Medicina (Kaunas) 2011;47(10):573-8

Analysis of Body Composition of 9- and 10-Year-Old Children in Latvia

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***Key words**: 9- and 10-year-old children; body mass index; fat mass index.*

***Summary.** Background and Objective. According to the data of epidemiologic research, the prevalence of both excessive and insufficient body weight is increasing in a pediatric population leading to the growing burden of health problems due to these changes.*

The aim of the study was to understand the current situation of physical development of 9- and 10-year-old boys and girls in Latvia and to estimate the prevalence of underweight, normal weight, overweight, and obesity among young adolescents.

Material and Methods. During 2007–2009, a random sample of healthy 9-year-old (n=184) and 10-year-old (n=320) children from all regions and different socioeconomic groups of Latvia was surveyed in a cross-sectional study. The anthropometric measurements of height, weight, 3 circumferences, and 5 skinfolds were performed. The percentage of body fat was calculated by the equation of Slaughter et al. Body mass index and fat mass index were calculated for each respondent. Children were divided into groups according to these indexes.

At the age of 9 years, 69.5% of boys had a normal nutritional level either by BMI or FMI, and 54.5% and 72.2% of the girls of the same age had a normal nutritional level by BMI and by FMI, respectively. Obesity according to BMI in 9-year-old boys was found to be 4.7% and in girls 6.1%; according to FMI, 3.7% and 2.3%, respectively. A similar trend was also observed in the cohort of 10-year-old children.

Conclusions. The results of the research showed that the problem of high prevalence of Latvian children with underweight is not smaller than the problem of children with obesity. Evaluation of physical development in children based only body mass index may lead to overdiagnosis of obesity.

Introduction

The ongoing epidemic of obesity in children has highlighted the importance of elevated amount of body fat for short-term and long-term health outcomes (1). According to scientific literature, the prevalence of overweight and obesity has increased 3 times during the last 3 decades (2). This is considered one of the crucial health problems nowadays (3, 4). Progressive increases in fat mass (FM) and progressive reductions in fat-free mass (FFM) have been noted, and both over- and undernutrition contribute to increased mortality and morbidity at older age (5, 6).

Epidemiological studies, which study the children's growth process, traditionally estimate the average values of body measurements that tend to increase with every subsequent series; body weight of children and adolescents is of particular concern. Internationally acceptable cutoffs to define thinness, overweight, and obesity for children's growth assessment comparing the children's body mass index (BMI) with the adults' BMI were designed by the scientist Cole in 2000 and 2007 (7, 8). The compliance of body weight to height is usually evaluated using BMI values. Individual physical development of children is evaluated by using standard curves and the percentile method because physique of children is tightly correlated not only with their gender, but also with their age. According to the WHO Child Growth Standards and the normative acts on children's physical development established in Latvia, the values of BMI below the 3rd percentile indicate critically low nutrition or thinness, while values above the 97th percentile indicate obesity (9, 10). As body mass is composed of both FM and FFM, the elevated values of BMI do not state clearly whether FM or FFM has increased (11). The circumferences of body depend on FM, muscle mass, and bone structure; the last two are directly proportional to FFM (12, 13).

The aim of the study was to evaluate the current situation of physical development of 9- and 10-year-old children in Latvia and to estimate the prevalence of underweight, normal weight, overweight, and obesity among young adolescents be-

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cause changes in children's body mass can often be indicators of health disorders. The study was also aimed at estimation of FMI using the rates of skinfolds measurements.

The hypothesis set for the study was to demonstrate that the number of adolescent children with underweight was as great as that of children who were overweight. Determining the degree of nourishment in children by BMI does not always precisely depict the situation and can cause overdiagnosis of obesity.

Material and Methods

Study Design and Population. The study on the nutritional level of healthy 9- and 10-year-old schoolchildren (n=504) representing all regions and socioeconomic groups of Latvia was carried out from 2007 to 2009.

A cross-sectional study of a national sample of primary schoolchildren whose parents signed informed consent was performed in all the 4 districts of Latvia. Schools for the survey were randomly selected – every 15th from the list of all schools of Latvia. Cluster sampling of classes was used. All the study subjects were divided into groups by age and gender. The group of 9-year-old schoolchildren was comprised of those children whose age at the definite screening time was from 8.51 to 9.5 years; similarly, the group of 10-year-old children was comprised of children from 9.51 to 10.5 years. All the children were anthropometrically measured by a trained researcher from the Faculty of Medicine, University of Latvia.

Measurements. The anthropometric measurements were taken according to the technique recommended by Martin and Saller (1957). Body weight was measured using a portable scale with a minimum reading of 0.1 kg; height was measured using a stadiometer measuring to the nearest 0.1 cm. In all the respondents, thicknesses of 5 skinfolds (biceps, triceps, subscapular, suprailiac, and abdominal) were measured using a caliper (minimum graduation 0.1 mm). In this paper, the data of body height, body weight, and triceps as well as subscapular skinfolds are analyzed and discussed. Measurements of skinfolds were taken on the right side of the body: triceps, the vertical fold on the midline of the posterior surface of the arm (over the triceps muscle); and subscapular, the diagonal fold about 45 degrees 1 to 2 cm below the inferior angle of the scapula. While measuring skinfolds, the EUROFIT method was used (14). All equipment was made by the Wiha Division KWB, Switzerland, and it was used in all the selected schools.

Calculation of Fat Mass. The percentage of body fat was calculated using the equation by Slaughter and colleagues (15). When the sum of triceps (tric) and subscapular (subscap) skinfolds is less than 35 mm, the percentage of body fat for girls is calculated by the following formula:

$$FM\ (\%)=1.33\times(tric+subsc)-0.013\times(tric+subsc)^2-2.5.$$

The percentage of body fat for boys is calculated by the following formula:

$$FM\ (\%)=1.21\times(tric+subsc)-0.013\times(tric+subsc)^2-1.7.$$

When the sum of triceps and subscapular skinfolds is more than 35 mm, the percentage of body fat for girls and boys is calculated by the following formulae, respectively:

$$FM\ (\%)=0.546\times(tric+subsc)+9.7;$$
$$FM\ (\%)=0.783\times(tric+subsc)+1.7.$$

Knowing the body weight and percentile of FM, the absolute amount of FM was calculated for each respondent. FMI was calculated as FM (kg) and divided by height squared (m^2).

As recommended by the WHO, BMI of children was calculated as the most appropriate index in describing the nutritional status and obesity (9).

According to the values of BMI calculated for population of Latvia, all the children were divided into 4 groups: underweight (BMI $\leqslant$15th percentile), normal weight (15th percentile < BMI $\leqslant$85th percentile), overweight (85th percentile < BMI $\leqslant$97th percentile), and obesity (BMI >97th percentile).

According to the values of FMI, the children were divided into 4 groups in the same way as according to BMI as follows: critically low and low level of body fat (FMI $\leqslant$15th percentile), normal level of body fat (15th percentile < FMI $\leqslant$85th percentile), high level of body fat (85th percentile < FMI $\leqslant$97th percentile), and very high level of body fat (>97th percentile).

Statistical Analysis. The SPSS 19.0 program for Windows was used for statistical analysis. The values of body composition parameters are expressed as mean (SD) and percentiles. Gender differences were assessed by using the independent *t* test. The α level was set at 0.05

Results

The anthropometric and body composition data of 9- and 10-year-old children are shown in Table 1. The mean values for BMI were found to be slightly greater in boys than girls, and the mean values for FM percentage, FM, and FMI were greater in girls, but these differences did not reach statistical significance. There were significant differences in both skinfold thicknesses comparing 9- and 10-year olds of both genders ($P<0.01$ and $P<0.05$, respectively).

The percentile values for FM% are shown in Table 2 and those for FMI in Table 3. The tendency was observed that in the analyzed age groups, the percentile values for both FM% and FMI were

Table 1. Anthropometric and Body Composition Characteristics of Children by Age and Gender

Characteristic	Boys		Girls	
	9-Year Olds n=85	10-Year Olds n=181	9-Year Olds n=99	10-Year Olds n=139
Height, cm	138.5 (6.63)	142.3 (6.5)	137.3 (7.01)	142.4 (7.6)
Weight, kg	33.0 (4.77)	35.7 (8.0)	32.5 (5.83)	35.2 (9.3)
Body mass index, kg/m^2	17.1 (5.55)	17.5 (2.8)	17.1 (2.35)	17.2 (3.4)
Fat mass, %	15.8 (3.99)	17.3 (6.5)	18.9 (4.56)	18.8 (6.5)
Fat mass, kg	5.3 (1.98)	6.7 (4.5)	6.3 (2.49)	7.2 (5.1)
Fat mass index, kg/m^2	2.8 (0.92)	3.2 (1.9)	3.3 (1.21)	3.4 (2.1)
Skinfold thickness, mm				
Triceps	10.7 (3.1)**	11.8 (4.6)*	13.5 (3.93)	12.9 (4.8)
Subscapular	5.7 (1.77)**	6.6 (3.8)*	7.0 (2.68)	7.9 (5.3)

Values are mean (standard deviation).
*P<0.05; **P<0.01 vs. girls.

Table 2. Percentile Values for Fat Mass (%) Based on the Measurements of Skinfold Thickness

Percentile	Boys		Girls	
	9-Year Olds	10-Year Olds	9-Year Olds	10-Year Olds
3rd	9.9	9.6	11.7	10.9
15th	11.6	11.9	14.2	12.7
50th	15.7	15.8	18.4	16.8
85th	18.6	23.2	23.2	26.2
97th	25.5	33.7	29.9	38.4

Table 3. Percentile Values for Fat mass Index (kg/m^2) Based on the Measurements of Skinfold Thickness

Percentile	Boys		Girls	
	9-Year Olds	10-Year Olds	9-Year Olds	10-Year Olds
3rd	1.5	1.4	1.6	1.5
15th	1.8	1.8	2.1	1.8
50th	2.7	2.6	3.0	2.8
85th	3.2	4.7	4.2	5.4
97th	5.0	8.5	6.7	10.0

greater in girls than boys, except for the 15th percentile value for FMI in 10-year-old children. Analysis of the values of marginal groups (3rd and 97th percentiles) showed that the value of 3rd percentile for FM% for both analyzed age groups differed very little in boys and girls. In the period from 9 to 10 years of age, the value of the 97th percentile for FM% for boys increased from 25.5% to 33.7%, but for girls from 29.9% to 38.4%.

The percentage of children classified as underweight, normal, overweight, and obese according to BMI using percentile scales developed for the pediatric population of Latvia and the results of body composition based on FMI in 9–10-year-old children in Latvia are presented in Table 4. It is evident that the percentage between the groups differs depending on the fact whether the nutritional degree

Table 4. Evaluation of the Nutritional Level by the BMI and FMI Percentile Values and its Percentage Distribution

Characteristic	Boys		Girls	
	9-Year Olds	10-Year Olds	9-Year Olds	10-Year Olds
Evaluation by body mass index				
Underweight	16.4	22.1	11.1	22.3
Normal weight	69.5	56.4	54.5	54.7
Overweight	9.4	14.9	28.3	15.8
Obesity	4.7	6.6	6.1	7.2
Evaluation by fat mass index				
Low fat level	14.6	16.9	12.2	14.1
Normal fat level	69.5	68.7	72.2	70.8
High fat level	12.2	11.6	13.3	12.3
Very high fat level	3.7	2.8	2.3	2.8

Values are percentage.

is estimated by BMI or by amount of fat in the body.

At the age of 9 years, the distribution of the nutritional level by percentage was analyzed using both BMI and FMI. The results show that the majority (69.5%) of the boys showed normal weight and also a normal amount of fat in the body. For the girls of this age, normal weight by BMI was seen in 54.5% of cases; however, 28.3% of 9-year-old girls were overweight and 6.1% obese. When determining FMI, i.e., the amount of fat in the body, a normal fat amount was observed in 72.2% of 9-year-old girls, increased in 13.3%, and very high, i.e., obesity, was seen only in 2.3% cases.

Assessing the nutritional level of children by BMI in the period from 9 to 10 years, an increase in the number of children who were underweight both for boys (22.1%) and girls (22.3%) was found, while the number of children with a normal nutrition level was respectively decreasing. There was a slight increase in the percentage of obese cases (from 4.7% to 6.6% in boys and from 6.1% to 7.2% in girls). Then, the FMI value showed that lower fat

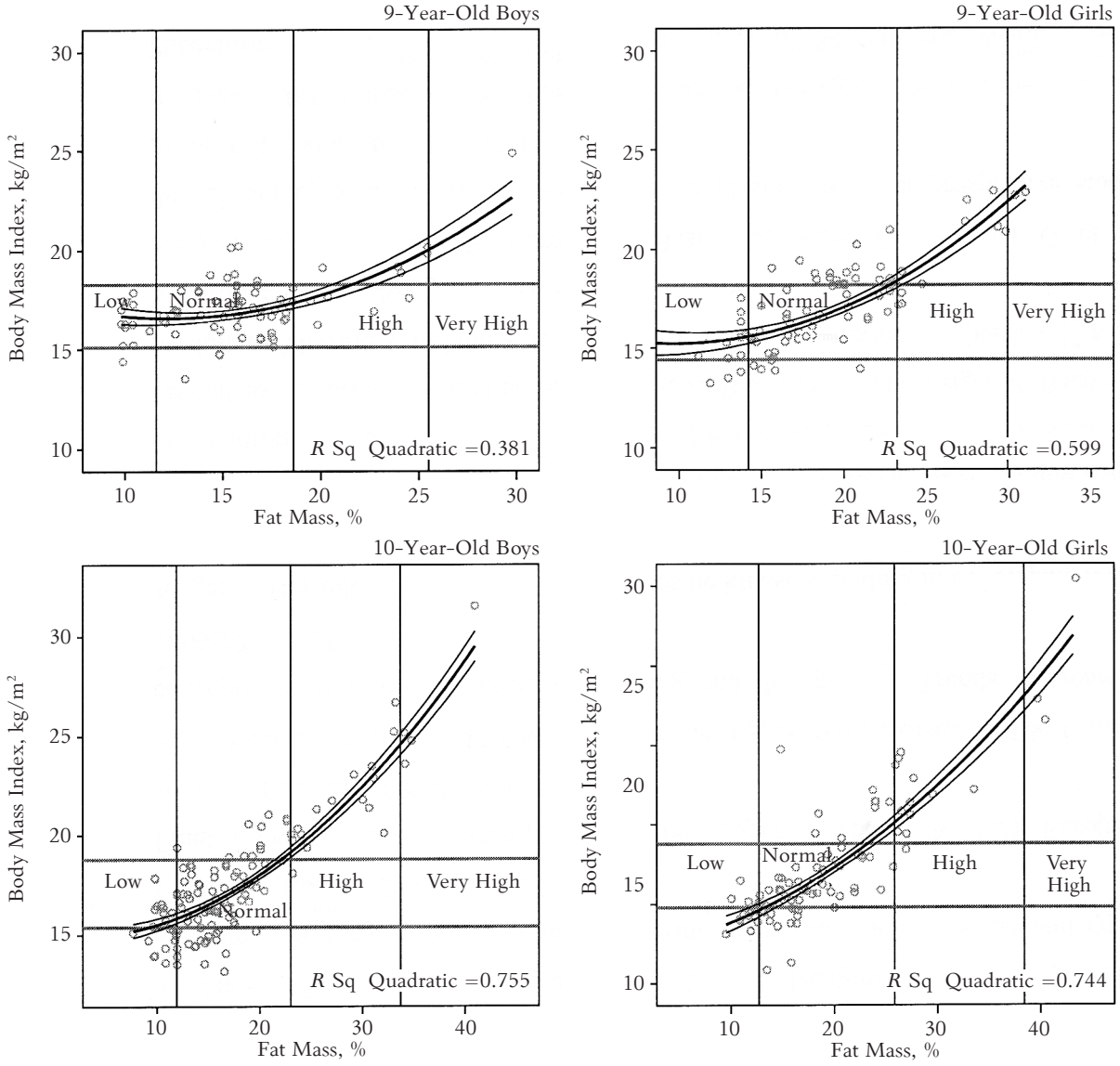

Fig. The nutritional level according to body mass index and fat mass

mass was observed less often, i.e., in 16.9% cases of the boys and 14.1% cases of the girls; however, the normal fat amount in the body was observed in 68.7% of the boys and 70.8% of the girls. The high fat level was seen in 11.6% of the boys and 12.3% of the girls, while only in 2.8% of both boys and girls, it was very high – obesity.

Horizontal lines in Fig. 1 show the norm interval of BMI (15th till 85th percentile according to the physical development guidelines worked out in Latvia). The threshold of FM in the graphical figures is calculated by the percentile method and defined as follows: low, ⩽15th percentile; normal, 15th percentile< FM ⩽85th percentile; high, 85th percentile < FM ⩽97th percentile; and very high, >97th percentile. The results acquired by this method certify that for the children whose BMI is within the norm the FM value is low, normal, or high.

Discussion

There have been lengthy discussions about the fact that overweight and obesity have been more frequently diagnosed in recent years in Latvia. This seems to be controversial to the retrograde changes in the economic situation in this country. There is a widespread opinion among physicians and health care professionals that the situation in Latvia is similar to that in the wealthy Western countries of developed democracy as far as the aggressive fast food marketing and yielding to hypodynamic lifestyle in the society are concerned. Unfortunately, the pediatric population is not an exception (16).

By studying the epidemiology of obesity and increased body weight among young adolescents, an astonishing conclusion can be drawn that the prevalence of underweight approximates to the prevalence of overweight and obesity in Latvia. Underweight

can occur either due to medical or social reasons. In order to help such children, it is necessary to evaluate whether underweight is not caused by a disease, for example, food allergy, celiac disease, or helminthiasis. The reason for low weight may be either lack of food, or just unbalanced food. The main function of lipids is energy storage for different biochemical processes that require energy. Lipids form cell membranes and participate in the process of synthesis of many biologically active compounds, for example, hormones. In addition, fat tissues also carry out functions of mechanic protection and thermal control. Consequently, children with underweight are likely to suffer from disturbances related with these functions and signs such as apathy, low immunity, long-term rehabilitation period, disturbance of hormonal balance, etc. It has been reported that normal fat level in the adolescent period is 13%–17% for boys, but higher, i.e., 20%–25%, for girls (11, 17). Our study data show that the mean FM% in 9- and 10-year-old girls in Latvia is lower.

FM and FFM are traditionally expressed in percent. Sometimes this may lead to a misunderstanding as the percentage of these parameters can be similar for a weakened person who has suffered from continuous protein deficiency and for a healthy, but short, person. To avoid such inaccuracies, scientists recommend to relate FM and FFM to body height, thus, obtaining FMI and FFMI that, similarly to BMI, are measured in kg/m^2 (18, 19). The purpose of using FMI is to facilitate the interpretation of body composition parameters regardless of body height. This approach is already recommended by Wells and other scientists, who in their studies conclude that FMI and FFMI values render significant information for the analysis of the children's body composition (20, 21).

These parameters have already been used for the detection of obesity in the pediatric population. The authors conclude that the increase in the BMI value can also occur as a result of increased fat-free mass leading to overdiagnosis of obesity (22, 23). Rodriguez et al. have estimated that the most significant congruence can be observed between the percentage of FM calculated by the equation of Slaughter et al. using the sum of two subcutaneous fat folds: the one above *regio subscapularis* and the one above *m. triceps brachii*. For the current study, FMI was calculated according to the thicknesses of these skinfolds.

Nowadays, laboratory methods, such as x-rays and bioimpedance, are still not suitable enough for field and clinical use. Therefore, measurements of height, weight, and skinfold thickness as well as calculation of FMI and FFMI are cheap and easily applied methods in most countries to assess children's body composition in addition to BMI. So far, the norms for FMI and FFMI have been developed only in Japan (24).

Compared with the data of 1998, when an extensive study was done in Latvia, the data acquired in 2007–2009 proved that 9- and 10-year-old children became taller and heavier. There is an evident tendency toward increasing mean values for BMI (10). Assessment of the percentage distribution of nutritional level showed that 28.3% of cases in 9-year-old girls had extra body weight. It might be related to hormonal changes, which already appear at this age, though this was not analyzed in the study. Growth and development in the majority of children are not steady; however, we have to mark a sharp percentual increase in both girls and boys in the age period from 9 to 10 years, which could be explained by accelerated growth in height in the period from late childhood to young adolescence.

For the first time in Latvia, the nutritional level of children has been assessed according to FMI; however, this study has some limitations as some of the parents refused to participate and there also were differences in the quantity of children's groups. This might have some impact on the results. Similar comments apply to the fact that no private schools were included. It would be interesting to compare the nutritional level of children in the countries where the economic situation is similar to Latvian, for example, Lithuania or Estonia; however, no such data have been found. Undoubtedly, our research is at its early stage, and it is necessary to carry out an extended epidemiological study that would include not only body measurements and calculation of BMI, but FMI and FFMI as well. This study shows only the trends in the nutritional level of 9- and 10-year-old children and is considered as a pilot study, as the sample, however, statistically reliable and presentable, could be bigger and also include children of other ages.

In order to estimate the nutritional level accurately, it is important to pay attention to the association between FM and FFM. The use of FMI, along with BMI, ensures a more exact perception of children's growth process in characterizing the nutritional level and epidemiologic situation.

Supplementing the norms of physical development of Latvian children with the FMI percentile scales is recommended.

Conclusions

Evaluation of the nutritional level among 9- and 10-year-old children by BMI showed that the prevalence of obesity was from 4.7% to 6.6% among boys and 6.1% to 7.2% among girls in the analyzed age group. A significant percentage of children (16.4%–22.1% of boys and 11.1%–22.3% of girls) are underweight, and this should be considered as a highly dangerous risk factor to their health and prospective

quality of life.

Analysis of body composition of children with normal BMI showed that the children had low, normal, and high body fat amount in this age group. Assessment of the nutritional level of the same children by FMI demonstrated a smaller proportion of overweight and obese children; thus, the evaluation of nutritional level only by BMI may lead to overdiagnosis of obesity.

Statement of Conflict of Interest

The authors state no conflict of interest.

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Received 10 February 2011, accepted 31 October 2011