Anthrop. Közl. *34;* 55–63. (1992)

THE COMPARABILITY AND STANDARDIZATION OF MEASUREMENTS, INDICES AND VARIABILITY-PARAMETERS OF DIFFERENT BODY HEIGHT

E. May

Institute of Human Biology, Section of Anthropology, Technical University, Braunschweig, Germany

Abstract: *Sometime ago the author publilshed allometrical equations to eliminate the influence of stature on other body measurements approximativly. Typological comparisons as well as comparative examinations on populations are possible with the transformed data. Now, the author's intention is to indicate the influence of stature on the value and variability of body measurements. But when one determines the variation of a certain body measurement, one often documents the variation of stature only. By means of theoretical and practical examples the correlation between body measurements and stature is shown with its consequence for the relative variability.*

The author gets a better separation of the compared samples by transforming his measurements and indices on a "reference stature", but distribution-free statistics have to be applied. For the standardization of measurements and proportions (indices) it is necessary to choose a special "reference stature": The parameters of variability of the transformed data are now automatically standardized, and operating with logarithmic data the coefficient of variation is of no use.

This methodical approach is significant for the interpretation of cross-sectional and longitudinal data as well as for typological investigations and acceleration phenomena.

Key words: *Comparability of body measurements; Standardization of body measurements; Body height.*

The growth of special body measurements are closely related to the processes of individual growth of the whole body. The same are body proportions of each period of development the result of the mean growth rate of their initial measurements. In most cases it is therefore necessary to analyse the mutal dependence of body height and form. This applies for defined periods of life and development, for the phenomenons of acceleration and retardation, and the typology of constitution, sex and race. Normally the comparison of measurements and proportions is fundamental for the assessment of the typological value, as well as their variability. It must be questioned if original data alone are appropriate to describe different types and their variations sufficiently and reproducibly. It is not known, if and to what extent different body height of individuals respectively populations determine the variations and size of measurements and proportions. The answers to these questions will not be without consequences for the interpretation of variability-parameters, which are often also typological characteristics.

Consequently, following questions of comparative assessment of measurements and their variabilities arise:

1. How and to what extent does the total body height vary?

2. How and to what extent do measurements and proportions, which are to examine, vary?

3. What kind of influence does the total body height have on measurements and proportions, which are to examine, on different periods of development?

4. How can the influence of total body height be eliminated, at least approximately?

5. The dependence of important proportions from the age after eliminating the influence of body height. (A 1.50 m-tall 12 year-old child has in principle different proportions than an adult of the same size!)

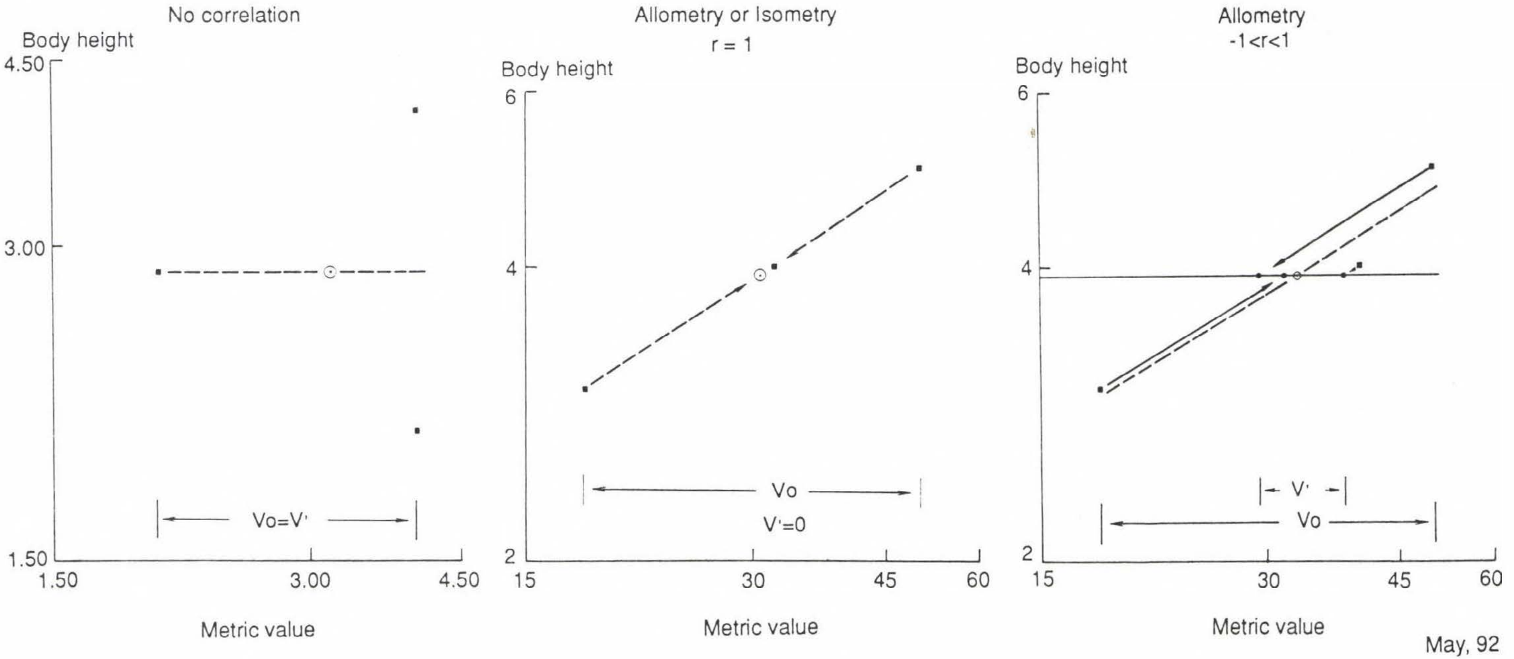

Fig. 1a　　Fig. 1b　　Fig. 1c

Fig. 1: Graphic examples of theoretical groups for different kinds of influence of body height on the relativized measurements and their variation.
a) No correlation of measurement and body height: the variability of the original data is the same as in the transformed data.
b) Absolute correlation of measurement and body height: the variability of transformed data approaches 0.
c) The coefficient of correlation of measurement and body height lays between −1 and +1: the variability of the transformed data is decreased by the influence of the body height. (r = coefficient of correlation, v_o = variability of the original data, v' = variability of the transformed data)

6. The determination of the age-dependent accelerationer and non-accelerationer. (The differences of these groups in measurements, proportions and their absolute and relative variability-parameters are to be assumed, after eliminating the influence of body height.)

The elimination of the influence of body height on measurements and proportions, for the proof of allometries, does necessarily leads to a transfer of individuals within the typ-spectrum, if the specific typology is defined by measurements and indices (*Fig. 1*), accordingly for changed variability-parameters. The questions above will help to *standardize the variability-parameter* for a lot of possible groups.

Some remarks must be made to the use of allometric methods. The term allometry is defined correctly only with reference to the parameter of the total body height. Real allometries are furthermore only ontogenetic allometries corresponding to true longitudional section, not to longi-section of transversal-sections. Only approximate allometry-parameter might be get by forming a longi-section out of transversal-sections.

Intraspecific and ontogenetic allometries are well proved for important main proportions of the human body, therefore this should be taken into account when the variability-parameter in different specific periods of life are defined. There is a shift of developmental age and body height due to acceleration, hence follows that metric original data cannot be transfered to other samples of a diverging acceleration degree. The original data must be translated to a certain (optional) reference body height.

Here, the author would like to refer to his proposed equations of transformation (May, 1985, 1990). These are now slightly simplyfied and improved (for a sensible comparison of samples of different mean body height). For the comparison of individuals within one sample it will do to determine the measured value which can be expected for a reference body height for all individuels (e.g. the mean body height of the sample), based on an equation of regression for body height and the concerning measurement. This can be done by the following equation:

$$MB = MI * (KHB/KHI)^{1/a}$$

The same as for measurements is valid for proportions (indices). From

$$I = MI_1/MI_2 * 100$$

and

$$It = MB_1/MB_2 * 100$$

consequences

$$It = I * (KHB/KHI)^{(1/a1-1/a2)}$$

where

I =original index from original measurements
It =transformed index to combined body height of all individuals of one population
$MI_{1,2}$ =real, individual measured value
$MB_{1,2}$ =theoretical measured value for $MI_{1,2}$ with KHB
KHI =real, individual body height
KHB =reference body height
$a_{1,2}$ =exponents of regression for the relation between $MI_{1,2}$ and KHI

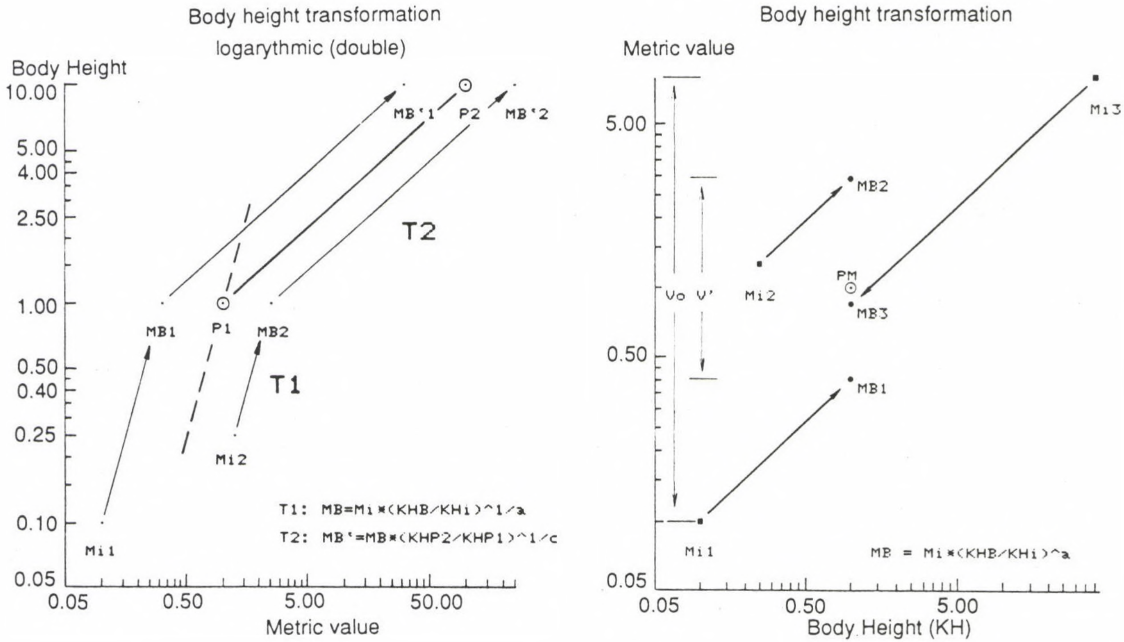

Fig. 2a

Fig. 2b

Fig. 2: Schematic representation of transformed measurements within one sample (T1) and between samples with different mean body height (T2). For further information see text

If

$$a_1 = a_2$$

then

$$(KHB/KHI)^{(1/a1-1/a2)} = 1 \text{ and } It = I$$

For this special case a transformation of the index becomes unnecessary.

To compare samples of different mean body height (e.g. with different degrees of acceleration) an other transformation is useful, if the body form should be equated critically: this is a methodical equivalent to the mathematical treatment of interspecific "allometries". The family of points of the sample with higher mean body height, groups on a parallel line of regression, due to a higher mean rate of individual growth. We have defined this phenomenon mathematically for measurements (MB') and indices (It') (May, 1985, 1990) and proposed the formula for an other transformation. The simplified and corrected equation reads as follows:

$$MB' = MB * (KHP_2/KHP_1)^{(1/c)}$$

This transformation enables to project the mean values of different samples, so the individuals of this samples will have the same *mean* body height (see *Fig. 2*) The *population*specific influence of the body height on the measurements will have been eliminated approximately (*Fig. 2*).

For indices (thus proportions) corresponding formula result directly. It emerges:

$$It' = MB_1{}^1/BM_2{}^1 * 100$$

and

$$It' = It * (KHP_2/KHP_1)^{(1/c1-1/c2)}$$

where

It' = double transformed index
$KHP_{1,2}$ = mean body height of two populations ($_{1,2}$), which are to be compared
$c_{1,2}$ = exponents of regression for the relation between $MB_{1,2}$ and $KHP_{1,2}$

In the author's opinion, only transformed data of population and/or samplespecific measurements and proportions of the body become registrationable and comparable, if there is no isometry. Without these transformations the differences found are actually due to samplespecific body height. Also variability-parameter must be interpreted under this aspect, respectively should be obtained by so transformed data. The transformations have no effect on the *mean value* of measurements, if the mean body height of the sample is the reference body height. The variability of transformed data must be smaller than these of original data, because of the influence of body height on original data, which is also valid for the coefficient of variability and their parameters. A better statistically separability of mean sample values can be expected because of the transformation. As a result, the transformed data are not normally distributed and should therefore be tested by a non-parametric test (e.g. Kolmogoroff–Smirnow-Test). In general the variance after transformation decreases the more, the higher the correlation between the measurements and the body height becomes.

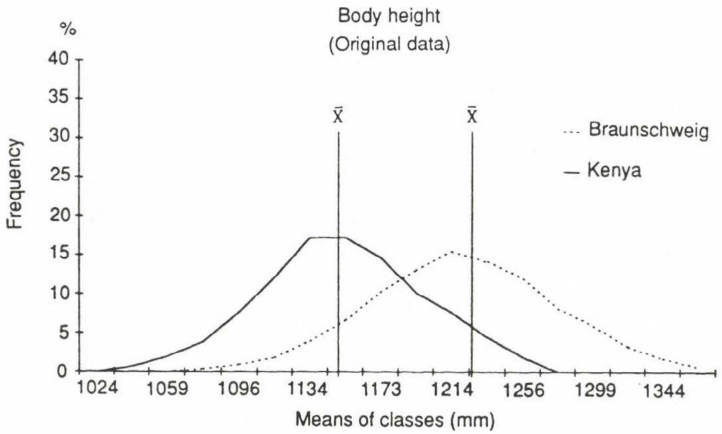

Fig. 3a

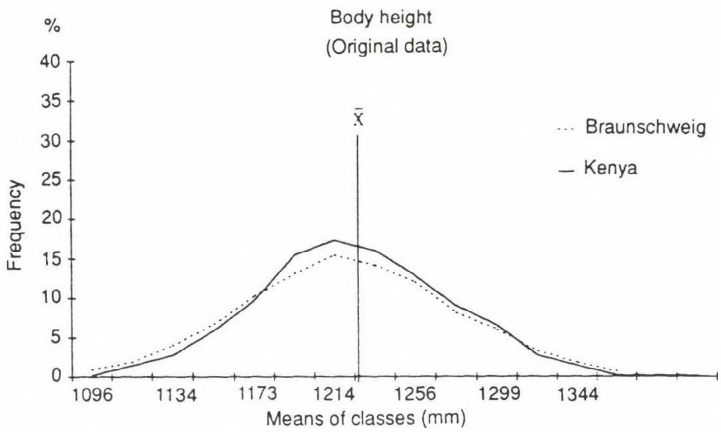

Fig. 3b

Fig. 3: Histograms of body height for the samples 6–7 year-old boys in Kenya and Braunschweig
a) Comparison of mean values; b) Mean values of both samples drawn one on top of the other.
Please, notice the good congruence of both histograms

Figures 3 and *4* show the histograms of original data for body height, and the original as well as the transformed data of armspan of both sample of 6–7 year-old boys from Braunschweig (n = approx. 800) and Kenya (n = 50). In *Fig. 5* the effect of the "intraspecific transformation" is illustrated on the examples from Kenya and Braunschweig (Longitudinal Study in Braunschweig – Braunschweiger Längsschnitt, 1978 and Kenya, 1990).

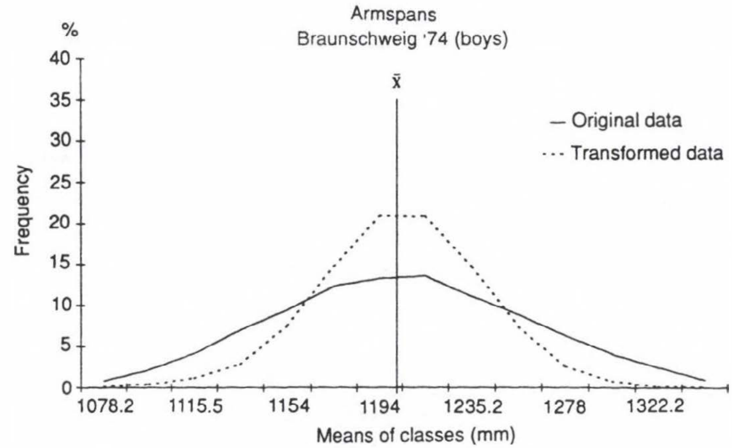

Fig. 4a

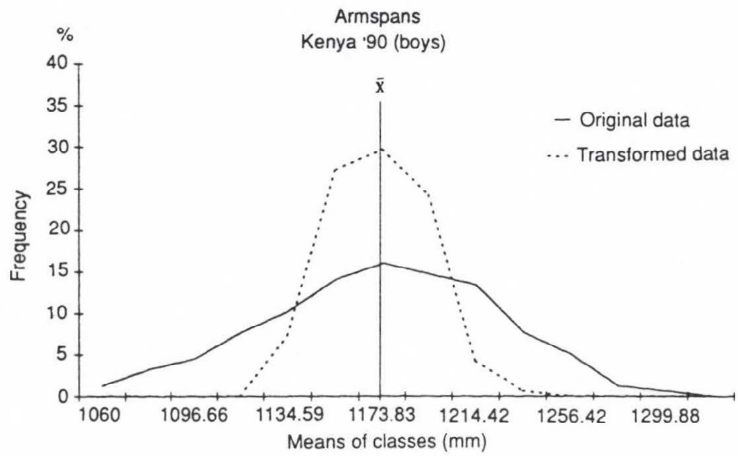

Fig. 4b

Fig. 4: Histograms comparing the armspan of 6–7 year-old boys for original and transformed data from Kenya and Braunschweig a) Braunschweig; b) Kenya

The variability of the original and the transformed measurements of both samples offer an especially good comparability, as seen in the *figures 4* and *5*, because the mean sample values were coincide with each other.

The comparison of the histograms with transformed data of both samples show a totally different relation of variabilities as the ones with the original data (*Fig. 5a, b*), hence the information follow, which are necessary for the interpretation of the variability-parameter in sense as mentioned above. In *Fig. 5b* the standardization of variability is shown.

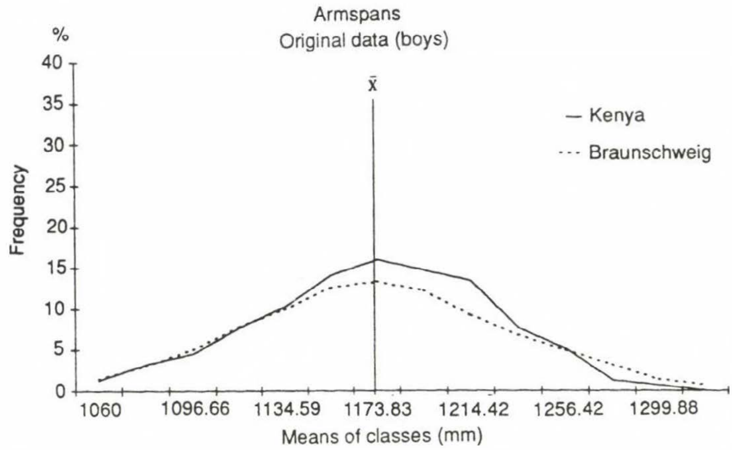

Fig. 5a

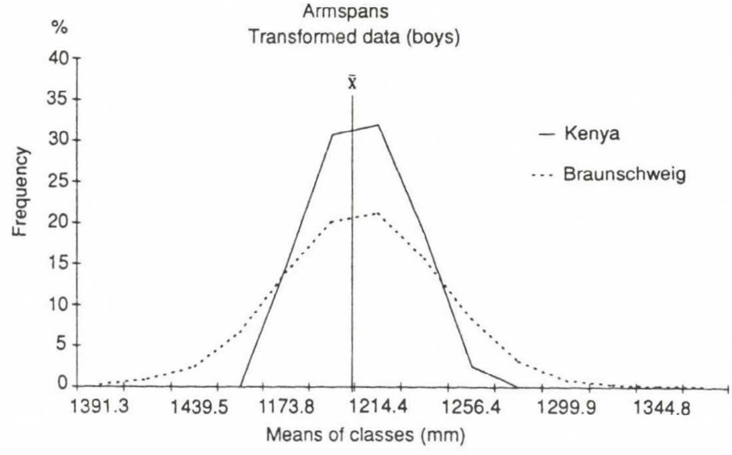

Fig. 5b

Fig. 5: **Histograms comparing the armspan of 6–7 year-old boys for original and transformed data from Kenya and Braunschweig a) original data; b) transformed data. — Please, notice the extrem different variability of data which are standardized by transfomation and on the contrary, the more homogeneous variability of the original data. Validity can only be assumed for the transformed data**

In total one may say that the comparison between the particular measurements and proportions within, as well as between, the populations will be meaningless, if the corresponding data and indices were not standardized with allometric methods. That means that individual results must be referred to their status within their population. Their status towards other populations can be used after additional consideration of the mean body height of the population which is compared.

This methodical reflection is with special interest for longitudinal and cross-sectional studies for the typology of sex, constitution and race, and for the interpretation of acceleration phenomena. In addition, the proposed standardization of measurements and variability-parameter may be helpful for a coming international anthropological atlas of data.

*

Acknowledgement: Thanks go to *Mrs. Dr. S. Grefen-Peters*, TU Braunschweig, for the critical review of the manuskript. — The "Braunschweiger Längschnittuntersuchung", 1978 was supported by the DFG.

*

Paper presented at the Conference of the Pediatric-Anthropological Subsection of the Anthropological Section, Hungarian Biological Society, Debrecen, Hungary, May 1992. — Received 14 August, 1992.

References

Bitzan M, May E (1992) Zur Interpretation morphometrischer Daten 10—13 jähriger Schulkinder aus dem Erhebungsjahr 1978 des Braunschweiger Längsschnittes. — *Anthrop. Anz., 50;* 127—144.

Flügel B, Greil H, Sommer K (1986) *Anthropologischer Atlas.* Verlag Tribüne, Berlin.

Jürgens HW, Aune IA, Pieper U (1989) *Internationaler anthropometrischer Datenatlas.* — Schriftenreihe der Bundesanstalt für Arbeitsschutz Forschung Fb 587, Dortmund.

May E (1977) Aktuelle methodische Aspekte zur Behandlung und Deutung "allometrischer" Daten. — Z. *Morph. Anthrop., 68;* 88—106.

May E (1977) Body Heights and the Relation of Measured Lengths. — *in:* OG Eiben (Ed.). *Growth and Development; Physique. Symp. Biol. Hung., 20;* 299—308.

May E (1985) Ein Beitrag zur Vergleichbarkeit und Interpretation von Maßen und Indices auf der Grundlage wachstumsbiologischer Überlegungen. — *Homo, 36;* 53—68.

May E (1990) Konstitution und Akzeleration aus allometrischer Sicht am Beispiel von Daten aus einer Längsschnittuntersuchung in Braunschweig. — *Ärztl. Jugendkd., 81;* 352—361.

Plenert W, Heine W (1978) *Normalwerte.* (5. Aufl.) Volk und Gesundheit, Berlin.

Mailing address: Prof. Dr E. May
Institut für Humanbiologie,
Abteilung Anthropologie
Technische Universität
D–W–3300 Braunschweig, P.O.Box 3329
Germany