Overweight and increased blood pressure in preschool-aged children

Apolinaras Zaborskis, Aušra Petrauskienė, Svajūnė Gradeckienė, Eglė Vaitkaitienė, Vilma Bartošiūtė

Institute for Biomedical Research, Kaunas University of Medicine, Lithuania

Key words: preschool-aged children, physical development, chronic noncommunicable diseases, risk factors, blood pressure, height, weight, body mass index, overweight.

Summary. This paper presents the data on height, weight, body mass index, systolic and diastolic blood pressure of 3–7 year old children. A sample of preschoolers (n=1441) was drawn from the kindergartens in Kaunas city (Lithuania). The 5th, 10th, 50th, 90th and 95th percentiles were estimated for studied variables and the criteria for the overweight and increased blood pressure were calculated. It was shown that body mass index could be used as an indicator of the child's physical development. Its value 14–18 kg/m$^2$ indicates an optimal child's growing, value ≤14 kg/m$^2$ – the underweight, value ≥18 kg/m$^2$ – the overweight. According to these criteria it was found that 7.4% of 3–7 year old children were underweight, 5.8% overweight. Increased blood pressure (over 90th percentile of systolic or/and diastolic blood pressure) had 21.4% of examined children. The prevalence of increased blood pressure was significantly higher in obese than in normal weight children. We conclude that the significant prevalence of childhood overweight and increased blood pressure emerge in preschool aged children. Thus, we recommend investigations of prevention and intervention programs to be used in the preschool setting.

Introduction

Many epidemiological studies have shown that cardiovascular diseases and other chronic noncommunicable diseases (NCD) develop earlier before they manifest clinically. They are becoming more frequent and their development in younger age causes great anxiety of physicians and scientists of many countries. At this time it is considered that an effective primary prevention of NCD is the early detection and correction of risk factors. One should remember that almost all risk factors, including biological ones, such as an increased blood pressure (BP) and overweight are associated with ones' lifestyle and habits formed in childhood and adolescence mainly. So the prophylaxis begun in early age is the most perspective if we want to reduce the morbidity, mortality and disability of the population from atherosclerosis, ischemic heart disease, and many other illnesses (e.g., cancer, stroke, diabetes mellitus, respiratory diseases, caries) (1–3).

A lot of data about risk factors of cardiovascular and other NCD diseases are collected in the world and Lithuania (4–9). It is well established that the increased BP and overweight are the main most widely spread risk factors of CND and they are the problem of health of many people. Knowledge about the development of these risk factors show that even in childhood some health indicators can be important in the development of high BP and overweight in elder age. A lot of scientific studies were focused on the investigation of risk factors of adults and adolescents, but in early childhood these factors are less explored.

In Kaunas University of Medicine the scientific investigations of health of children and adolescents have begun before three decades (1). A particular attention was paid to the prevalence of risk factors and the possibilities of their prevention of school-aged children (3, 10). The recommendations on detection of common RF in childhood and adolescence were prepared; norms of child growth and BP were determined (10, 11). The longitudinal prospective study on Juvenile Hypertension, started in 1977, received a lot of attention (6–8, 12). The evolution of blood pressure from adolescence (12–13 years) to adulthood was investigated and the important prognostic significance of its development from increased BP in childhood to hypertension in adulthood was determined in this study. Overweight was of great importance in the development of hypertension as well.

The above-mentioned investigations show how important it is to better understand the peculiarities of
growth and the development of arterial blood pressure of a child. There are few such investigations in Lithuania.

The aim of this work was to study the physical development and trends of BP among 3–7-year old children and to determine the prevalence of overweight and increased BP in this age period.

**Material and methods**

The survey of 3–7-year old children attending 12 randomly chosen kindergartens of Kaunas was carried out. All children who were present in the kindergartens on the days of the survey were examined. A total number of 1441 children (92–95% from the lists of the groups) was examined. The distribution of children by gender and age is given in the Table 1. The number of children in groups was sufficient in order to receive reliable estimations.

The research group of three pediatricians was formed. At the beginning of the work they discussed the methodology of the survey and carried out the control tests on measures of anthropometrical values and BP in a standardized way.

The examination of health of children was performed in preschool institutions. Ordinary rooms for children, such as bedroom or classroom, were chosen. The examination was performed at 10–12 o’clock in the morning, while children haven’t had any greater physical activity (e.g. physical training in a sport hall).

Height and weight were measured by “Seca” equipment. Height was measured by accuracy of 1 cm, weight – of 0.1 kg. Children were without outdoor clothes and footwear.

Physical development of a child was estimated by body mass index (BMI). The 10th percentile of BMI distribution was considered as underweight criterion and the 90th percentile was considered as overweight criterion. Also, height and weight of examinees were estimated according to the tables of physical development of Lithuania’s children (13). According to these tables children were grouped into three main groups by body weight: normal (group a), underweight (group b), and overweight (group c).

Blood pressure was measured by mercury sphygmomanometer. The cut-off of appropriate size was selected according to child’s age and development (it should cover 2/3 of upper arm). Blood pressure was measured on the right arm when a child was calm and sitting. Systolic tone was registered when Korotkoff tone was clearly listened for the first time and diastolic – when tones disappeared entirely. Blood pressure was measured two times, when analyzing data average means were used. Criterion of lightly increased BP was the 90th percentile and criterion of severely increased BP was the 95th percentile of systolic and diastolic tones.

The average yearly growth of anthropometrical and BP values of 3–7-year old children were estimated by standardized coefficient of linear regression ($b_{\text{stand.}}$).

**Results**

There were no substantial differences in height changes between 3–7-year old girls and boys (Fig. 1). Average yearly growth of height during this period of age was 6.3 cm ($b_{\text{stand.}}=0.806$).

Children’s weight in 3–7 years old period increased in proportion to age as well, approximately 2.2 kilo per year ($b_{\text{stand.}}=0.637$). The increase of weight of boys and girls did not differ in the age group of 3–4 years, however since the fifth year the 90th and the 95th percentiles of weight of girls start to fall behind from that of boys (Fig. 2).

Although the rates of height and weight since 3 to 7 years old rapidly increased, however the BMI had been changing narrowly during this period of age (Fig. 3). That is explainable that height increases more rapidly than weight during this period of age (as we can see in comparison estimations of appropriate $b_{\text{stand.}}$ values).

There are almost no differences between the estimations of BMI of boys and girls. Summarizing the evolution of BMI during this period of age in both gender groups, we can define that values of the BMI equal or less than 14 kg/m², show too small weight of a child (underweight), values of the BMI from 14 to 18 kg/m² – normal weight (harmonious development), and values of the BMI equal or major than 18 kg/m², – too big weight (overweight).

The presented criteria of the assessment of child’s physical development based on BMI correspond well...
to the tables of the evaluation of physical development of Lithuania’s children (13). Table 2 shows the comparison of two methods of the assessment of children’s physical development. Presented data show that on the strength of evaluation from the tables of physical development of Lithuania’s children, overweight had 8.3% of children and when applied the criterion of BMI $\geq 18$ kg/m$^2$ – 5.8%. In comparison with the tables, the offered criterion of BMI $\geq 18$ kg/m$^2$ is more specific (allows properly estimate the overweight with bigger probability), however it is less sensitive. Estimate of normal weight was confirmed in 77.4% of all the cases. Mistakes were done because of too big lowest point of the BMI rate (14 kg/m$^2$). Really, this point was a little bit bigger than the value of the 10th percentile, however this value was chosen because of viewpoint of practical use (was round till whole number).

Trends of the 5th, 10th, 50th (median), 90th and 95th percentiles of systolic and diastolic BP in examined

Fig. 1. Age trends for the percentiles of height by sex in children, ages 3 to 7 years

Fig. 2. Age trends for the percentiles of weight by sex in children, ages 3 to 7 years

**Table 2.** Comparison of two methods for evaluation of physical development of children, ages 3 to 7 years

<table>
<thead>
<tr>
<th>Weight parameters</th>
<th>Weight groups¹</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>small weight (group b)</td>
<td>normal weight (group a)</td>
</tr>
<tr>
<td>Group of BMI, kg/m²</td>
<td>≤14</td>
<td>101</td>
</tr>
<tr>
<td></td>
<td>14–18</td>
<td>242</td>
</tr>
<tr>
<td></td>
<td>≥18</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>n</td>
<td>343</td>
</tr>
<tr>
<td></td>
<td>proc.</td>
<td>24.1</td>
</tr>
</tbody>
</table>

¹ Group of weight according to the tables of physical development of Lithuania’s children (13).

**Table 3.** Criteria for detection of increased blood pressure in children aged 3–7 years, mm Hg

<table>
<thead>
<tr>
<th>Age, years</th>
<th>Systolic BP</th>
<th>Diastolic BP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>lightly increased</td>
<td>severely increased</td>
</tr>
<tr>
<td>3</td>
<td>104–111</td>
<td>≥112</td>
</tr>
<tr>
<td>4</td>
<td>108–113</td>
<td>≥114</td>
</tr>
<tr>
<td>5</td>
<td>112–119</td>
<td>≥120</td>
</tr>
<tr>
<td>6</td>
<td>116–123</td>
<td>≥124</td>
</tr>
<tr>
<td>7</td>
<td>118–125</td>
<td>≥126</td>
</tr>
</tbody>
</table>
**Fig. 4.** Age trends for the percentiles of systolic blood pressure by sex in children, ages 3 to 7 years

**Fig. 5.** Age trends for the percentiles of diastolic blood pressure by sex in children, ages 3 to 7 years

**Fig. 6.** Prevalence of increased blood pressure by sex and age
3–7 years old boys and girls are shown in Fig. 4 and 5. The increase of BP level during this period of age is apparently visible (average yearly growth of systolic BP was 3.7 mm Hg (b_{stand} = 0.379), diastolic – 4.3 mm Hg (b_{stand} = 0.251)). The 5th and 10th percentiles of systolic BP in girls were a little bit less (to 6 mm Hg) than that in boys, however the 50th (median), 90th and 95th percentiles were almost the same in all groups of age. The median, 90th and 95th percentiles of diastolic BP of 3 years old girls were significantly bigger than that of boys (P<0.05). 5% of examined children had diastolic BP equal to zero, in younger groups of age (girls till 6 years old).

On the strength of results of research criteria of increased systolic and diastolic BP for 3–7-year old children were estimated (Table 3). These criteria are recommended for physicians who estimate individual blood pressure of preschoolers.

According to the chosen criteria increased systolic BP was found for 12.7% and increased diastolic BP for 13.3% of a child. Increased systolic and/or diastolic BP had 21.4% of children. Fig. 6 presents prevalence of increased BP by children’s gender and age. It is noticeable that with reference to represented criteria increased BP was more often estimated for 3 and 7 years old girls.

After all we wanted to verify the hypothesis about relation between BP and physical development of children. Rated frequency of increased BP of examined children by values of BMI showed that such hypothesis could be acceptable. Data presented in Table 4 indicate that the frequency of increased BP among children with BMI≥18 kg/m² was more than twice bigger than among children whose BMI values were less.

**Table 4. Prevalence of increased blood pressure by body mass index**

<table>
<thead>
<tr>
<th>Weight parameters</th>
<th>Prevalence of increased BP, %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>boys</td>
</tr>
<tr>
<td>Groups of BMI, kg/m²</td>
<td></td>
</tr>
<tr>
<td>≤14</td>
<td>13.0</td>
</tr>
<tr>
<td>14–18</td>
<td>18.6</td>
</tr>
<tr>
<td>≥18</td>
<td>50.9</td>
</tr>
<tr>
<td>Total</td>
<td>20.5</td>
</tr>
<tr>
<td>p刊</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

1Statistical significance of hypothesis on relation of increased blood pressure and overweight estimated by chi-square test.

Discussion

All parts of body grow intensively during the period of preschool age (from 3 to 7 years). The uncompleted formation of morphologic and functional development of child’s body and body systems, continuous processes of growth and differentiation of tissues determine less resistance of organism to negative factors of environment and therefore risk factors of chronic NCD start to develop.

Data of latest years show that number of healthy children decreases and number of children who have various health disorders and chronic diseases increases (14). The risk factors of chronic NCD are determined still in younger age (10). In this article attention is paid to overweight and elevated BP – common risk factors of chronic NCD – detection and correction of which take a very important place in prophylactic programs.

Physical development is one of the indicators of children’s health. Usually, child’s physical development is estimated by comparison of the parameters of height and weight. Dr. N. Dačiliūniene et al (14) gathered anthropometrical data of nearly 3 thousands 4–7 years old Lithuania’s preschoolers and determined that growth was disharmonic nearly of one third of them; it means that parameters of weight were contravene to that of height. Weight of the biggest part of preschoolers whose development was disharmonious was too small. Our research data on physical development of children by the same criteria were analogous to the data of authors mentioned above. These findings show that values of physical development of Lithuania’s children were a little bit better than the values of developing countries published by WHO where 43% of preschoolers had low physical development (15).

Data on the values of arterial BP of preschool-aged children are especially scarce in our country. Therefore we suppose that observations represented in this article fill this gap a little. We succeeded to find information about the values of arterial BP only of 7 years old children. For example, dr. J. Tutkuvienė (16) noted that 90th percentile of systolic BP of 7 year olds is equal to 115.3 mm Hg, diastolic BP is equal to 70 mm Hg in boys, and respectively 112 mm Hg and 64 mm Hg in girls. Our criteria of increased systolic BP of 7 years old children of both genders were a little bit higher (118 mm Hg) and diastolic BP – a little bit lower (62 mm Hg) in comparison with the cut-points mentioned above.

The wide known report Task Force on Blood Pressure in Children summarizes the results of foreign epidemiological studies on children’s BP (17). Our estimated criteria of lightly and severely increased systolic BP coincide well in comparison with the repre-
sent criteria in the report. Our estimated criteria of diastolic BP are 8–10 mm Hg lower than in the document mentioned above.

Dynamics of BP is closely associated with physical development of children in young age. Therefore scientists widely discuss about relation between overweight and increased BP in early childhood. The results of our study confirm that this relation is rather significant. It was estimated in resembling works that overweight and obesity intensify occasion of increased BP (the odds ratio is equal to 2–3) (4, 5, 18).

Summarizing the results of the represented study it might maintain that increased BP and overweight are very significant risk factors of chronic NCD not only for adults but for preschoolers as well. For general practitioners we recommend to invoke criteria of increased arterial BP and overweight described in this article. It is important that investigations of prevention and intervention programs of risk factors of chronic NCD should be started in younger age, even before child starts to go to school. Preschool institutions can do a lot by implementing programs for education of healthy lifestyle and health promotion.

**Conclusions**

It is advisable to put body mass index as an indicator of estimation of physical development of 3–7 years old children into practice. Independently from age of a child the values of this index from 14 to 18 kg/m² indicate that weight of a child is optimal (harmonious growth), values ≤14 kg/m² indicate that weight of a child is too small (underweight), values ≥18 kg/m² indicate that weight of a child is too big (overweight).

1. According to the criterion of body mass index ≥18 kg/m², overweight was found for 5.8% of 3–7 years old children.
2. The increased arterial blood pressure (bigger than the values of 90th percentile of systolic and/or diastolic blood pressure) was determined for 21.4% of examined children.
3. The elevated blood pressure was ascertained more frequently in overweight children.

The significant prevalence of overweight and increased blood pressure emerges in preschool-aged children. We recommend investigations of prevention and intervention programs to be used in preschool settings.

**Ikimokyklinio amžiaus vaikų antsvoris ir padidėjęs arterinis kraujospūdis**

**Apolinaras Zaborskis, Aušra Petrauskienė, Svajūnė Gradeckienė, Vilma Bartošiūtė**  
**Kauno medicinos universiteto Biomedicininių tyrimų institutas**

**Raktąžodžiai:** ikimokyklinio amžiaus vaikai, fizinė reiškia, lėtinė neinfekcinės ligos, rizikos veiksmai, arterinis kraujospūdis, ūgis, svoris, kūno masės indeksas, antsvoris.

**Santrauka.** Straipsnyje analizuojami 3–7 metų vaikų ūgio, svorio, kūno masės indekso, sistolinio ir diastolinio arterinio kraujospūdžio duomenys. Tikimybių baigtis buvo atrinkti iš Kauno miesto ikimokyklinių įstaigų (n=1441). Taikant procentilinius įverčius, apskaičiuoti analizuotų rodiklių normatyvai ir antsvorio bei padidėjusio arterinio kraujospūdžio kriterijai. Patebėta, kad 3–7 metų vaikų kūno masės indeksas mažai kinta, o jo reikšmės nuo 14 iki 18 kg/m² rodo, jog vaiko svoris yra optimalus (vaiko indas yra harmoningas), ≤14 kg/m² – per maža vaiko svorio (sulysimą), ≥18 kg/m² – per didelį vaiko svorį (antsvori). Tuo remiantis, 7,4 proc. 3–7 metų vaikų konstatuotas sušylimas, 5,8 proc. vaikų – antsvoris. Padidėjęs arterinis kraujospūdis (didėjimai už 90–tą sistolinį ir (arba) diastolinio kraujospūdžio procentilio reikšmę) nustatytas 21,4 proc. ištirtų vaikų. Padidėjęs arterinis kraujospūdis dažniausiai nustatytas tarp antsvorių turinčių vaikų.

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