

EXPERIMENTALLY DERIVED MODEL OF HUMAN BODY GROWTH

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INTRODUCTION

The proportion between body mass and body height serves as a general description of human body shape (HBS). Different indexes have been used to describe HBS. The most common is Quetelet's body mass index (BMI) that is the ratio between body mass and the second power of body height. The ability of BMI to detect obesity in children is limited by its relatively high level of unexplained variance. Ponderal index (PI) is a geometrically based index (the ratio between body mass and the third power of body height) of HBS. PI is based on a geometrical model, which follows the rules of allometry [1] and scaling of biomechanical parameters [2]. The growth (an age related increase in body height and mass) in children 6-18 years is often considered as geometrically similar, because the body proportions remain almost unchanged. It is unclear how close human growth follows the model of geometrically similar growth.

The aims of this study were to (1) explore the assumption of geometrical growth by developing an experimentally derived model of human body growth; (2) to establish a modified body mass index (MBMI) that is invariant of the effect of growth; and (3) to compare variability of different indexes in a sample population of 6-18 year old children.

METHODS

We used the demographic data collected in able-bodied children age 6-18 years [3] (444 girls and 403 boys). To model growth, the best fit between the body height (H) and body mass (BM) was calculated separately in boys and girls with the function $BM = m_i H^p$. The modified body mass index (MBMI) was calculated as $MBMI = BM / H^p$ in boys and girls separately. In addition an average body height power across the genders was used to calculate the common modified body mass index (cMBMI) in all children. The BMI ($BMI = BM / H^2$) and PI ($PI = BM / H^3$) were also calculated. The means, standard deviation and variability (standard deviation expressed as a percentage of the mean value) of all indexes were calculated. The correlation coefficients and regression lines were used to assess the relationship between indexes and body height. Statistica, StatSoft Inc. software was used in the analysis at $p < 0.05$.

RESULTS AND DISCUSSION

The best mathematical fit between body mass and body height found in girls was $BM_G = 13.6 H^{2.71}$ ($R^2 = 0.89$) and in boys $BM_B = 13.9 H^{2.65}$ ($R^2 = 0.91$). The difference between the

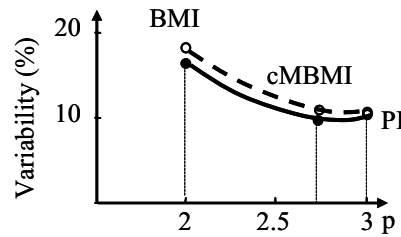


Figure 1 The variability of different body mass indexes in girls (dashed line) and in boys (solid) as a function of p in the equation $BM = m_i H^p$

experimentally obtained powers and the third power of body height reflected the discrepancy between the experimental and geometrically similar model of the human body growth. The different powers obtained in girls and boys may reflect the gender specific differences in body build. There were no statistically significant correlations between indexes and body height, except for BMI, which also exhibited the largest variability (18 % in girls and 17.7 % in boys) (Fig.1). The MBMI, cMBMI and PI exhibited similar variability (12.2%-13.9%) (Table 1). The increase of BMI with the body height in children requires an application of age charts and a z-score or percentile analysis. The fact that the other indexes are independent of body height sanctions a characterization of population with one mean and one standard deviation. Future studies should include the development of models of growth in various populations and in individual subjects.

CONCLUSIONS

Human growth in children 6-18 years old does not follow the geometrically similar growth model.

Using variability as a guide, MBMI and PI appear to be superior to BMI in reflecting the relationship between the body height and geometry.

Based on the differences in the coefficients cMBMI is superior to PI in the context of the differences due to growth in children 6-18 years old.

REFERENCES

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Table 1 The characteristic of different body mass indexes (mean± std) and their dependency on body height in children 6-18 years old.

Body mass index Gender	BMI		PI		cMBMI	
	Mean±std (kg/m ²)	Regression equation	Mean±std (kg/m ³)	Regression equation	Mean±std (kg/m ^{2.68})	Regression equation
Girls N=444	18±3.2	2.23 + 10.9 H r=0.65	12.47±1.64	15.81-2.28 H r=-0.24	14.02±1.95	12.47+1.07H r=0.1
Boys N=403	17.7±2.9	5.2 + 8.57 H r=0.62	12.21±1.62	17.32-3.46 H r=-0.06	13.76±1.82	14.14+0.5 H r=-0.05