberflächenformeln

Oberfläche: Kollektiv

Reliabilität: **126** Probanden im Rahmen der Feasibility-Studie

Evaluierung & Reparametrisierung: **1.435** aus LIFE-Adult





Oberfläche: Material & Methoden

- Reliabilitätsmaß: **OCCC**
- **18** empirische Oberflächenformeln aus der Literatur (**Körpergröße** + **Körpergewicht**)
- Reparametrisierung: Formelstrukur gemäß

$$\text{Surface} = \beta_0 \times \text{Height}^{\beta_1} \times \text{Weight}^{\beta_2}$$

- ➢ Lineare Regression
- ➢ Adjustierung auf Geschlecht und BMI

Oberfläche: Ergebnisse (1/2)

Table 3 OCCCs and confidence intervals for comparison of 3D body scanner and formulae

Formula	All			Normalweight			Overweight			Obesity		
	OCCC	Lower 95% CI	Upper 95% CI	OCCC	Lower 95% CI	Upper 95% CI	OCCC	Lower 95% CI	Upper 95% CI	OCCC	Lower 95% CI	Upper 95% CI
Anderson	0.901	0.894	0.908	0.944	0.935	0.952	0.861	0.847	0.874	0.796	0.772	0.817
Bardeen	0.409	0.391	0.426	0.361	0.330	0.391	0.298	0.277	0.319	0.286	0.258	0.314
Boyd	0.936	0.931	0.941	0.958	0.950	0.964	0.906	0.895	0.915	0.875	0.859	0.890
Brody	0.955	0.952	0.959	0.984	0.981	0.987	0.949	0.943	0.955	0.883	0.868	0.897
DuBois and DuBois	0.969	0.967	0.972	0.965	0.959	0.970	0.950	0.944	0.955	0.959	0.952	0.965
Fujimoto and Watanabe	0.988	0.987	0.990	0.983	0.980	0.986	0.986	0.984	0.988	0.980	0.976	0.984
Gehan and George	0.900	0.893	0.907	0.942	0.932	0.950	0.859	0.845	0.872	0.796	0.772	0.818
Haycock et al.	0.896	0.889	0.903	0.953	0.945	0.960	0.861	0.847	0.874	0.775	0.750	0.798
Isaksson	0.954	0.949	0.958	0.936	0.922	0.948	0.937	0.929	0.944	0.928	0.918	0.937
Livingston and Lee	0.801	0.788	0.813	0.943	0.932	0.952	0.762	0.740	0.782	0.559	0.524	0.593
Mosteller	0.925	0.920	0.930	0.957	0.949	0.963	0.893	0.881	0.903	0.849	0.830	0.866
Reading and Freeman	0.931	0.926	0.936	0.962	0.955	0.967	0.902	0.891	0.911	0.858	0.840	0.874
Schlich et al.	0.946	0.941	0.950	0.937	0.927	0.946	0.933	0.925	0.941	0.911	0.895	0.925
Sendroy and Cecchini	0.981	0.979	0.982	0.980	0.976	0.983	0.975	0.972	0.977	0.968	0.963	0.972
Shuter and Aslani	0.985	0.983	0.986	0.987	0.984	0.989	0.977	0.973	0.980	0.974	0.969	0.978
Takahira	0.953	0.949	0.956	0.943	0.934	0.951	0.924	0.915	0.932	0.939	0.930	0.948
Tikuisis et al.	0.955	0.951	0.959	0.959	0.952	0.965	0.931	0.923	0.938	0.921	0.909	0.931
Wang and Hihara	0.907	0.901	0.913	0.938	0.929	0.947	0.866	0.852	0.878	0.821	0.799	0.840

Results of the entire data set and for all BMI scenarios

Oberfläche: Ergebnisse (2/2)

Allgemeine (reparametrisierte) Formel

$$\text{Surface} = 0{,}0151 \times \text{Height}^{0{,}5751} \times \text{Weight}^{0{,}4259}$$

Beispiele

Größe = 180 cm	Gewicht = 80 kg	Oberfläche = **1,93** m^2
Größe = 170 cm	Gewicht = 65 kg	Oberfläche = **1,71** m^2
Größe = 195 cm	Gewicht = 130 kg	Oberfläche = **2,49** m^2

Eur J Appl Physiol (2017) 117:371–380
DOI 10.1007/s00421-016-3525-5

CrossMark

ORIGINAL ARTICLE

Body surface assessment with 3D laser-based anthropometry: reliability, validation, and improvement of empirical surface formulae

Andreas Kuehnapfel[1,2] · Peter Ahnert[1,2] · Markus Loeffler[1,2] · Markus Scholz[1,2]

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Abstract
Purpose Body surface area is a physiological quantity relevant for many medical applications. In clinical practice, it is determined by empirical formulae. 3D laser-based anthropometry provides an easy and effective way to measure body surface area but is not ubiquitously available. We used data from laser-based anthropometry from a population-based study to assess validity of published and commonly used empirical formulae.
Methods We performed a large population-based study on adults collecting classical anthropometric measurements and 3D body surface assessments ($N = 1435$). We determined reliability of the 3D body surface assessment and validity of 18 different empirical formulae proposed in the literature. The performance of these formulae is studied in subsets of sex and BMI. Finally, improvements of parameter settings of formulae and adjustments for sex and BMI were considered.
Results 3D body surface measurements show excellent intra- and inter-rater reliability of 0.998 (overall concordance correlation coefficient, OCCC was used as measure of agreement). Empirical formulae of Fujimoto and Watanabe, Shuter and Aslani and Sendroy and Cecchini performed best with excellent concordance with OCCC > 0.949 even in subgroups of sex and BMI. Re-parametrization of formulae and adjustment for sex and BMI slightly improved results.
Conclusion In adults, 3D laser-based body surface assessment is a reliable alternative to estimation by empirical formulae. However, there are empirical formulae showing excellent results even in subgroups of sex and BMI with only little room for improvement.

Keywords 3D body scanner · Anthropometry · Body surface area · Reliability · Validity

Abbreviations
BMI Body mass index
LIFE Leipzig Research Center for Civilization Diseases
OCCC Overall concordance correlation coefficient

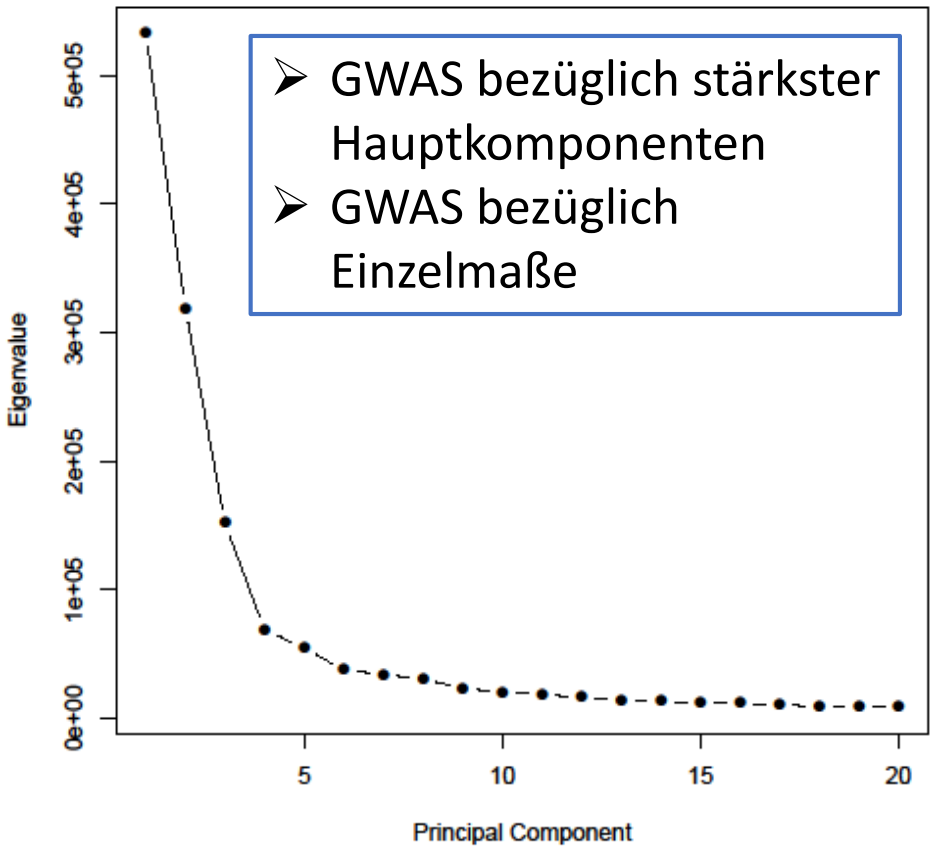
Introduction

Body surface area is a physiological quantity relevant for

Ausblick

Genomweite Assoziationsstudie

10.149 Probanden aus LIFE-Adult



1. Hauptkomponente: **35%**
Total Torso Girth
Weight
Arm Length to Neck Back Left
2. Hauptkomponente: **21%**
Body Mass Index
Middle Hip
Distance Breast to Vertical
3. Hauptkomponente: **10%**
Waistband to Buttock Height Left
Waistband to Buttock Height Right
3D Waistband Right to Crotch
4. Hauptkomponente: **5%**
Distance Waist Back to Vertical
Distance Belly Height to Vertical
Distance Back in Maximum Belly Height to Vertical

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