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# Body Mass Index, Some Circumference Indices and their Ratios for Monitoring of Physical Development and Nutritional Status of Children and Adolescents

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The aim of this paper is to construct modern age/sex-specific percentile norms of body Mass Index (BMI, kg/m$^2$), waist circumference (WC, cm), and its ratio with that of the hips (WHR) for monitoring of the physical development and for assessment of the nutritional status of children and adolescents from Smolyan region. The percentile norms have been developed using the database of the height, weight, waist and hip circumferences of 1174 children from Smolyan region (597 girls and 577 boys). The database was collected after an anthropometric transversal study conducted in the period 1998-2001. The anthropometry used the method of M a r t i n-S a l e r [7], while the derivatives were calculated by means of formulae. The percentiles were constructed on the basis of the empirical distribution of the characters and the following levelling by means of the method of the smallest squares. The graphic norms offered can be used in the clinics and schools for monitoring of the physical development and for assessment of the nutritional status of the children and adolescents from Smolyan region.

*Key words:* growth monitoring, nutritional status, undernutrition, overweight, obesity, abdominal obesity.

## Introduction

For assessment of the physical development and the nutritional status of children and adolescents [13, 11, 3, 4, 5, 12, 8, 9 ] are used more methods, but the most widely used are based on different anthropometric characters, among which is the body mass index (BMI kg/m$^2$), waist circumference (WC), its ratio with hip circumference (WHR) and others. BMI used for diagnosing undernutrition and obesity in children and adolescents [12, 13, 11, 5, 1], and for intra-group and inter-group comparisons [2, 10, 1]. WC and WHR are indicators of abdominal (central) obesity and they are largely responsible for the risk of cardio-vascular illnesses, of increase of fats in the upper body segment, and the higher risk of metabolic dysfunctions, and of various illnesses [8, 9, 6, 1].

The specific features in the physical development and nutritional status of children and adolescents of different populations require the monitoring to be realized

on the the modern assessment norms, which have been constructed within specific time and space coordinates, i.e. the time (secular) alterations should be registered on the basis of populational (local) material.

In this context, the **aim** of this paper is to construct modern age/sex-specific percentile norms of BMI, WC and WHR for monitoring of the physical development and of assessment of the nutritional status of children and adolescents from Smolyan region.

## Material and Methods

The percentile norms have been developed using the database of the height, weight, waist and hip circumference of 1174 children from Smolyan region (597 girls and 577 boys). The database was collected after an anthropometric transversal study conducted in the period 1998-2001. The anthropometry used the method of Martin-Saller [7] in which the database of directly measured metric characters was used to calculate the body mass index (BMI), and the waist-hip ratio (WHR). The percentile curves for the three characters were constructed on the basis of their empirical distribution and the following levelling by means of the method of the smallest squares.

## Results

As a result of the created norms for BMI (Fig. 1, 2), the following categories for assessment of the nutritional status of the children from Smolyan region have been defined: undernutrition (BMI $\leq P_3$); nutritional disorders and risk of undernutrition ($P_3 - P_{10}$); slightly-under-the norm weight ($P_{10} - P_{25}$), normal body weight ($P_{25} - P_{75}$), slightly-over-the norm weight ($P_{90} - P_{97}$), overweight ($P_{90} - P_{97}$), and obesity ($\geq P_{97}$). In the clinical and school practice, however, classifying a child to one or other category according to BMI, should be done with care and after taking into consideration other body composition characters, such as development of the muscle or fat component, etc.

The waist circumference values (WC, Fig. 2, 3) and the waist/hip ratio (WHR, Fig. 3, 4) ranging between $\geq P_{90}$ and $\leq P_{97}$ are indicative of extra abdominal i.e. central body fats, while values $\leq P_{97}$ — the central or abdominal obesity.

Values of BMI, WC and WHR ranging between $P_3$ and $P_{10}$ signal the beginning of growth dysfunctions probably and nutritional disorders, while values under $P_3$ signal obvious growth disturbances and undernutrition.

Children with values of the three indices above $P_{90}$ and under $P_{10}$ are a risk group for development of various illnesses at a greater age, that is why they should be under regular monitoring.

In **conclusion**, we suggest that the constructed percentile norms should be used in clinical and school practice for monitoring of the physical development and for assessment of nutritional status of children and adolescents from Smolyan region.

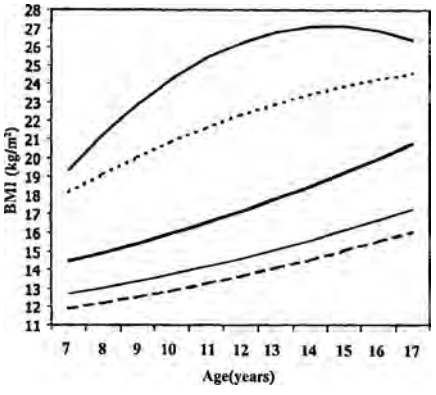


Fig. 1. BMI — girls

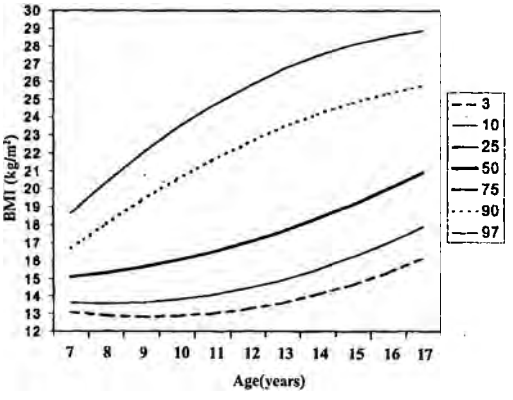


Fig. 2. BMI — boys

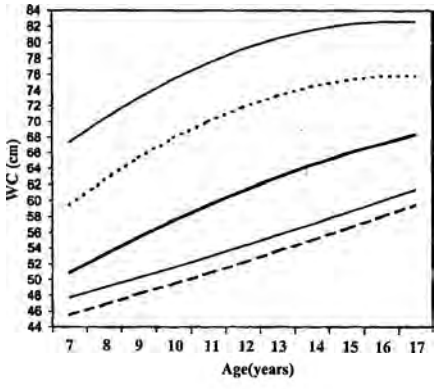


Fig. 3. Waist circumference — girls

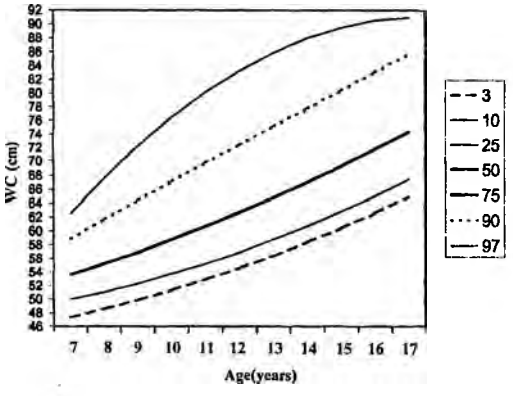


Fig. 4. Waist circumference — boys

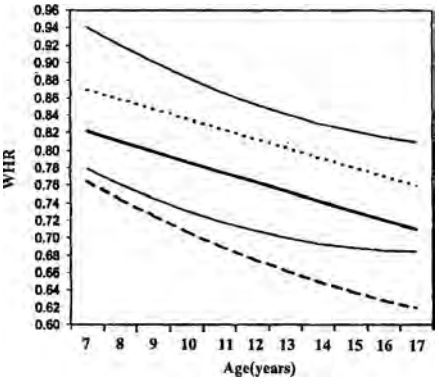


Fig. 5. Waist/Hip ratio — girls

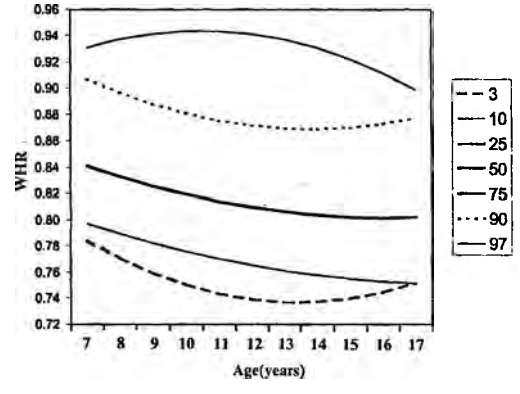


Fig. 6. Waist/Hip ratio — boys

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