

A study on health and the association between overweight/obesity and otorhinolaryngological diseases in 6- to 17-year-old children from Wrocław, Poland

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Abstract

Introduction: Childhood overweight and obesity have become a global problem in the past three decades. There are very few studies which examine the correlation between body mass index (BMI) and the development of otorhinolaryngological diseases in children. The objective of the study was to determine the association between overweight or obesity in children and the occurrence of otorhinolaryngological diseases.

Material and methods: The survey study was based on a parent-reported multidisciplinary questionnaire on children's medical status among elementary and junior high school children in the city of Wrocław, the capital city of Poland's Lower Silesia region. The children were taking part in the pro-health campaign "Let's Get the Kids Moving".

Results: The study was conducted among 2,913 children. A statistically significant correlation was observed between the assessment of the children's BMI and the occurrence of adenoid hypertrophy. Adenoid hypertrophy was more common in the overweight and obese children. The children with adenoid hypertrophy had higher BMI than the children without adenoid hypertrophy. There was a statistically significant correlation between BMI and the incidence of adenoidectomy. There was a statistically significant correlation between BMI and the incidence of tonsillectomy.

Conclusions: The development and introduction of preventive programs like "Let's Get the Kids Moving" in the future will contribute to building a healthier society. The study findings suggest that primal prevention may lead to a decrease in the development of otorhinolaryngological diseases. We also showed that higher body mass correlates with higher prevalence of otorhinolaryngological diseases. Further studies are needed to establish the etiopathology of this association.

Key words: obesity, prevention, public health, body mass index.

Introduction

The increasing number of adults and children affected by overweight and obesity has become a global concern in the past 30 years. A 2017 report from the Commission on Ending Childhood Obesity of the World Health Organization (WHO) estimated that the number of overweight children increased from 31 million in 1990 to 42 million in 2015 [1]. According to the WHO, over 22% of children in Poland are affected by

overweight or obesity. Obesity has been considered a non-communicable disease and is seen as a health challenge.

Excessive body weight in childhood contributes to an increased risk of overweight in adulthood. A study by Nader revealed that children with a body mass index (BMI) above the 85th percentile, or with a BMI in the high reference range, were more prone to remain affected by obesity into adulthood than children whose BMI was below the 50th percentile [2].

It has been established that overweight and obesity in childhood constitute the most common risk factor for the development and premature onset of cardiovascular diseases and that it is strongly connected with a higher risk of hyperinsulinemia, impaired glucose tolerance, type 2 diabetes mellitus, dyslipidemia, hypertension and adverse changes in the walls of blood vessels [3]. Kelsey *et al.* stated that the health effects related to excessive body weight in childhood may have long-term sequelae in adulthood – despite normalization of body weight – and, consequently, may increase the likelihood of early morbidity and mortality [4].

Childhood obesity may predispose one to otorhinolaryngological diseases by interfering with the immune system and mechanically through an excess concentration of visceral fat. The consequences of increased body mass include the development of abdominal obesity and, to some extent, ectopic fat deposition in adulthood. An association between obesity, adenotonsillar hypertrophy and obstructive sleep apnea (OSA) has been reported. The role of increased body weight in the aetiopathogenesis of those conditions is not fully understood. The increased prevalence of both adenoid and tonsillar hypertrophy among the pediatric population affected by obesity in comparison to normal weight peers was reported. It may be connected with endocrine changes. Endocrine mediated somatic growth in children promotes accumulation of larger and/or heavier fat pads, soft palate, and tongue [5]. Also obesity may contribute to the development of OSA by narrowing the upper airways through an accumulation of fat. Fat-induced obstruction enhances inflammatory responses [6]. A study conducted by Rubinstein [7] revealed the presence of nasal inflammation, in the form of an increased number of polymorphonuclear leukocytes and the concentrations of bradykinin and vasoactive intestinal peptide, in patients with OSA and suggested that it influences upper airway obstruction in OSA. As adipose tissue is considered to be immunologically active, an association between obesity and chronic otorhinolaryngological inflammatory diseases including adenoid and tonsillar hypertro-

phy may be connected with increased secretion of inflammation-related substances in youths with high BMI.

There are very few studies which examine the correlation between BMI and the development of otorhinolaryngological diseases in children.

The aim of this study was to determine the association between overweight or obesity in children and the occurrence of otorhinolaryngological diseases.

In particular, answers to the following questions were sought:

1. Which otolaryngological diseases occur among children affected by overweight and obesity?
2. Is there a relationship between BMI and the occurrence of otorhinolaryngological diseases?

Material and methods

The survey study was conducted from September 2016 to July 2017. It was based on a parent-reported multidisciplinary questionnaire on children's medical status among elementary and junior high school children in the city of Wrocław, the capital city of Poland's Lower Silesia region.

Parents of 2,913 children – aged between 6 and 17 years and recruited from 34 elementary and junior high schools in the city of Wrocław – completed and returned the questionnaire (33% response rate; the questionnaire was handed out to 10,000 families). The children were taking part in the pro-health campaign “Let's Get the Kids Moving” (“Uruchamiamy dzieciaki”). “Let's Get the Kids Moving” is an obesity prevention program. The campaign was launched in 2016 and created and organized by the employees of Wrocław Medical University and the “Run for Health” Foundation (Fundacja “Biegaj dla Zdrowia”) and addressed to physical education teachers, parents, educators and trainers.

The aim of the campaign is to promote a healthy lifestyle, physical activity and a balanced diet and to draw attention to the problem of overweight and the resulting diseases in children by 1) organizing sports events and 2) educating teachers and parents during periodic meetings.

The questionnaire was designed especially for this study by the team of specialists including otorhinolaryngologists from Wrocław Medical University and the University Clinical Hospital in Wrocław. The questionnaires regarding children's medical condition were distributed to school coordinators and handed out to parents during periodic school meetings. The survey inquired as to whether the child/children had suffered or currently suffered from the following conditions or groups of conditions: adenoid hypertrophy, tonsillar hypertrophy or obstructive sleep apnea syndrome. The other questions concerned otolaryngological conditions

(where applicable) and consisted of: adenoidectomy and/or tonsillectomy and the presence of complications after such operation(s).

Body mass index was calculated from self-reported weight and height measurements of the participants. The BMI was calculated by dividing the body mass in kilograms by the square of the body height in meters. Overweight and obesity were determined on the basis of the percentile categories according to current reference charts for Polish children correlated by body weight and height [8, 9]. The participants were divided into five groups according to current reference charts for Polish children correlated by body weight and height: 1) underweight; 2) slim; 3) normal body weight; 4) overweight; and 5) affected by obesity.

Permission for the subjects to participate in the study described in this manuscript was approved and granted by the Local Ethics Committee of the Medical University in Wrocław, Poland (KB – 738/2018). All participants took part in the study voluntarily and were able to discontinue their participation at any time without repercussion. The participants and their legal guardians were informed of the nature of the study and in each case they formally expressed their consent to the study. This study was performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments.

Statistical analysis

Statistical analysis was performed using the Statistica v.13 software package (StatSoft Inc., Tulsa, OK, USA). All quantitative parameters (BMI, frequency of consumption of specific products and activities) in all subgroups were examined for normality of distribution using the Kolmogorov-Smirnov test or Shapiro-Wilks test, if the numbers in the subgroups were less than 50, at the threshold level of significance $p < 0.05$. Quantitative characteristics of the study group are shown in tables as means (M) and standard deviations (SD), and nominal characteristics are shown as numbers (n) and percentages (%). The significance of differences in the quantitative parameters in two groups of children (e.g. differing in otitis media with middle hypertrophy or hypertrophy of the third tonsil) was verified by the Mann-Whitney U test. Hypotheses on the independence of nominal and ordinal characteristics were verified using Pearson's χ^2 test. For all tests, a significance threshold of $p < 0.05$ was used.

Results

The survey study was conducted among 2,913 children (1,418 girls and 1,495 boys). The majority

of the surveys were completed by mothers: 2,407 surveys in total (82.6%). 456 surveys were filled in by fathers (15.7%) and 50 (1.7%) by another guardian. A sociodemographic analysis of the study participants in terms of BMI categorization is presented in Table I.

Adenoid hypertrophy

A statistically significant correlation was observed between the assessment of the children's BMI and the occurrence of adenoid hypertrophy (Figure 1). Adenoid hypertrophy was more common in children affected by overweight and obesity ($p < 0.05$).

A statistically significant correlation was present between BMI values in the groups and the presence of adenoid hypertrophy (Figure 2, $p < 0.01$). The children with adenoid hypertrophy had higher BMI than the children without adenoid hypertrophy (18.4 vs. 17.9 kg/m²; $p = 0.002$).

Adenoidectomy/tonsillectomy/tonsillotomy

There was a statistically significant correlation between BMI and the incidence of adenoidectomy and tonsillectomy (Figure 3, $p < 0.001$; Figure 4, $p < 0.001$). Adenoidectomy and tonsillectomy had been performed significantly more often among the children affected by overweight and obesity ($p < 0.001$, $p < 0.05$, respectively).

Obstructive sleep apnea

The values for the children's otorhinolaryngological status concerning obstructive sleep apnea syndrome (OSA/OSAS) and adenoid hypertrophy are shown in Tables II and III.

There was no statistically significant association between BMI and the prevalence of obstructive sleep apnea ($p > 0.05$).

There was a statistically significant association between BMI and the prevalence of adenoid hypertrophy ($p < 0.01$). In slim children, adenoid hypertrophy occurred significantly less often than in children with normal body weight (21.8% vs. 26.7%; $p = 0.026$), in overweight children (21.8% vs. 30.9%; $p = 0.004$) and in children affected by obesity (21.8% vs. 35.7%; $p = 0.002$).

Discussion

Childhood overweight and obesity have become a global problem in the past three decades. Cultural and socio-economic changes, increased urbanization, advanced computerization and technological progress have contributed to the increased prevalence of obesity and overweight. In developed countries, nourishment is more accessible and affordable, hard physical work that in

Table 1. Sociodemographic analysis of the 2,913 participants in terms of body mass index (BMI) categorization

Characteristic	Total						BMI categorization						P-value
	N = 2,913		Underweight, n = 262		Slim, n = 523		Normal body mass, n = 1,694		Overweight, n = 320		Affected by obesity, n = 114		
	n	%	n	%	n	%	n	%	n	%	n	%	
Sex:													
Females	1,418	48.7	130	49.6	231	44.2	828	48.9	164	51.3	65	57.0	0.078
Males	1,495	51.3	132	50.4	292	55.8	866	51.1	156	48.8	49	43.0	
Filled in by:													
Mother	2,407	82.6	209	79.8	448	85.7	1,387	81.9	268	83.8	95	83.3	0.020
Father	456	15.7	52	19.8	69	13.2	278	16.4	41	12.8	16	14.0	
Guardian	50	1.7	1	0.4	6	1.1	29	1.7	11	3.4	3	2.6	
Place of residence:													
Rural area	201	6.9	15	5.7	47	9.0	112	6.6	21	201	6.9	15	0.507
Small city: < 20,000 citizens	16	0.5	2	0.8	1	0.2	10	0.6	2	16	0.5	2	
Average city: 20,000–100,000 citizens	8	0.3	0	0.0	1	0.2	7	0.4	0	8	0.3	0	
Big city: > 100,000 citizens	4	0.1	0	0.0	1	0.2	2	0.1	0	4	0.1	0	
Wrocław	2,684	92.1	245	93.5	473	90.4	1,563	92.3	297	2,684	92.1	245	

many cases involved human labor is constantly being replaced by machines, and car ownership has increased along with labor-saving devices and techniques. In a study by Sidell *et al.* [10], approximately 95% of children were affected by obesity, representing 22.2% of the U.S. population between the ages of 6 and 17 years.

The prevalence of overweight and obesity in Polish children, according to a WHO report, was approximately 22%. A radical improvement in socioeconomic conditions in Poland has promoted a higher prevalence of excess weight in childhood in recent years [3, 11]. The international OLAF Study by Kutaga *et al.* [8] showed that almost 20% of Polish children are affected by overweight or obesity and that 30% had waist circumference measurements above the international cardiovascular risk threshold. The study also revealed that the distributions of height, weight and BMI in children and adolescents differed from those of children in the international growth reference charts. In a study by Czyż *et al.*, the prevalence of overweight and obesity was 13.1% and 4.06%, respectively [12].

In our study, overweight was present in 11% of the children (51.3% of girls and 48.8% of boys), while obesity was reported in 4% of them (57% of girls and 43% of boys).

According to Kutaga *et al.* the prevalence of excessive body weight in Polish children and adolescents was medium to high in comparison to the other European countries. In a nationwide survey study, conducted in Poland in 2007–2009 and covering a population of elementary and high school pupils (17 427 children), the prevalence of overweight and obesity was determined using three childhood obesity definitions: the Centers for Disease Control and Prevention (CDC), the International Obesity Task Force (IOTF), and the WHO. Overweight or obesity was present in the range 14.6–19.4% of boys and 10.3–13.0% of girls aged 13–18 years, including obesity in older children (13–18 years) in

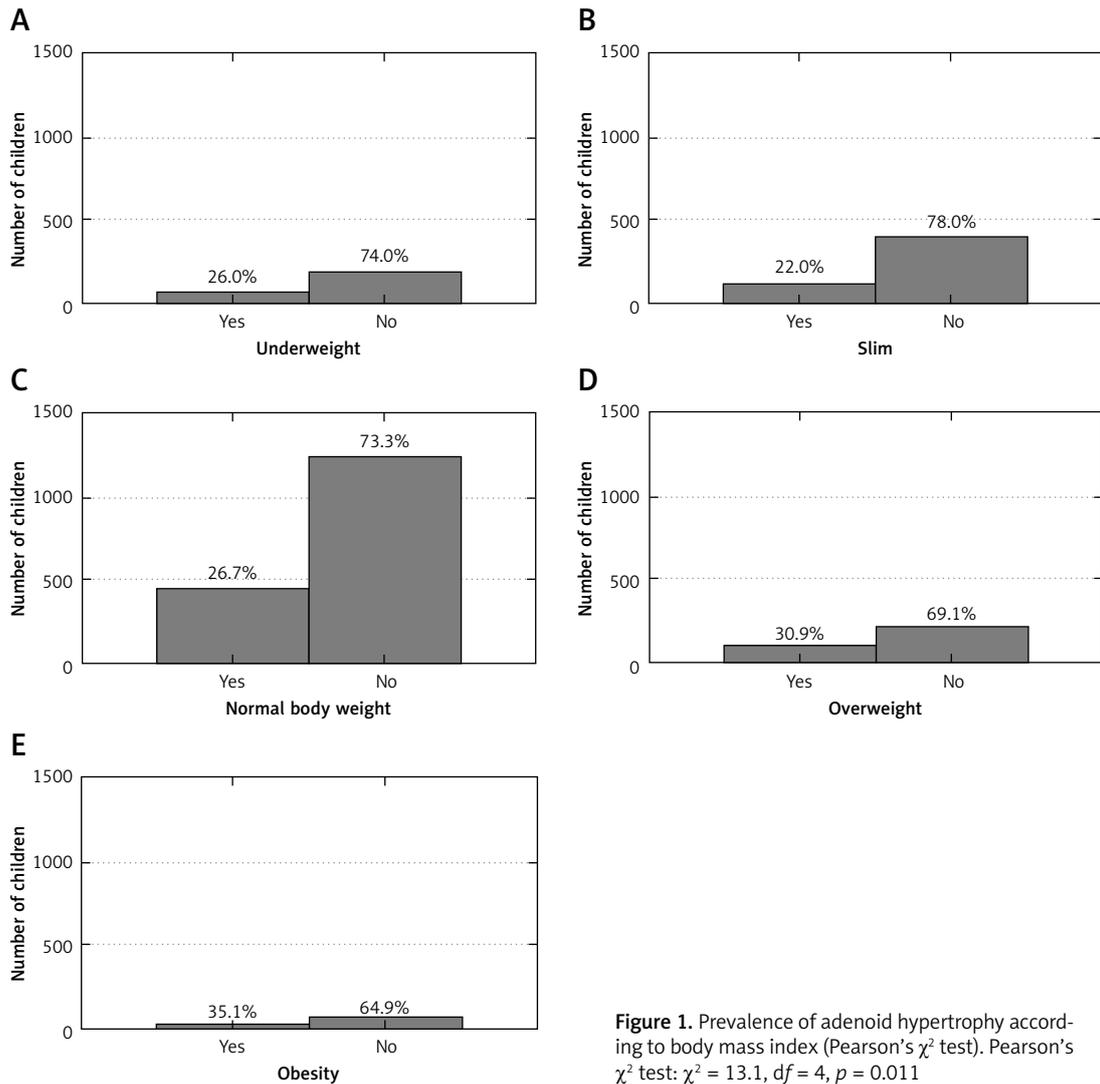


Figure 1. Prevalence of adenoid hypertrophy according to body mass index (Pearson's χ^2 test). Pearson's χ^2 test: $\chi^2 = 13.1$, $df = 4$, $p = 0.011$

the range 3.4–5.0% of boys, and 2.0–2.6% of girls. The prevalence of obesity in younger children aged 7–12 years was in the range 5.5–13.1% of boys and 3.6–6.4% of girls [13]. Research conducted by Wozniacka among a group of 3405 Polish children aged 5–14 in 2009–2010 estimated body weight according to different BMI cut-offs: IOTF, CDC and the Polish 2010 standard. The study showed that overweight occurred in 15%, 11.3% and 9.5% (IOTF, CDC, Polish 2010, respectively) of boys and 15.5%, 11.6% and 9.9% of girls. 3.3%, 6.1% and 3.3% of boys (IOTF, CDC, Polish 2010, respectively) and 3.4%, 6.3% and 5.7% of girls were affected by obesity. The study estimated the prevalence of obesity and overweight according to the protocol of the European Childhood Obesity Group [14]. Similar results were obtained by Tomaszewski *et al.* In a study conducted on a pupils from primary schools in Warsaw, Poland (367 girls and 424 boys aged 6.5–10.5 years) and based on BMI 15% of all participants were classified as overweight, and

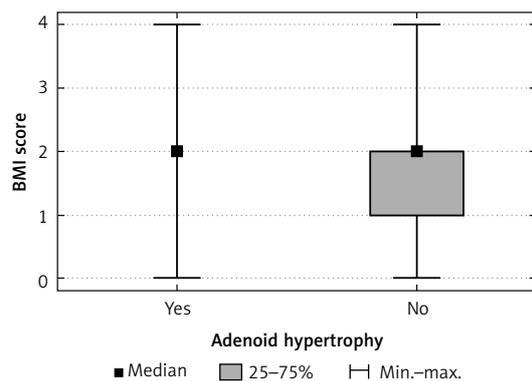


Figure 2. Prevalence of adenoid hypertrophy according to body mass index (0 – underweight, 1 – slim, 2 – normal body weight, 3 – overweight, 4 – affected by obesity) (Mann-Whitney U test). U Mann-Whitney test; $Z = 3.072$, $p = 0.002$

approximately 4% of girls and 6% of boys aged 7–10 were obese [15].

In another study, the body weight, height and BMI of 70,329 children aged between 6 and 13

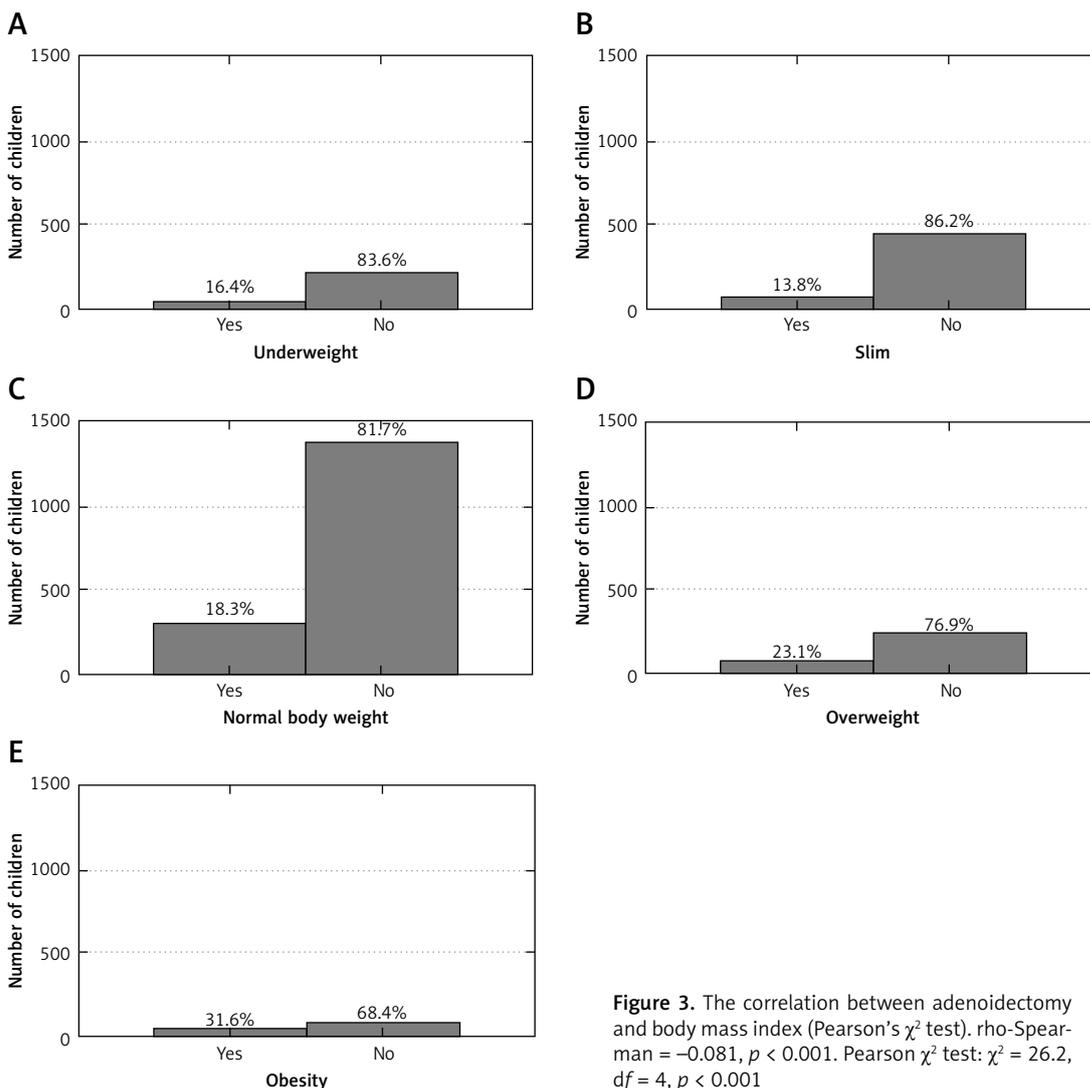


Figure 3. The correlation between adenoidectomy and body mass index (Pearson's χ^2 test). rho-Spearman = -0.081 , $p < 0.001$. Pearson χ^2 test: $\chi^2 = 26.2$, $df = 4$, $p < 0.001$

years were studied during annual child health measurements in Gdańsk schools between 1992 and 2012. Brzeziński *et al.* [16] did not identify any trend in increasing prevalence of overweight or obesity among the children studied. However, an age-related increase in the prevalence of excess body weight among 6-, 7-, and 12-year-old children born between 1993 and 1997 was noted. The prevalence of excess body weight was higher in girls than in boys from all age categories, except 12- and 13-year-old children, in whom no gender-specific differences were documented.

In a study by Daar *et al.* [17], children affected by obesity aged between 3 and 18 years had a higher prevalence of adenotonsillar hypertrophy compared to normal-weight peers. This could be connected with endocrine-mediated somatic growth [17].

In another study [18], it was revealed that children with adenoid and tonsil hypertrophy had lower high-density lipoprotein cholesterol (HDL-C) than normal children. The authors state

that HDL-C may be a sensitive indicator of serum lipid changes in sleep-disordered breathing (SDB) children, as the HDL-C concentration was lower in children with more enlarged adenoids and tonsils.

Children affected by obesity have an increased risk of obesity-associated comorbidities, including obstructive sleep apnea (OSA), compared to their normal-weight counterparts. Adenotonsillar hypertrophy and, consequently, the development of airway obstruction is a significant cause of OSA in children affected by obesity and those not affected by obesity. OSA is a breathing disorder during sleep which is characterized by the repetitive collapse of the upper respiratory tract. In the United States, the prevalence of this condition is estimated to be 3–7% in men and 2–5% in women [19]. Among patients with a BMI greater than 28, OSA was reported in 41% of subjects [20]. Wang *et al.* [21] compared palatine tonsil size (volume, weight, width, height and thickness) in two groups of children with SDB, those affected by obesity and those not affected by obesity.

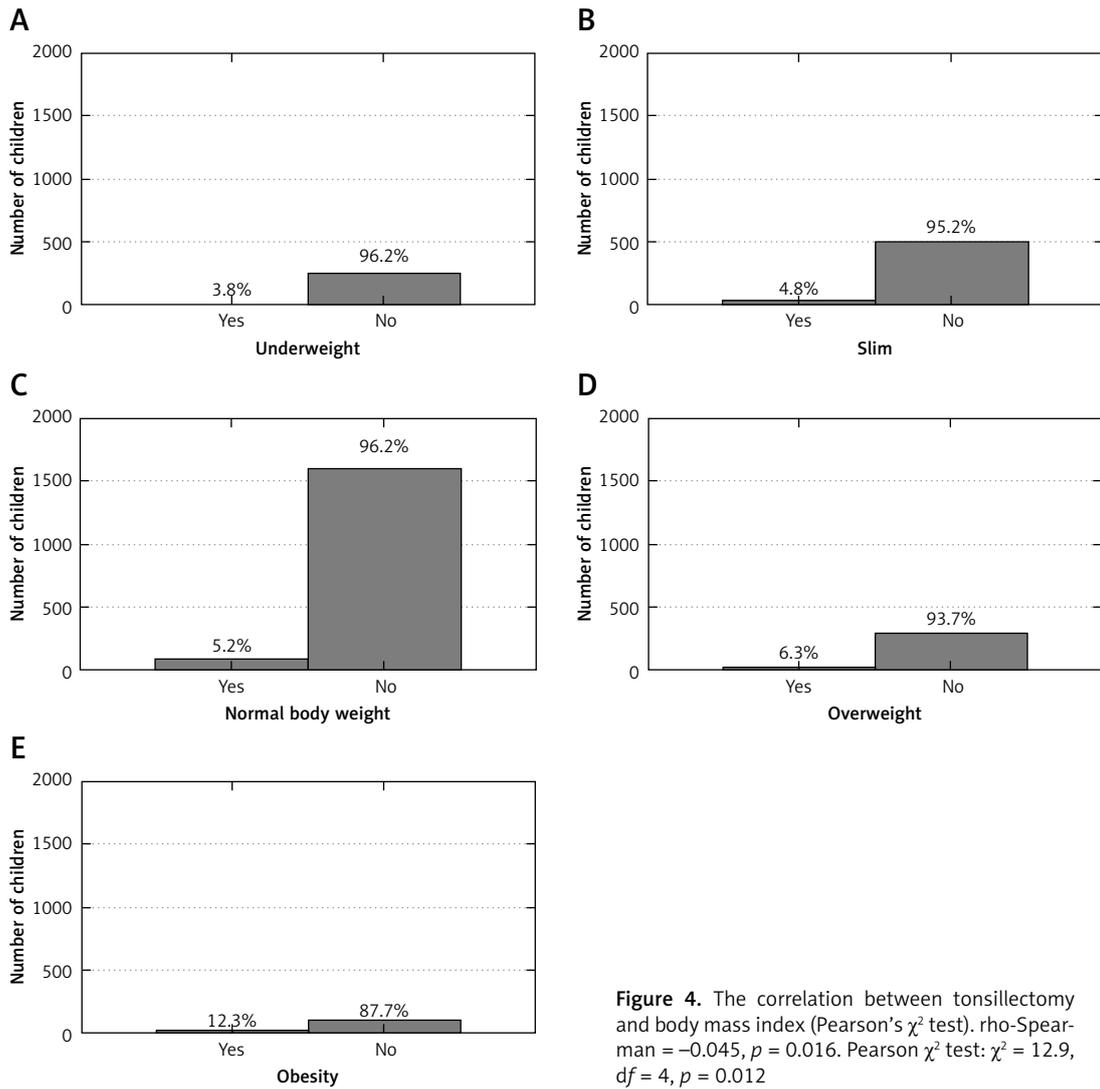


Figure 4. The correlation between tonsillectomy and body mass index (Pearson's χ^2 test). rho-Spearman = -0.045, $p = 0.016$. Pearson χ^2 test: $\chi^2 = 12.9$, $df = 4$, $p = 0.012$

Table II. Answers to the question, "Does the child suffer from obstructive sleep apnea/sleep apnea syndrome?" in groups of children categorized by body mass index (BMI)

Response	Total		BMI categorization								P-value		
	N = 2,764		Underweight, n = 250		Slim, n = 499		Normal weight, n = 1,604		Overweight n = 308			Affected by obesity, n = 103	
	n	%	n	%	n	%	n	%	n	%		n	%
No (0)	2,697	97.6	242	96.8	483	96.8	1,572	98.0	299	97.1	101	98.1	0.463
Yes (1)	67	2.4	8	3.2	16	3.2	32	2.0	9	2.9	2	1.9	

Table III. Answers to the question, "Has the child ever had adenoid hypertrophy?" in groups of children categorized by body mass index (BMI)

Response	Total		BMI categorization								P-value		
	N = 2,874		Underweight, n = 259		Slim, n = 514		Normal weight, n = 1,672		Overweight, n = 317			Affected by obesity, n = 112	
	n	%	n	%	n	%	n	%	n	%		n	%
No (0)	2,110	73.4	191	73.7	402	78.2	1,226	73.3	219	69.1	72	64.3	0.008
Yes (1)	764	26.6	68	26.3	112	21.8	446	26.7	98	30.9	40	35.7	

The study revealed that in children affected by obesity tonsils were larger than in normal-weight control subjects with SDB. This finding suggests that larger palatine tonsils may have a greater effect on upper airway obstruction in children affected by obesity than in normal-weight children with SDB. In another study, Arens *et al.* [22] studied lymphoid tissues in children affected by obesity with obstructive sleep apnea syndrome (OSAS) versus controls affected by obesity. Patients with OSAS had larger adenoid, tonsils and retropharyngeal nodes. The authors revealed that BMI did not correlate with the size of lymphoid tissues. However, children affected by obesity with OSAS demonstrated larger parapharyngeal fat pads and abdominal visceral fat compared to normal-weight peers.

The volume of upper airway tissue structures in OSAS patients is enlarged and is involved in the development of sleep apnea along with other factors, such as age, craniofacial size, being male and genetic factors [18]. A higher prevalence of OSAS was observed in children and adults, and a higher incidence of OSAS in children affected by obesity was also reported [5].

Several possible limitations of the study need to be considered. The children's weight and height were self-reported by their parents or legal guardians. Self-reported values are believed to underestimate BMI. In the study we are conducting this year, the children's weight and height will be measured by the nurse. Also, as otorhinolaryngological diseases were also self-reported, there may be issues about the accuracy of the diagnosis.

In conclusion, we strongly believe that the development and introduction of preventive programs like "Let's Get the Kids Moving" in the future will contribute to building a healthier society. The study findings suggest that primal prevention may lead to a decrease in the development of otorhinolaryngological diseases.

Our research indicates that higher body mass correlates with higher prevalence of otorhinolaryngological diseases. Overweight and obesity may be considered as a potential contributor to the development of those conditions. Further studies are needed to establish the etiopathology of this association.

Our further future studies will focus on longitudinal assessments of weight, height, BMI and otorhinolaryngological diseases in order to establish trends and changes in overweight and obesity and the development of non-communicable diseases in the pediatric population of Wrocław.

Conflict of interest

The authors declare no conflict of interest.

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