CHILDHOOD OBESITY AND ITS IMPACT ON YOUNG ARTERIES

PhD THESIS
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**ABSTRACTS**


Introduction

Childhood Obesity

The increasing number of overweight and obese children and adolescents has become a serious and alarming phenomenon worldwide. Between 1980 and 2013, the prevalence of overweight and obesity increased from 10% to 12.7% in the population aged 2–19. Medical researchers have long recognized that being overweight or obese carries many serious health risks for adults. Children are more vulnerable to obesity-related diseases, because their bodies are in a growing and developing phase. Prevalence of overweight and obesity changes constantly, repeating measurements targeting frequency of elevated body mass index (BMI) is essential nowadays.

Measurements of arterial function parameters

Non-invasive assessment of arterial function parameters in adults is getting more common among health care professionals, to perform proper risk stratification for cardiovascular morbidity, furthermore to measure possible target organ damage in patients. Featuring parameters of arterial function include aortic pulse wave velocity (PWV_{ao}), aortic augmentation index (Aix_{ao}) and central systolic blood pressure (SBP_{ao}). Each previously mentioned parameter is considered as strong, independent predictors of mortality and morbidity of CVD in adulthood. Arteriograph, is a non-invasive, occlusive-oscillometric device, which is user-independent as it is fully automatic, requires only 2 minutes for the measurement of arterial function parameters (AFPs). Recently, normal values were established for children and adolescents regarding their AFPs. Overview of the relevant literature revealed, that data published on AFPs in OW and O youth, comparing to normal weighted patients are conflicting.
Aims

1. To determine the prevalence of overweight and obesity in a healthy population aged 3–18 in Szolnok city and in the surrounding area.

2. To observe if there have been any changes in the prevalence of overweight and obesity compared with the data measured previously in Hungary.

3. To answer what trends can be seen in the changes regarding the prevalence of overweight and obesity in Hungary.

4. To discover if there is a difference in age and sex distribution regarding the prevalence of overweight and obesity.

5. To compare AFPs (PWV$_{ao}$, Aix$_{ao}$, SBP$_{ao}$) in overweight and obese patients with healthy controls in population of wide age range (3–18 years).

Materials and methods

Subjects

6,824 subjects (3,673 boys) aged 3–18 years were recruited from elementary, primary and high schools in Szolnok city (Hungary) between 2012 and 2016. To assess the prevalence of OW and O we have included all data from the investigated population. To set up a correct method for AFPs analysis, from this group we have involved children with OW/O (n=1,363). Subjects with elevated brachial systolic and/or diastolic blood pressure ($\geq$95$^{th}$ percentile related age and sex and height) using by the relevant guideline, were excluded from this study. Finally, 719 subjects (431 boys) fulfil the inclusion criteria. Controls have been chosen by identical peripheral systolic blood pressure, age and height. All the subjects were Caucasian with no any chronic diseases and they were not on any regular medications. Informed consent for the measurements was asked for from the parents of the subjects. The protocol was reviewed and approved by the local Institutional Ethics Committee of the University of Pécs, Pécs, Hungary.
**Methods**

Height and weight measurements were performed in accordance with the Hungarian professional rules, using a Kern MGB 150K 100type personal scale and a MSF 200 type mechanical height rod (Kern & SOHN GmbH, Germany). The subjects were categorised by their BMI into normal weight, OW and O groups regarding their age and sex, as well. AFPs were measured by Arteriograph (TensioMed Ltd, Budapest, Hungary). Validations and the detailed method of the device have been published previously. Briefly, the method of the device is based on the physiological fact that the early systolic pulse pressure wave (P₁) generated by the left ventricle travels via the aorta and is reflected from the level of the aortic bifurcation and comes back to the aortic root and augments as a second or reflected wave to the first wave even in the systole (P₂) (Figure 1).

$$\text{PWV}_{ao} = \frac{\text{YugSy}}{[\Delta t / 2]}$$

$$\text{Aix}_{ao} = \frac{[P_2 - P_1]}{PP} \times 100$$

$$\text{SBP}_{ao} = \text{DBP}_{ao} + \text{PP}$$

**Figure 1** Original pulse pressure wave registered by Arteriograph

The travel time of the aortic pressure wave from the aortic root to the aortic bifurcation and to back is equal to the time between P₁ and P₂ (return time, RT). By measuring the distance between the sternal notch and the upper edge of the pubic bone (jugulum – symphysis distance, [Jug-Sy]) - which shows the strongest correlation to the true aortic length and having the RT, the velocity of PWV_{ao} can be calculated. The brachial augmentation index (Aix_{brach}) is calculated with the use of the formula: \((P2-P1/PP)*100\), where PP is the pulse pressure. The augmentation index of the aorta (Aix_{ao}) is calculated with the help of the invasively measured, very strong (R=0.94) linear correlation between Aix_{brach} and Aix_{ao}. SBP_{ao} is calculated as diastolic blood pressure (DBP) plus aortic/central pulse pressure (PP_{ao}). Measurements were taken at rest, after lying for 2–3 minutes in comfortable, supine position.
Results

Prevalence of overweight and obesity

Out of the 6,824 subjects assessed, 2,881 boys (78.4% of the boys) and 2,580 girls (81.9% of the girls) had normal BMI. Altogether 14.1% of the boys (n=518) and 12.6% of the girls (n=397) were found to be overweight, while 7.5% of the boys (n=274) and 5.5% of the girls (n=174) were obese. In the total population studied, the prevalence of overweight was 13.4% (n=915), and 6.6% of obesity, which is 20% (n=1,363) of the studied population aged 3–18, in total. The rate of overweight and obesity is higher in the case of boys, than in the case of girls, since the total prevalence of overweight and obesity was 21.6% (n=792) in boys and 18.1% (n=571) in girls, this difference was proven by statistical analysis (chi-square test, p<0.005).

Arterial function parameters

After excluding OW/O patients with momentary increased systolic and/or diastolic blood pressure regarding the relevant guideline, data from 326 OW and 105 O boys, and data from 243 OW and 45 O girls were analysed.

The mean age of O boys (11.7±3.5 years) and O girls (11.5±3.7 years) were lower than of OW boys (12.4±3.9 years) and OW girls (12.6±3.8 years); however, the difference was not significant. No significant differences were detected regarding body height between OW/O patients and controls. According to the study design, the mean SBP

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\text{brach}
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values were equivalent in OW/O patients and controls.

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\text{PWV}_{ao}
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did not show significant differences either in OW, or in O boys, or in O girls compared to controls (5.8±0.8 m/s OW boys vs 5.8±0.8 m/s controls, 5.8±0.7 m/s O boys vs 5.7±0.6 m/s controls, 5.8±0.7 m/s O girls vs 5.7±0.8 m/s controls), while it was significantly lower in OW girls than in controls (5.6±0.8 m/s OW girls vs 5.8±0.7 m/s controls, p<0.05) (Figure 2).

![Figure 2 PWV_{ao} values in OW and O subjects and controls, in boys and girls. NS: non-significant, *: p<0.05](image-url)
Aix\textsubscript{ao} was lower in every OW/O patients groups. The differences were significant in O boys (6.7±7.0% O boys vs 9.5±8.7% controls, p<0.02) and in OW girls (8.4±6.6% OW girls vs 10.2±6.8% controls, p<0.004), while it did not differ statistically either in OW boys (7.2±6.9% vs 7.8±7.2% in controls, NS) or in O girls (8.5±5.8% in O girls vs 10.8±9.1% in controls, NS) (Figure 3).

![Figure 3](image)

**Figure 3** Aix\textsubscript{ao} in OW and O subjects and healthy controls, in boys and girls. NS; non-significant, *; p<0.05

SBP\textsubscript{ao} did not differ significantly either in boys, or in girls, nevertheless, SBP\textsubscript{ao} was slightly lower in O/OW patients (104.3±7.9 mmHg in OW boys vs 104.8±7.7 mmHg in controls, 103.2±7.3 mmHg in O boys vs 104.6±7.5 mmHg in controls, while 103.4±7.1 mmHg in OW girls vs 103.9±6.9 mmHg in controls, 102.4±6.9 mmHg in O girls vs 103.5±6.6 mmHg in controls) (Figure 4).

![Figure 4](image)

**Figure 4** SBP\textsubscript{ao} in OW and O subjects and healthy controls, in boys and girls. NS; non-significant

**Discussion**

**Prevalence of overweight and obesity**

Our findings may give a picture of the condition of a well-balanced in terms of sex (54% male), young generation with considerable number (n=6.824) of participants. In our study, the prevalence of overweight and obesity was 20% in total, namely 13.4% of the participants
were overweight and 6.6% were obese. Our findings essentially correspond to the global prevalence published by Ng and her co-workers.

We have established, that the prevalence of overweight and obesity was increased in boys. This data agrees with the European and global findings.

Such differences may arise from biological, sociological and cultural differences, or perhaps from the combined effect of these. Studies have found that adolescent girls are more likely to give attention to healthy nutrition, whilst boys are more apt to consume more fast food. These differences may stem from the Western societies’ perception of the ideal body figure and from the fact that certain foods are gendered. For example, power and virility is symbolized by meat, therefore men eat more meat than women, while fat and carbohydrate rich foods are more often consumed by women in accordance with their menstrual cycle.

One of the most important observation of this study is that compared to the previous Hungarian data, mild decrease occurred in the youngest age group (3–9 years) in both sexes, in respect of overweight and obesity. Furthermore, the prevalence of overweight significantly decreased, while the prevalence of normal BMI significantly increased in the older age group (7–14 years). While in the third age group (14–18 years), due to the lack of the raw numbers regarding Hungary, we could not perform statistical comparison.

The fact that the total prevalence of overweight and obesity demonstrated a slight decrease in the age group 3–9 year compared to the previous Hungarian researches, may be explained by several factors. Recent studies have pointed out that increased protein intake (+6–8 g daily) during the first year of life could lead to 2.43 times higher risk for obesity at the age of 6. Moreover, the daily rhythm of nutrition of this age group is not well-balanced, some meals are often omitted, which may also increase the risk of obesity. Since parents have the greatest influence on nutrition at this age, they may have a key role at eliminating these anomalies. Consequently, education of parents in the field of nutrition is crucial, since they are the ones who are mostly responsible for the daily eating routine of their children.

**Arterial function parameters**

According to the relevant literature, our study provides a considerable number of data on AFP in OW and O children and adolescents, owing to a new, occlusive-oscillometric, “one-cuff” method, which brought a new era in the field of AFPs measurement, especially in children. Recently, reference values of PWV$_{ao}$, Aix$_{ao}$ and SBP$_{ao}$ for children and adolescents have been published, which proves that AFPs vary physiologically with the increasing age during
childhood and adolescence. The most important findings of this study regarding AFPs are the following: Firstly, $\text{PWV}_{ao}$ was not higher in OW/O patients. Secondly, $\text{Aix}_{ao}$ was lower in OW/O patients. Thirdly, $\text{SBP}_{ao}$ did not differ significantly measured in OW/O patients and controls. Fourthly, the effects of OW and O -as different entity of quality- on AFPs were practically the same.

$\text{PWV}_{ao}$

Analysing the reference values of $\text{PWV}_{ao}$ measured in children and adolescents, it is apparent that the median curve shows a flat period between the age of three and the beginning of puberty with a steeper increase thereafter in both sexes. Therefore, it is crucial to match for age of the investigated patients and control groups precisely. Moreover, $\text{PWV}_{ao}$ is dependent on the $\text{SBP}_{ao}$. Eliminating these possible modifying factors, age and $\text{SBP}_{brach}$ matched control groups were formed in our study. Because of this, no significant differences were found regarding $\text{PWV}_{ao}$ either in OW/O boys, or in OW/O girls. Moreover, $\text{PWV}_{ao}$ was significantly lower in OW girls than in control cases.

Several studies proved that already 10% of healthy, 15–19-year-old population has fibrous plaques on the abdominal aortic wall. OW and O might raise the prevalence. Based on our findings, these presumed phenomena (fatty streaks; and fibrous plaques) might not influence the physical features of the aortic wall, and therefore aortic stiffness may remain unaltered in this age period in the OW/O population.

$\text{Aix}_{ao}$

In our study the $\text{Aix}_{ao}$ was consonantly lower in OW/O patients groups, and the differences were significant in OW girls and O boys. This finding could be explained by the increased metabolism observed in OW/O patients, which causes a remarkable increase in stroke volume and heart rate, consequently the cardiac output elevates notably. Due to the increased cardiac output and the concomitantly increasing SBP, the lateral tension towards the aortic wall is also increased; thus, the aortic wall becomes stiffer and, as its consequence, the $\text{PWV}_{ao}$ will be higher. We may hypothesize, that to compensate the increased cardiac output and SBP, the vascular regulation system lowers the TPVR by dilating the small arterioles; therefore, decreased $\text{Aix}_{ao}$ can be detected.
In our study, no significant differences were found regarding SBP\textsubscript{ao} in OW/O patients and controls; moreover, SBP\textsubscript{ao} was slightly lower in OW/O patients. This finding could be explained by our study design: SBP\textsubscript{brach} was precisely matched in OW/O patients and controls; hence, - based on the formerly discussed relationship between SBP\textsubscript{brach} and SBP\textsubscript{ao} – the SBP\textsubscript{ao} could not be higher than the SBP\textsubscript{brach}. According to our hypothesis, the slight lowering of SBP\textsubscript{ao} detected in OW/O patients may be the consequence of the decreased Aix\textsubscript{ao}, otherwise the diminished TPVR.
**Summary**

Conclusions of the studies presented in the thesis are:

1. We have found the prevalence of overweight and obesity in total is 20% in Szolnok and its surrounding area, namely 13.4% of the patients were overweight, 6.6% were obese.
2. Compared to the previous Hungarian data, we have identified a mild decrease in the youngest age group (3–9 years) in both sexes, in respect of overweight.
3. We have established, that the prevalence of overweight significantly decreased, while the prevalence of normal BMI significantly increased in the older age group (7–14 years).
4. Our study provides remarkable number of AFPs data in OW/O patients (n=719).
5. By creating proper control groups, no significant differences were found regarding $PWV_{ao}$ either in OW/O patients.
6. We may conclude, that lower $Aix_{ao}$ in OW/O patients, may stem from the decreased TPVR in order to compensate the increased metabolism presented in OW/O patients.
7. We could not identify significant differences regarding $SBP_{ao}$ in OW/O patients.
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