

Association of Allergic Rhinitis in Female University Students with Socio-economic Factors and Markers of Estrogens Levels

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Abstract

The aim of this study is to investigate the association of allergic rhinitis in female university students with socio-economic factors and sex-hormone markers, including age at menarche, menstrual disorders, and selected anthropometrics indexes. The research was conducted among 640 female university students, aged 19–25 years. The measurements of body height, body mass, waist and hip circumference were taken. Each person completed a questionnaire. The occurrence of allergy was determined on the basis of answers to the questions whether the allergy and its allergens were defined on the basis of medical work-up. We found that a significantly larger number of cases of allergic rhinitis were recorded in the university students coming from families of high socio-economic level than those from lower level. Allergic rhinitis also was more frequent in the students who spent their childhood in cities than in those who lived in the countryside. The prevalence of allergic rhinitis was inversely correlated to the number of siblings. There were no differences in the prevalence of allergic rhinitis in relation to the birth order. The estrogen level seemed unassociated with rhinitis. However, there were slightly more allergic among females with an earlier age of menarche.

Keywords

Age at menarche • Allergic rhinitis • Birth order • Socio-economic status • Obesity

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1 Introduction

Many countries, especially highly industrialized ones, have recently seen an abrupt increase in the prevalence of asthma and allergic diseases. According to latest reports, in some populations nearly 50 % of individuals show symptoms of atopic sensitization. The prevalence of allergic rhinitis among European adults ranges from 17 % in Italy to 29 % in Belgium, with an overall value of 23 % (Bauchau and Durham 2004). The cause of this phenomenon is not fully explained; yet it is commonly associated with changes in terms of exposure to pathogens, mainly bacteria and parasites (Okada et al. 2010).

One of the most popular hypotheses, posited by Strachan (1989), indicates excessive hygiene as the main risk factor contributing to the occurrence of allergic diseases. Many a study has reported a connection between the socio-economic status and the prevalence of allergies. Allergic diseases tend to occur more and more frequently in children from high-status families and families living in cities, a finding explained by reduced exposure to bacteria and parasites, as well as spending more time in a 'sterile' environment compared to children of low-status families and those living in rural areas (Okada et al. 2010; Pawlińska-Chmara et al. 2008). Differences in the prevalence of allergies are also noticeable across countries. The so-called 'westernization' of lifestyle is conducive to the development of allergies, with more frequent occurrence observable in societies with high mean living standards (Gold 2006).

However, the hygiene hypothesis is not the only one which attempts to explain the growing number of persons with allergies. Atopy is listed as one of the negative effects of early onset of puberty (MacSali et al. 2012; Al-Sahab et al. 2011). In the twentieth century, the development of medicine and the overall improvement of living conditions in many countries translated into inter-generation changes in the biological condition of individuals and populations. An example of secular trends is the acceleration of age at menarche. Also, significant differences in

biological development rate dependent on lifestyle and living conditions are reported within a single generation. Age at puberty is considerably earlier in wealthier countries than in states with poorer living standards; within the same country, children brought up in families of high socio-economic status reach puberty earlier than their counterparts from low-status families.

It is possible that providing a child with optimum conditions for biological development, including less exposure to bacteria, viruses and parasites, reduces the risk of diseases in childhood, and allows for rapid biological growth and earlier sexual maturation. On the other hand, there are negative consequences of early puberty, including the lability of the immune system.

The relation between the onset of puberty and the prevalence of asthma and allergies is particularly noticeable in females. It is supposed that high oestrogen level increases the risk of asthma and allergies. This theory is confirmed by studies in which the prevalence of allergies is higher in females than in males, as well as by results of the tests on the relationship between hormone levels and the occurrence of allergy or the varying intensification of allergic symptoms across the menstrual cycle in women.

An early age at menarche may be the marker of hormone levels. In females who reach puberty at early age, estrogen level is much higher both during adolescence and adulthood than in those who reach puberty at normal or later age. The amount of adipose tissue could be another factor connecting allergic diseases with early adolescence. Obesity is referred to as one of risk factors contributing to the incidence of asthma and allergies. Early menarche is also known to cause a greater deposition of adipose tissue and more frequent occurrence of overweight and obesity.

The present study was aimed at determining factors correlated with the prevalence of allergic rhinitis in university students. Socio-economic factors, as well as factors which could be indicative of estrogen level, including age at menarche, menstrual cycle regularity, waist-to-hip ratio (WHR), and body mass index (BMI) were taken into consideration.

2 Methods

The study protocol was approved by a local Ethics Committee. Data were collected following the ethical principles as stated in the Declaration of Helsinki. It was a cross-sectional study conducted among 670 female students of Krakow universities and colleges. The mean age of participants was 20.1 ± 1.4 years, with a range of 19–25 years of age. In a group of women without allergy the mean age was 20.1 ± 1.5 years and the allergic women were 20.1 ± 1.3 years of age.

Each student responded to a questionnaire. The questions concerned the incidence of allergic conditions, socio-economic status, the age at the onset of adolescence, and the menstrual cycle pattern.

The incidence of atopy was determined using the response to the question 'Have you been diagnosed with an allergy on the basis of medical tests, and if yes, which allergens are you allergic to?'. Allergic rhinitis was defined by a positive response to the question: 'Do you get attacks of 'hay fever' (i.e., sneezing, running or blocked nose, sometimes with itchy eyes or nose)?'.

Socio-economic status was established by means of variables used as standard in axiological studies: place of residence before the university or college period, mother's level of education, father's level of education, and the number of siblings. Place of residence before going to university/college was considered in three categories: village, town (up to 100,000 inhabitants), and city (more than 100,000 inhabitants). Mother and father's education levels were provided as three categories: vocational, secondary, and higher. On the basis of all the above factors, a complex socio-economic status indicator was calculated. Students were divided into three groups: low, average, and high status.

Age at menarche was established by means of the retrospective method. The questions related to the menstrual cycle patterns concerned both regularity and length of menstrual cycles.

Every subjects' height, body mass, waist and hip measurements were taken, on the basis of which BMI, WHR, and waist-to-height ratio (WhtR) were calculated.

3 Results

Twenty three percent of female subjects reported that they suffer from allergic rhinitis or both respiratory and food allergy. The most commonly named aeroallergens included pollens, house dust mite, and pet dander.

Table 1 contains socio-economic characteristics of female subjects, including the prevalence of allergic rhinitis. In groups of high socio-economic status more students reported allergic rhinitis than in groups of average and low status. The results of a chi-squared test revealed that the differences were statistically significant. Considering individual socio-economic factors, there were no differences in the prevalence of allergic rhinitis depending on mother and father's education level. A significantly higher prevalence of allergic rhinitis was noticeable in students who prior to going to university lived in an urban area, in particular in large cities, than in those who lived in rural areas. As for the 'sibling count' factor, there was a significant increase in the prevalence of allergic rhinitis along with a growing number of children in the family. The students were further divided into four groups: single children in the family, children with younger sibling(s), children with older sibling(s), and children with both younger and older sibling(s). Single children suffered from allergic rhinitis more frequently than children with sibling(s). No differences in the prevalence of allergic rhinitis were reported between the other three groups.

Another group of factors under consideration was related to estrogen levels. The first factor was the age at which the first menstruation occurred. The mean age at menarche for allergic students did not differ from that in students without allergies. The subjects were divided into

Table 1 Prevalence of allergy among students in relation to socio-economic status

Factor	Category	Allergy incidence		p-value
		no	yes	
		n (%)	n (%)	
Mother's education	Vocational	74 (72.6)	28 (27.5)	NS
	Secondary	178 (73.9)	63 (26.6)	
	University	224 (68.5)	103 (31.5)	
Father's education	Vocational	174 (72.2)	67 (27.8)	NS
	Secondary	152 (73.1)	56 (26.9)	
	University	150 (67.9)	71 (32.1)	
Number of siblings	0	72 (62.6)	43 (37.4)	<0.01
	1	214 (69.5)	94 (30.5)	
	2	129 (74.6)	44 (25.4)	
	3 and more	61 (82.4)	13 (17.6)	
Siblings	Lack	72 (62.6)	43 (37.4)	NS
	Younger	162 (71.7)	64 (28.3)	
	Older	157 (72.7)	59 (27.3)	
	Younger and older	85 (74.6)	29 (25.4)	
Place of living	Village	172 (80.8)	41 (19.3)	<0.001
	Cities below 100,000 inhabitants	174 (73.4)	63 (26.6)	
	Cities above 100,000 inhabitants	130 (59.1)	90 (40.9)	
Socio-economic status	Low	127 (79.9)	32 (20.1)	<0.001
	Average	237 (71.4)	95 (28.6)	
	High	112 (62.2)	68 (37.8)	

three groups: early onset of puberty (age at menarche lower than the 25th centile), average onset of puberty (age at menarche ranging from the 25th to 75th centile), and late onset of puberty (age at menarche higher than the 75th centile). In the group of girls with early onset of adolescence slightly more subjects reported allergic rhinitis than in groups with the average or late onset of puberty, although the difference was not statistically significant. Also other factors under analysis which may be indicative of estrogen levels, such as WHR and menstrual cycle regularity, were not significantly correlated with the prevalence of allergic rhinitis (Table 2).

The final stage of the analysis involved verifying the relationship between indicators of abnormal amount of adipose tissue and the prevalence of allergic rhinitis. No statistically significant differences in the incidence of allergic rhinitis between underweight, normal-weight, overweight, and obese students were reported; the same was also true of students with and without abdominal obesity (Table 2). Moreover,

no significant differences in the mean values of BMI, waist circumference, and WHtR between students with and without allergies were found (Table 3).

4 Discussion

All variables analyzed in the present work were referred to in the scientific literature as factors correlated with risk of allergic conditions. Most studies have demonstrated that the development of allergic conditions is strictly connected with living conditions. Likewise, the present study indicates that the prevalence of allergies is to a larger extent caused by socio-economic factors than high level of estrogens. The present findings indicate that three factors showed significant in terms of their effect on the prevalence of allergies: overall socio-economic status, sibling count, and the place of residence, i.e., a degree of urbanization. Other researchers, too, have shown a significant relationship between social and

Table 2 Prevalence of allergy among female students in relation to age at menarche and obesity

Factor	Category	Allergy incidence		p-value
		no	yes	
		n (%)	n (%)	
Age at menarche	Early	62 (66.7)	31 (33.3)	NS
	Average	366 (71.8)	144 (28.2)	
	Late	48 (71.6)	19 (28.4)	
Menstrual cycles	regular	344 (71.2)	139 (28.8)	NS
	irregular	132 (70.6)	55 (29.4)	
Body mass index (kg/m ²)	Underweight	65 (65.7)	34 (34.3)	NS
	Correct	361 (72.1)	140 (27.9)	
	Overweight and obese	50 (71.4)	20 (28.6)	
Waist circumference (cm)	≤80	394 (72.0)	153 (28.0)	NS
	>80	50 (66.7)	25 (33.3)	

Table 3 Anthropometric indices in relation to the incidence of allergy

Anthropometric indices		Allergy incidence		p-value
		no	yes	
BMI (kg/m ²)	$\bar{x}$	21.3	21.5	NS
	s	2.95	3.36	
	min-max	16.6–36.8	16.7–35.6	
Waist circumference (cm)	$\bar{x}$	71.3	70.9	NS
	s	8.1	8.6	
	min-max	56–106	58–106	
WHR	$\bar{x}$	0.75	0.74	NS
	s	0.06	0.07	
	min-max	0.62–1.01	0.64–1.10	
WHtR	$\bar{x}$	0.43	0.42	NS
	s	0.05	0.05	
	min-max	0.32–0.66	0.34–0.60	

BMI body mass index, WHR waist-hip ratio, WHtR waist-height ratio

economic factors, and the incidence of allergies (Okada et al. 2010). In European and North American countries it has been observed that the percentage of people with asthma and allergic conditions grows with an increase in the gross domestic product (Bach 2002). This correlation is also visible in a single country. Allergic conditions are more common in wealthier than in poorer regions. As mentioned in the introduction, the prevalence of allergies is also connected with the socio-economic status of the family in which the child is brought up (Patterson et al. 1996). Almost all studies demonstrate that allergic conditions are related to high socio-economic status. The only exception is asthma, as studies indicate that it occurs more frequently in persons living in worse conditions. The

reasons for this phenomenon are not entirely explained. It is often emphasised that the causes may be linked to differences in exposure to infections in childhood or in environmental pollution (Eggleston 2009; Bach 2002). The present study confirmed the above hypothesis. Similar to other authors' findings, we report that allergies were more often in single children in the family than in those having sibling(s). The reason for this could be that children with sibling(s) receive more exposure to infections. Of special significance is the exposure to infections during the first 6 months of life. Therefore, what is important is not only the fact of having brothers or sisters, but also the sequence in which the children are born. Older siblings lead to a greater risk of allergies than younger ones (Cardwell et al. 2008;

Strachan 1989). Latest studies provide another explanation of the relationship between the number of children in the family and the prevalence of allergies. It is believed that the prevalence of allergies depending on birth sequence is a reflection of *in utero* effects. It has been shown that exposure to a high cord blood immunoglobulin E level in the prenatal period is positively correlated with allergies later on in the child's life (Tariq et al. 1999; Michel et al. 1980). In addition, it is established that cord blood immunoglobulin E level decreases with consecutive births (Karmaus et al. 2001). Devreux et al. (2002) have reported decreasing T helper proliferative responses of cord blood mononuclear cells with increasing birth order (Devreux et al. 2002). Our present findings did not reveal any relationship between the birth sequence and the prevalence of allergies. Indeed, students with sibling(s), irrespective of the age of the sibling(s), reported allergic conditions less often than students who were their parents' only children.

The connection between the prevalence of allergies and the place of residence is explained by varying exposure to air pollution and endotoxines. Air pollution contributes to the development of allergic conditions and asthma, and exposure to a high level of endotoxines prevents asthma and allergies (Tavernier et al. 2006; Braun-Fahrlander et al. 2002). Villages are characterized by lower air pollution level, higher level of endotoxins, as well as greater exposure to pathogens compared to cities. From an early age on, children in rural areas live in an environment rich in allergens such as animal hair or plant pollen (Ege et al. 2006; Braun-Fahrlander et al. 2002; Riedler et al. 2001).

The two remaining socio-economic factors discussed in the present study, i.e., mother and father's level of education were not correlated with the prevalence of allergic conditions. This could be attributed to the homogenization of living conditions and lifestyles across groups of different education levels.

In this study we reported no effect on the prevalence of allergies of factors related to estrogen level either. The first of such factors, i.e., the age at menarche, is the indicator of the endogenous level of estrogens, which in turn has a significant

influence on the development of the immune system. Westergaard et al. (2003) have shown that early age at menarche is associated with a greater risk of allergic rhinitis in adulthood. However, Xu et al. (2000), having examined a group of 10,000 female subjects, do not find any relationship between age at menarche and allergies in adulthood. Interestingly, they reported that offsprings of mothers whose first period occurred at a later age suffer much less frequently from allergic conditions in adulthood. The cohort of female students investigated in the present study did not exhibit any significant difference in the prevalence of allergies depending on the onset of puberty, although students whose period of adolescence began earlier reported allergies somewhat more frequently than those whose onset of puberty was normal or late. Other analyzed markers of estrogen level were not related to the prevalence of allergies either. Still, the literature provides information that the prevalence of allergies is related to irregular menstrual periods (Galobardes et al. 2012) and reproductive history (Rangaraj and Doull 2003).

The findings concerning the effect of high estrogen level on the development of allergies are not fully unanimous. This could be caused by the fact that, rather than blood hormone levels, many studies make use of indirect indicators. It must be noted that even in the case of direct hormone tests, it is only the current level of a hormone that is being measured. What is unknown is to what extent such level reflects a high exposure to estrogen in previous periods of life critical to the development of the immune system. It is also suggested that the risk of allergy is affected to a much lesser extent by endogenous hormones than hormones present in the natural environment, mainly food (Chighizola and Meroni 2012; Daxenberger et al. 2001).

Studies on allergy risk factors are problematic in that a person throughout his life is exposed to numerous environmental factors, which are often interrelated. It is thus difficult to isolate a single factor(s) and recognize the way in which it exerts an influence. Studies using animal models may prove helpful in this respect, as they make it possible to control conditions. However, the human model of development is unique and

different from other animal species. For this reason, monitoring studies on the prevalence of allergies and factors correlated with the incidence of allergies should be constantly conducted, and meta-analyses of published data will allow researchers to identify risk factors and limit the number of allergic individuals in the future.

Conflicts of Interest The authors declare no conflicts of interest in relation to this article.

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