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ON THE USEFULNESS OF INDICES FROM POSTCRANIAL BODY MEASUREMENTS IN CLASSIFICATION OF CONSTITUTIONAL COMPONENTS, ILLUSTRATED BY DATA OF THE "BRAUNSCHWEIG LONGITUDINAL STUDY"

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Abstract: *After studying available allometric literature and as a conclusion from our own investigations, we are convinced that the use of indices in comparing populations (not individuals) should be restricted to cases (1) of proven isometry or (2) where there is no significant correlation between the measurements pertinent to the index.*

Using data from the "Braunschweig Longitudinal Study", we shall demonstrate this inference for measurements which are relevant for classification of constitution.

The initial data in nearly all utilized pairs of measurements show highly significant correlations. However, these correlations are due chiefly to the influence of body height. After eliminating this influence by using regression the significant correlations between many of the body measurements were subsequently lost. This may make the use of indices justifiable, provided that the raw data were transformed in the appropriate manner.

Key words: *Population comparison; Constitution; Dependence of body measurements on standing height; Indices*

Introduction

In the allometric literature, discussions dating back to the sixties and seventies can be found which explain that a (median) index for comparing populations can be utilized only under certain conditions. In anthropology, however, the necessary consequences of this fact are still hardly taken into consideration when the proportions of different populations are being compared.

The use of an index is justified only in the case of two constellations where the proportions found in random samples are adequately described (*Fig. 1*).

(1) *Isometry* (see *Fig. 1b*): The first case is when both of the related body measurements (not dependent on height) are isometric, that is, when the line of regression through the cluster of data points shows a slope of 45 degrees; the regression coefficient $b = 1$. The median index adequately describes the relationship of measurement parameters, since the relationship of ΔY to ΔX is constantly equal to one ($\Delta Y : \Delta X = 1$) for all values of "X".

(2) *No correlations* (see *Fig. 1c*): In the second constellation, the utilized body measurements (not dependent on height) must show no significant correlation, i.e. (r) is approximately equal to zero ($r \approx 0$). Then, any measurement "X" within the population can belong to any measurement "Y", and the median index reflects this proportion in a random sample.

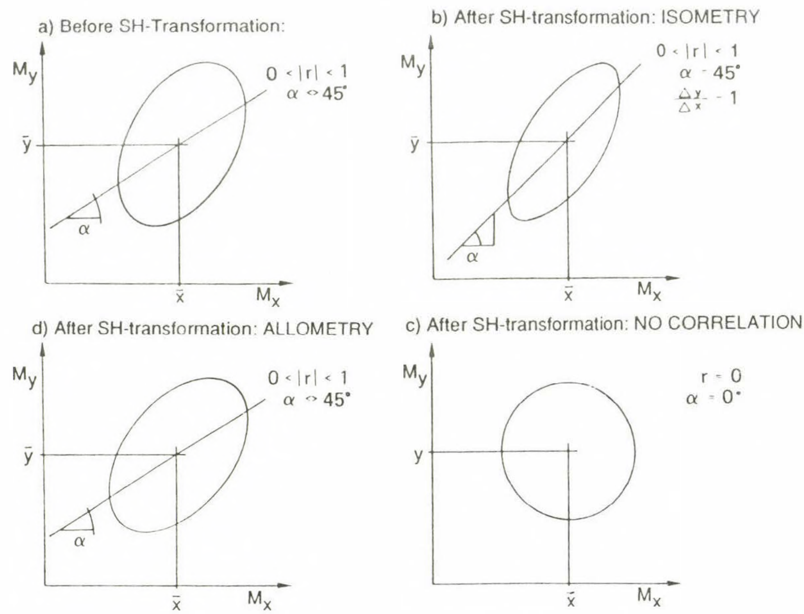

Fig. 1: (a) Raw data, i.e. Population before SH-transformation, (b) after SH-transformation: isometry; (c) after SH-transformation: no correlation; (d) after SH-transformation: allometry; r: correlation; α: slope; further explanation see text and Fig. 2.

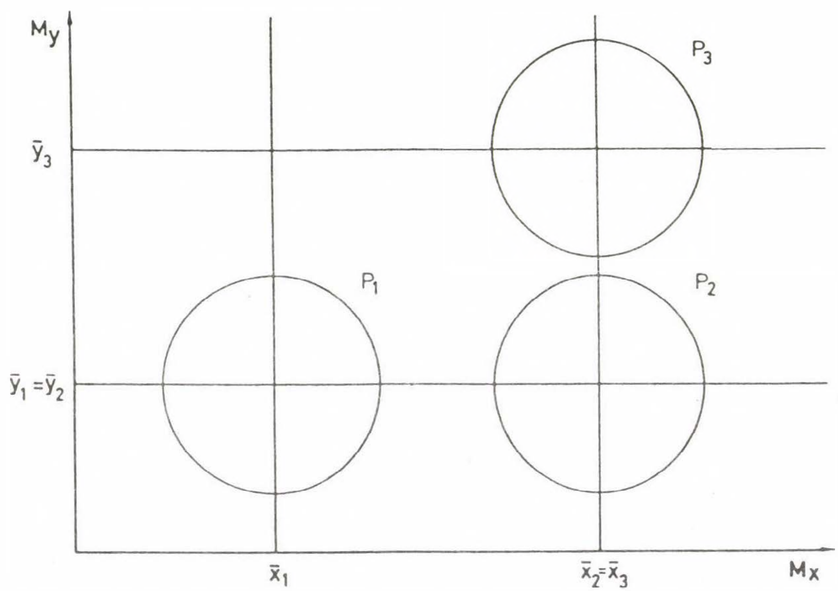

Fig. 2: Differences between populations without a significant correlation in the pair of measurements can be made true only when there is a significant difference between one or both means of the measurements. $P_{1,2,3}$: population 1–3; $\bar{x}$, $\bar{y}$: mean of the measurement; M_x, M_y: logarithms of the investigated body measurement

Figure 2 displays the comparison of populations, in which the investigated measurements have no correlation. We only find differences between those populations where there is a significant interval in mean value between at least one of the measurements (M_x or M_y).

Allometry (see *Fig. 1d*): If a combination of body measurements shows a significant correlation and a significant regression coefficient where (b) is not equal to one ($b \neq 1$), then regression from "Y" to "X" must be determined in order to compare the populations. In this case, it would not make any sense to use an index as the reference measurement, because it varies in accordance with "X". The index is therefore dependent on the measurement dimensions, which fulfills the definition of intraspecific allometry.

Because of the influence of height on the total body proportions and, thus, on constitution (see Schwidetzky 1974, May 1977a, May & Kurth 1977, Knußmann 1980, May 1990, Bitzan & May 1992), we considered the question of the reliability of comparison of populations when the individuals have different median heights. In 1985, May had already discussed a possible corrective measure.

According to Schwidetzky (1974), bodily structure or constitution is defined as the main proportions of the body, that is, the proportional relationship between the trunk and the extremities. These proportions, similar to those of the long bones, vary according to a person's height (see also May 1977a, May & Kurth 1977). By including allometric methods, May (1976, 1977a, 1977b, 1985) addressed the problem of standardizing body measurements and indices attempting to find a corresponding transformation which could eliminate the influence of height on (other) measurements and indices. The standing height (SH) computation formulas of Manouvrier (1892) and Breitinger (1937) are good examples of how the growth tendencies of different populations can be combined by means of the appropriate transformations (also see Bitzan 1984, Bitzan & May 1991). It now seems appropriate to transfer these ideas and results to index studies with indices used for evaluation of constitution.

Subjects and Method

Based on data taken from the "Braunschweig Longitudinal Study", we will demonstrate the effects of transformation of the individual measurement values on the measurements in question.

Study Group Autumn 1978: 919 boys with an average age of 11 years, 0.6 months (= 4034 days; i.e.: from 3573 to 5036 days, which equals 9 years, 9.4 months to 13 years, 9.5 months) and 883 girls with an mean age of 10 years, 11 months (= 3985.3 days; i.e.: from 3582 to 4889 days, which equals 9 years, 9.7 months to 13 years, 4.6 months). The raw data for each individual were transformed to the median age of random samples for males and females, respectively, by means of semi-logarithmic regression (Bitzan & May 1991). The body measurements of these now age-standardized children were then used as the raw data for our further computations.

By means of linear regression, the logarithms of all body measurements were then transformed into agreement with the logarithm-derived heights based on the median value of random samples. Due to limitations of space, we cannot go into the details of this technique right now, see Knaust (1979), May (1985) and May & Bitzan (1992), as well as to mathematical literature on the basics of regression analysis (like Weber 1980; Sachs 1978; Tabachnik & Fidell 1983).

According to current opinions, the postcranial body measurements discussed here (in conformity with Knußmann 1980, p. 189) are relevant to constitutional evaluation of an individual (*Table 1*).

Table 1. **Abbreviations and definitions of the body measurements used**

Abbr.	Measurement	Martin/Knußmann (1988) No.	Martin/Knußmann (1988) Page
SH	standing height	1	259
SSH	suprasternal height	4	260
SYH	symphyseal height	6	260
BAB	biacromial breadth	35	263
THD	thoracic depth	37	264
BIB	bi-iliocristal breadth	40	264
THC	thoracic circumference	61	270
BW	body weight	71	273

While Knußmann (1980) placed heavy significance on the "standing height (SH)" with respect to the leptomorphic/pyknomorphic factor, we totally disregarded this measurement, since it comprises exactly the influence which we wish to eliminate when comparing populations of different sizes. One must also consider that the constitutional type is principally genetically determined. The standing height (SH), however, reaches different values, for example, due to acceleration of growth processes and many other non-genetic reasons.

Results

All 42 possible combinations of raw data displayed a highly significant correlation for both sexes ($p < 0.01$). Isometry was seen in only a few combinations (boys 9, girls 5).

After height transformation had been performed, the situation was greatly changed. Only 31 of the boys original 42 data pairs (girls 28 pairs) still showed relevant correlation. Isometry is merely found altogether for 5 combinations. THD : SSH, THC : SSH for both sexes, and THD : BW for boys. Entirely the last measurement pair shows a slope significantly different from zero. The median index would therefore be an appropriate reference measurement for an adequate, different population only if it possesses just this attribute.

As a first example see the boys thoracic depth (THD) to body weight (BW).

Isometry (corresponding with *Fig. 3*).

♂ THD : BW	Correlation (r)	Slope (b)	Intercept (a)
before transform.	0.6803^{s}	$1.0063^{n} = 45.2°$	3.8273
95% confid. limits	0.5567 — 0.8040	43.1° — 47.1°	3.7426 — 3.9119
after transform.	0.6076^{s}	$1.1551^{n} = 49.1°$	3.6479
95% confid. limits	0.4852 — 0.7301	46.67° — 51.4°	6.3437 — 6.6730

^{s} : Significant when $\alpha = 0.01$

^{n} : No significant difference to one, when $\alpha = 0.05$.

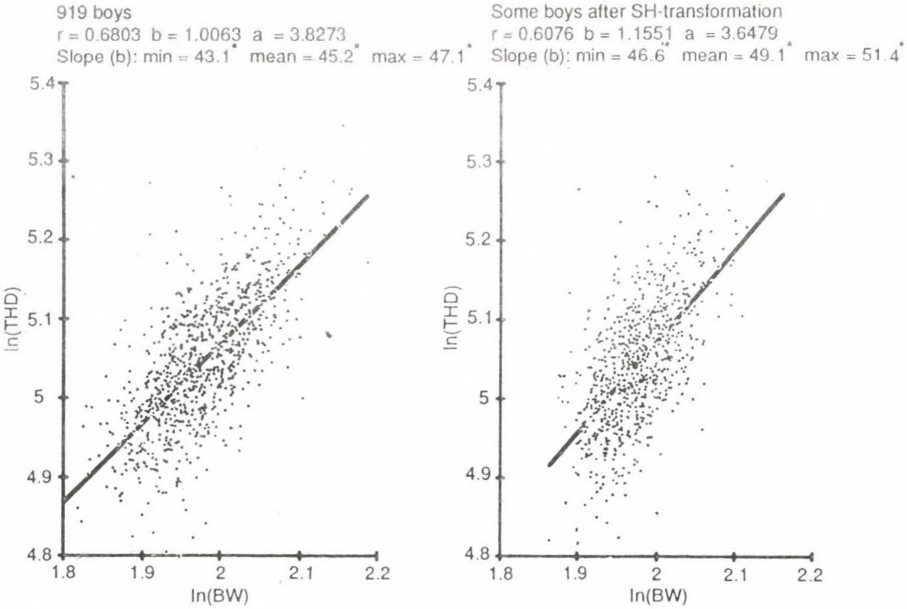

Fig. 3: 'Braunschweig Longitudinal Study': example for isometry in boys between THD and BW; r: correlation coefficient; b: slope; a: intercept; . (points): individual pair of measurements; ■ : sample mean $(\bar{x}, \bar{y})$; — : regression line.

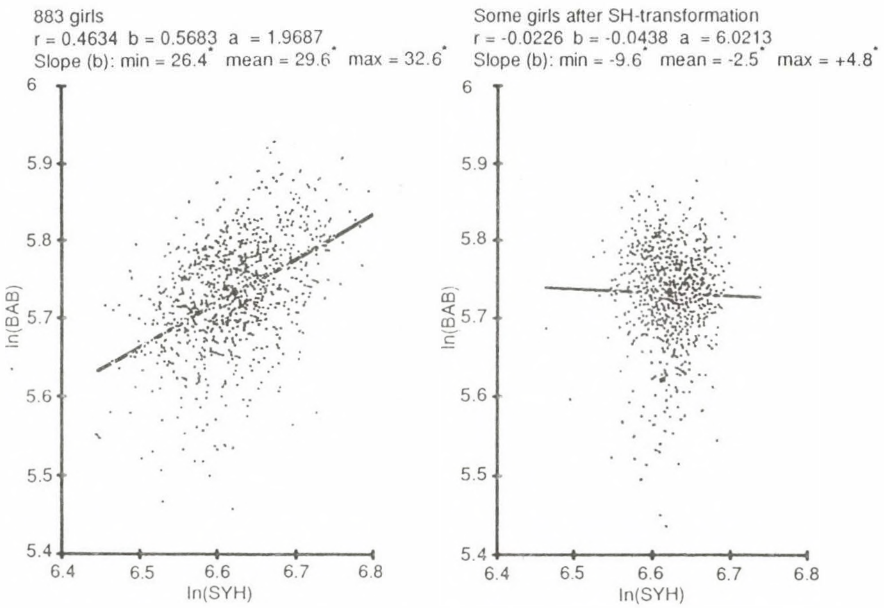

Fig. 4: 'Braunschweig Longitudinal Study': example for loss of correlation in girls between BAB and SYH: for further explanation see Fig. 3.

11 data combinations in boys thus no longer show a significant correlation after standing height (SH) transformation ($P > 0.05$; earlier value $p < 0.01$). This also applies to girls with respect to the same 11 data pairs as well as to 3 additional ones. As an example see *Fig. 4*, biacromial breadth (BAB) to symphyseal height (SYH) in girls.

Loss of correlation (corresponding with *Fig.* 4)

♀ **BAB : SYH**	**Correlation (r)**	**Slope (b)**	**Intercept (a)**
before transform.	0.4634^{s}	$0.5683 = 29.6^{\circ s}$	1.9687
95% confid. limits	0.3380 — 0.5887	26.4° — 32.6°	1.4935 — 2.4440
after transform.	-0.0226^{n}	$-0.0438 = -2.5^{\circ n}$	6.0213
95% confid. limits	−0.1401 — 0.0948	−9.7° — +4.8°	5.1755 — 6.8672

s : Significant r or $b \neq 1$, when $\alpha = 0.01$

n : No significant r or difference to one, when $\alpha = 0.05$.

With the exception of a few unclear results discussed in connection with isometry, the remainder of measurement data combinations show intraspecific allometry, even after the approximate exclusion of SH influence. For example, take the data pair thoracic depth (THD) to thoracic circumference (THC) of the boys (as shown in *Fig. 5*), which seemed unsuitable for use with indices. It requires the use of a regression equation.

Allometry (corresponding with *Fig.* 5)

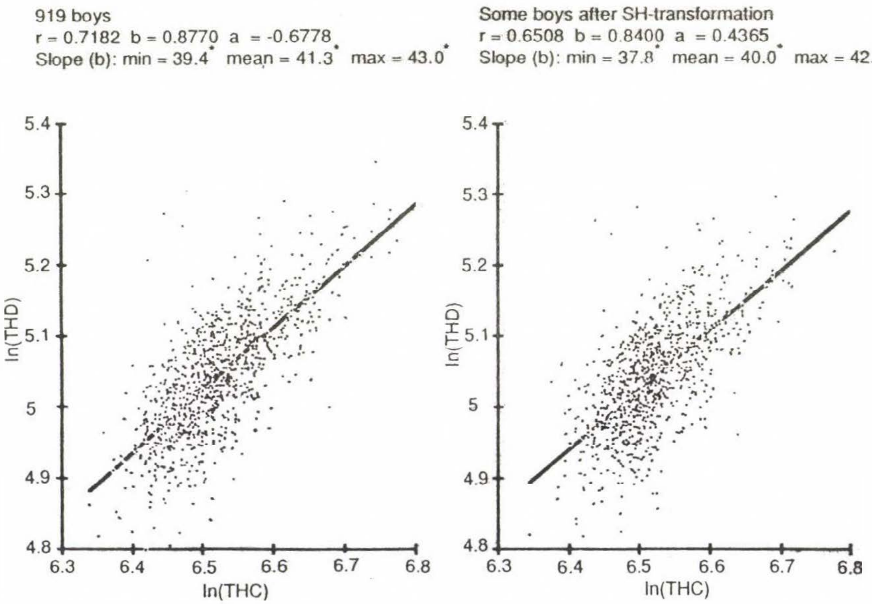

Fig. 5: "Braunschweig Longitudinal Study": example for isometry in boys between THD and THC: for further explanation see Fig. 3.

♂ THD : THC	Correlation (r)	Slope (b)	Intercept (a)
before transform.	0.7182^s	0.8770 = 41.3^{os}	0.6778
95% confid. limits	0.6008 — 0.8356	39.4° — 43.0°	−1.0364 — −0.3193
after transform.	0.6508^s	0.8400 = 40.0^{os}	−0.4365
95% confid. limits	0.5338 — 0.7679	37.8° — 42.1°	−0.8500 — −0.0229

^{s} : Significant r or b ≠ 1, when $\alpha = 0.01$

These examples demonstrate that indices for evaluation of constitution can be utilized only in certain situations, since the measured bodily proportions do not automatically allow comparative statements on the constitutional type.

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