

Specific Immune Response to Occupational Antigens in Asymptomatic Egg Processing Workers

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Background *Hen's egg proteins are known sensitizers and may cause occupational respiratory diseases in exposed workers. The study was conducted in order to ascertain the prevalence of sensitization to work-related antigens in asymptomatic egg processing factory workers.*

Methods *Clinical history, respiratory function, atopy and the presence of specific antibodies to environmental and occupational antigens were evaluated in 77 workers. A total of 116 unexposed and non-professionally exposed controls were also studied. The antigen concentration of the factory environment was measured.*

Results *Specific IgE and precipitin positivity to egg components was more frequently present in workers than in the two control groups. The egg white protein concentration was higher in the egg breaking area.*

Conclusions *The avian proteins inhaled induced immune responses to occupational antigens in asymptomatic, professionally exposed subjects. Measures to decrease environmental antigen concentrations and thorough clinical monitoring of sensitized workers are advocated..* Am. J. Ind. Med. 41:490–497, 2002. © 2002 Wiley-Liss, Inc.

KEY WORDS: *inhaled egg proteins; avian antigens; egg processing workers; occupational sensitization*

INTRODUCTION

Hypersensitivity to hen's egg proteins is a common feature in subjects with food allergies who are often atopic and may present cutaneous, gastrointestinal and respiratory symptoms, such as asthma, when eggs are ingested [Bock, 1982; Norgaard and Bindslev-Jensen, 1992; Sampson, 1998].

The main sensitizing components have been identified as the egg white proteins ovalbumin and ovomucoid, which lead to specific IgE production; other pathogenetic mechanisms related to immunocomplex formation have also been postulated [Paganelli et al., 1984; Sampson, 1998]. Egg allergy sometimes occurs in adults in the presence of airway sensitization to avian antigens and may cause "bird-egg syndrome," due to crossreactivity between antigens in bird serum and hen's egg yolk [De Maat-Bleeker et al., 1985, 1988; Bausela et al., 1991; Szepefalusi et al., 1994]. More over, inhaled egg products can also induce airway sensitization and occupational respiratory diseases in egg exposed workers in the food industry [Edwards et al., 1983; Bernstein et al., 1987; Berrens and Edwards, 1987; Blanco Carmona et al., 1992; Quirce et al., 1998]. In various series, IgE and IgG responses to common and specific allergens have been detected in such workplaces [Bernstein et al., 1987; Berrens and Edwards, 1987; Smith et al., 1990].

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The occurrence of occupational asthma in an egg processing factory, in two workers employed in the egg breaking area who exhibited IgE and precipitin responses to avian proteins and molds, prompted us to evaluate immunologic reactivity to common and occupational antigens in a series of 77 asymptomatic workers from the same factory in order to ascertain the presence of exposure-related patterns of sensitization and the risk of developing occupational respiratory symptoms. A group of 116 healthy controls, 50 of whom lived in a rural environment and were non-professionally exposed to avian antigens, were also studied in order to determine the possible role of different kinds of contact with these proteins in developing immunologic reactivity.

MATERIALS AND METHODS

Study Population and Workplace

In this study, we investigated a series of 77 workers, 16 males and 61 females, aged 21–58 (mean age 36) years, employed in an egg processing factory.

The work process includes different tasks and exposure levels. Some eggs are transported on trolleys to the sorting area, loaded onto a conveyor belt, sorted and divided on the basis of weight and size and then packed. Other eggs are machine-broken in a different department and then homogenized into yolk, white or whole egg. Packed eggs or their products are temporarily stored and then prepared for shipment. Twenty-six, 42, and 6 workers were employed in the sorting, breaking and storage/despatch areas, respectively; two subjects were part of the maintenance squad and one worked in the quality control laboratory.

All workers gave their informed consent to participation in the study, which included a medical interview to obtain information on atopy, occupational history, previous, and work-related respiratory disorders; spirometry and blood collection for immunologic studies were also requested. Individual exposure time ranged from 1 to 21 (mean 8.8) years; subjects were currently exposed when studied.

Two control groups of subjects were also examined: Group I (urban controls) included 66 blood donors working in public health units (20 males and 46 females, aged 22–59; mean age 35 years); Group II (rural controls) consisted of 50 individuals (24 males and 26 females, aged 12–84 years; mean age 49 years), living in a rural environment and non-professionally exposed to poultry.

Lung Function Tests

Lung function tests were performed in exposed workers with a rotating vane spirometer (Cosmed Pony Spirometer, Rome, Italy) in the factory medical care facility.

Immunologic Studies

Atopic markers

The presence of atopy in workers and controls was evaluated by total IgE determination using a commercial immunoassay (Pharmacia Cap-System, Uppsala, Sweden) and the Phadiatop[®] Feia test (Pharmacia Diagnostics, Uppsala, Sweden) for the qualitative screening of common inhalant sensitization, according to the manufacturers' instructions.

Atopy was defined as the presence of total IgE $\geq$ 200 kU/L according to the cut-off value for adults established by our reference laboratory, and/or positivity to Phadiatop[®].

Specific IgE

Specific IgE determination was performed using a commercial immunoassay (Pharmacia Cap-System RAST Feia, Uppsala, Sweden). The environmental allergens tested were: *Dermatophagoides pteronyssinus* and *farinae*, the storage mites *Acarus siro*, *Lepidoglyphus destructor*, *Tyrophagus putrescentiae*, *Glycyphagus domesticus*, and the molds *Aspergillus fumigatus*, *Alternaria tenuis* and *Penicillium notatum*; the occupational antigens chicken feathers, egg white and yolk, ovalbumin, ovomucoid, and lysozyme were tested.

Precipitins

Precipitating antibodies were determined by double immunodiffusion against commercially available extracts of the same *Dermatophagoides*, storage mites and molds (Lofarma, Milan, Italy), egg white and yolk, ovalbumin, ovomucoid and lysozyme (Sigma Chemicals, St. Louis, MO), and crude extracts of chicken feathers, serum and litter, obtained from the egg processing factory. Egg white and proteins were dissolved in PBS 10 mM, pH 7.4, added with sodium chloride 0.9%, to the concentration of 20 mg/ml. Egg yolk was dissolved in isotonic saline, dialyzed against PBS for 96 hr, centrifuged at 8,000g for 30 min, and resuspended at the final concentration of 20 mg/ml. Chicken feathers and litter were dissolved in borate buffer 0.1 M, pH 9.4, at the concentration of 100 mg/ml, placed on a rotator at 4°C for 72 hr, and then centrifuged at 8,000g for 30 min. The supernatant was stored at –20°C. Chicken serum was obtained by centrifugation of blood at 1,600g for 10 min.

The test was performed in Veronal agar 1%, pH 8.6, in 100-mm Petri dishes, with a 3-mm depth of agar. Two hundred microliter of serum were tested in a central well measuring 13 mm in diameter, surrounded by six peripheral 5 mm- wells with 25 μ L of antigen. The distance between the centers of the serum and antigen wells was 5 mm.

The Petri dishes were held at room temperature for 72 hr, then washed with isotonic saline, and examined to identify precipitins. Positivity was graded as follows: 1 + when precipitins were present with undiluted serum, 2 + with a 1:2 dilution, 3 + with 1:4 dilution, and 4 + with 1:8 dilution or more. The titer corresponds to the highest serum dilution with visible precipitation lines.

Environmental Monitoring

Environmental monitoring of egg antigen concentrations was carried out with stationary samplers in two different workplaces, the egg sorting area and the egg breaking department, and seven personal samplers: three for egg sorters, three in the breaking area and one in the storage department. Two stationary samplers were placed in a room in our hospital and used as controls.

The air samples were collected on glass fiber or cellulose acetate filters by stationary samplers at a flow rate of 15–20 L/min for 3 hr at 22–24°C; personal pumps were run at a flow rate of 2 L/min. Filters were analyzed by RAST inhibition to determine the relative potency of the allergenic extract capable of inhibiting 50% of the maximal RAST binding of the positive sera pool. Filters were extracted in 1 ml of PBS pH = 7.2 containing NaN_3 0.1% under continuous stirring for 24 hr at 4°C. The suspension was centrifuged at 10,000g and the supernatant collected to prepare a series of dilutions in PBS in duplicate. Positive and negative sera pools for specific IgE to egg white were used as controls. The internal standard (lyophilized egg white) was reconstituted with deionized water and diluted in 0.15 M PBS, pH = 7.2 in geometric progression. Polystyrene beads measuring 6.4 mm in diameter with allergen bound and ^{125}I -anti-IgE reagent are included in the commercial RIA Sferikit® for specific IgE detection (Lofarma, Milan, Italy). The RAST inhibition assay was performed with 30 μL of each dilution transferred into plastic tubes added with 20 μL of the positive sera pool; the tubes were vortexed briefly and then incubated for 2 hr at room temperature. An allergen-coated bead was placed in each tube for 18-hr incubation at room temperature under gentle shaking. The solution was then aspirated from the bottom and the tubes were washed three times with NaCl 0.15 M + Tween 20 0.4%. Fifty microliter of ^{125}I -anti-IgE and 50 μL of PBS were added and the tubes were kept for 18 hr at room temperature under gentle shaking. After three washings, bound radioactivity was measured using a gamma-counter. The relative potency of the sample was expressed as the amount of allergenic extract capable of inhibiting 50% of the maximal RAST binding of the positive sera pool (in microliter). The inhibition rate was calculated according to the Yman formula [Yman et al., 1975]:

$$\frac{(\text{cpm positive control}) - (\text{cpm sample})}{(\text{cpm positive control}) - (\text{cpm negative control})} \times 100$$

Results were plotted on lin-log paper with dilutions on the log scale (horizontal axis) and inhibition rate on the lin scale (vertical axis). Linear regression lines were calculated taking into account only inhibition rates ranging from 10 to 90%. The test was considered valid if the correlation coefficient was 0.9 or more. The dose corresponding to the 50% inhibition rate (antilog) was calculated and expressed in microliter (C50). The allergenic potency of each sample was expressed as microgram of protein compared with the internal standard, with a protein content of 17,862 mg/ml of egg white, according to the following formula:

$$\frac{\text{Protein content of the standard}}{\text{C50 of sample/C50 of standard}}$$

The results were corrected for each filter according to the air volume sampled and expressed in microgram per cubic meter.

Statistics

The χ^2 test with two degrees of freedom was used for statistical evaluation, and a *P* value of less than 0.05 was considered significant.

RESULTS

Clinical Evaluation

The clinical history of the exposed workers showed that 5/77 subjects complained of respiratory diseases before employment in the factory: 2 had allergic asthma, 2 allergic rhinitis, and 1 chronic sinusitis; 3/5 were atopic with no work-related respiratory symptoms.

Respiratory function tests showed normal lung volumes in 60/77 (78%) workers, mild obstruction ($\text{FEV}_1 < 100\%$ and $> 70\%$ of predicted values) in 7 subjects, and moderate obstruction ($\text{FEV}_1 < 70\%$ and $> 50\%$ of predicted values) in one; 9 workers presented slightly reduced forced vital capacity [American Thoracic Society, 1991].

Clinical data regarding the controls revealed 16 subjects suffering from allergic diseases (rhinitis, or rhinitis plus asthma, allergic dermatitis, drug or insect sting allergy) in the first group and 10 in the second group.

Immunologic Studies

Atopic markers

Atopy determination showed $\text{IgE} \geq 200 \text{ kU/L}$ in 7/77 (9%) workers, 13/66 (20%) urban controls, and 8/50 (16%) rural controls. Phadiatop yielded a positive response in 11/77 (14%) exposed subjects, 16/66 (24%) urban controls, and 11/50 (22%) rural controls. Altogether, the atopic subjects

TABLE I. Pattern of Allergen Response in Specific IgE Positive Subjects

Allergen specificity	IgE positive workers; n = 27 (atopic = 10, not atopic = 17)	IgE positive controls I; n = 16 (atopic = 13, not atopic = 3)	IgE positive controls II; n = 19 (atopic = 10, not atopic = 9)	χ^2 ^a	Probability level
Environmental allergens	17 (63%)	16 (100%)	17 (89%)	10.20	< 0.01
Atopic	9	13	10		n.s. ^b
Not atopic	8	3	7		n.s. ^b
Occupational allergens	18 (66%)	5 (31%)	2 (11%)	15.34	< 0.001
Atopic	5	3	0	6.82	< 0.05
Not atopic	13	2	2	7.23	< 0.05

^a χ^2 test with two degrees of freedom.^bn.s., not significant.

numbered 13/77 (17%), 20/66 (30%), and 13/50 (26%) in the three groups, respectively, with no significant differences between groups.

Specific IgEs

Specific IgEs to one or more allergens were found in 27/77 (35%) workers, 16/66 (24%) urban controls, and 19/50 (38%) rural controls; the differences were not significant.

Table I shows the pattern of allergen response in specific IgE positive subjects. A response to environmental allergens was present in 17 workers (22%), 16 (24%) urban controls, and 17 (34%) rural controls, with no significant differences between groups. Specific IgEs to occupational allergens were more frequently found in workers, with 18/77 (23%) positive cases, compared with 5/66 (8%), and 2/50 (4%) in the control groups ($\chi^2 = 12.67$, $P = 0.00177$).

Among the IgE positive subjects, common inhalant positivity was observed more frequently in the two control groups, in 100 and 89% of subjects, respectively, than in workers (63%), the differences in both cases being significant. A specific response to occupational allergens was significantly more frequent in workers (66%), than in controls (31 and 11%, respectively). Workers reacting to common inhalants and to avian proteins were on the whole not

the same individuals. On correlating these patterns of response to atopic status, we found a prevalence of positivity to occupational antigens mainly in non-atopic workers; IgE positive controls in the urban group were prevalently atopic subjects reacting more frequently to environmental antigens. Specific IgE responses in rural controls were mainly directed against common inhalants regardless of atopic status.

Specific IgEs to occupational antigens were significantly prevalent in workers for egg white, ovomucoid, and lysozyme as compared with the two control groups (Table II).

IgEs to single storage mites and molds were more frequently present in controls than in workers, but the differences were not significant.

Considering the tasks of positive workers, we found that the majority of IgE positive subjects for the main sensitizing occupational antigens were employed in the egg breaking process, though no statistically significant differences were found (Table III).

Precipitins

Precipitating antibodies to at least one environmental or occupational antigen were more frequently found in workers (92%) than controls (76 and 70%, respectively) with

TABLE II. Prevalence of Specific IgE to Occupational Antigens

Antigens	Workers (n = 77)	Urban controls (n = 66)	Rural controls (n = 50)	χ^2 ^a	Probability level ^b
Egg white	18 (23%)	4 (6%)	2 (4%)	14.2	< 0.001
Egg yolk	1 (1.3%)	2 (3%)	0 (0%)	n.s.	n.s.
Ovalbumin	0 (0%)	2 (3%)	1 (2%)	n.s.	n.s.
Ovomucoid	7 (9%)	0 (0%)	0 (0%)	10.94	< 0.01
Lysozyme	8 (10%)	1 (1.5%)	0 (0%)	9.60	< 0.01
Chicken feathers	0 (0%)	0 (0%)	0 (0%)	n.s.	n.s.

^a χ^2 test with two degrees of freedom.^bn.s., not significant.

TABLE III. Positivity to the Main Occupational Antigens in Relation to the Different Tasks of Workers

Antigen	Positive subjects (n)	Occupational task			χ^2 ^b	Probability level ^b
		Egg sorting (26 workers) subjects (n)	Egg breaking (42 workers) subjects (n)	Other ^a (nine workers) subjects (n)		
Specific IgE						
Egg white	18	3 ^c	14	1	5.11	0.078 (n.s.)
Lysozyme	8	1	7	—		n.s.
Ovomucoid	7	2	5	—		n.s.
Precipitins						n.s.
Egg white	31	8	21	2		n.s.
Egg yolk	23	6	16	1		n.s.
Lysozyme	54	19	30	5		n.s.
Ovomucoid	10	3	7	0		n.s.
Chicken feathers	11	6	4	1		n.s.
Chicken serum	22	3	19	0	13.01	< 0.01
Chicken litter	32	11	16	5		n.s.

^aOther = storage/despatch, maintenance, quality control laboratory.^b χ^2 test with two degrees of freedom; n.s., not significant.^cPreviously employed in egg breaking.

significant differences between the groups ($\chi^2 = 11.31$, $P = 0.003494$).

Workers showed precipitin responses to common allergens, with significant differences for the storage mites *Lepidoglyphus destructor*, positive in 38% of workers, compared with 20% in urban controls and 6% in rural controls ($\chi^2 = 17.73$, $P = 0.00014$) and *Glycyphagus domesticus* specific reactivity, observed in 12, 3 and 2%, respectively ($\chi^2 = 6.63$, $P = 0.0363$). Practically none of the positive subjects were atopic.

Table IV shows the prevalence of precipitins to occupational antigens in exposed workers and controls. Egg processing workers exhibited particularly marked immune

reactivity to occupational antigens. The highest prevalences of positivity were found in response to lysozyme, egg white and yolk, chicken litter and serum; all urban controls and the majority of rural controls had negative responses to egg white and yolk, ovalbumin, ovomucoid and serum, with highly significant differences versus egg processing workers. For egg white and chicken serum, the workers also showed high positivity grades. The frequency of precipitins in response to chicken feathers was significantly higher in workers than in controls; 8 (16%) subjects belonging to the rural group also proved positive. The lysozyme response, though significantly prevalent in workers (70%), was also frequently present in the control groups (52 and 42%, respectively). In 16

TABLE IV. Prevalence of Precipitins to Occupational Antigens

Antigens	Workers (n = 77)	Urban controls (n = 66)	Rural controls (n = 50)	χ^2 ^a	Probability level
Egg white	31 (40%)	0 (0%)	1 (2%)	52.02	< 0.0001
Egg yolk	23 (30%)	0 (0%)	2 (4%)	32.92	< 0.0001
Ovalbumin	2 (3%)	0 (0%)	1 (2%)	n.s.	n.s.
Ovomucoid	10 (13%)	0 (0%)	1 (2%)	12.87	< 0.01
Lysozyme	54 (70%)	34 (52%)	21 (42%)	10.76	< 0.01
Chicken feathers	11 (14%)	1 (1.3%)	8 (16%)	8.55	< 0.05
Chicken serum	22 (29%)	0 (0%)	1 (2%)	33.96	< 0.0001
Chicken litter	32 (42%)	19 (29%)	14 (28%)	n.s.	n.s.

^a χ^2 test with two degrees of freedom.

n.s., not significant.

urban and 15 rural controls, precipitin responses to occupational antigens were detectable only against lysozyme. Chicken litter frequently caused precipitin positivity in the three study groups. Although this reactivity was prevalent in workers (42%), the differences were not significant in comparison with the control groups.

Precipitin positivity for egg white and yolk, lysozyme, ovomucoid, and chicken serum was prevalent in workers employed in the breaking area (Table III). A significant difference was found for chicken serum, which was positive in 19/42 workers employed in the egg breaking area, compared with 3/26 subjects working on egg sorting and none of the workers employed in other tasks.

Environmental Monitoring

The protein content of filter extracts obtained from the fixed and personal samplers in the different workplaces is reported in Table V. Different egg white concentrations were observed in the factory departments, being higher in the breaking area compared with the sorting zone using the fixed and personal samplers. The personal sample obtained from the storage department yielded a negative result, as did the two samplers used as controls (in hospital).

DISCUSSION

Occupational allergic diseases, such as asthma and extrinsic alveolitis, have been reported in subjects exposed to avian proteins [Reed et al., 1965; Berrens et al., 1986; Bernstein et al., 1987; Blanco Carmona et al., 1992]. Sensitization has already been demonstrated in symptomatic

and asymptomatic workers, by the presence of specific IgE, IgG, and precipitating antibodies [Edwards et al., 1983; Berrens et al., 1986; Bernstein et al., 1987; Berrens and Edwards, 1987].

In this study, we demonstrate that avian protein inhalation in the workplace can induce occupational sensitization in workers even in the absence of work-related allergic symptoms or diseases, particularly in subjects employed in higher exposure risk areas, as identified by environmental determination of egg antigens. The immune response showed a particular pattern with a high frequency of IgE to egg white, ovomucoid and lysozyme ($P < 0.01$) and precipitin positivity to egg white and yolk and chicken serum ($P < 0.0001$). Neither type of reactivity appeared to correlate with atopic status and both were higher in subjects employed in the egg breaking area, with a greater exposure to aerosolized egg components. The immune response thus appeared to be related to the environmental exposure risk.

The presence of IgE and precipitins to environmental and occupational antigens was also evaluated in 66 urban controls and in 50 members of a farming population, non-professionally exposed to avian antigens. The latter were included in the study, since some of the workers lived in a rural area and we believe that the possible influence of this environment in developing a specific response ought to be considered.

Specific IgEs

In our groups, specific IgE responses showed different positivity patterns when considering common environmental agents, which are probably also present in the workplace,

TABLE V. Egg White Protein Concentration in the Air Sampling Filters and Environmental Air of Different Areas of the Factory

Filter ^a	Sorting area			Breaking area			Storage/despatch		
	C50 ^b (μl)	μgeq ^c	μgeq/m ^{3d}	C50 (μl)	μgeq ^c	μgeq/m ^{3d}	C50 (μl)	μgeq ^c	μgeq/m ^{3d}
A				0.334	133.69	37.13			
B				0.521	85.71	25.5			
C							45.2	0.79	0.29
D							—	—	Neg
1							—	Neg	—
2				0.679	65.76	150.82			
3				0.89	50.17	115.59			
4				1.834	24.34	202.83			
5	35.324	1.011	2.88						
6	62.125	0.575	1.64						
7	9.585	3.727	10.64						

^aA,B,C,D: fixed samplers; 1–7: personal samplers.

^bDose corresponding to 50% inhibition rate.

^cProtein content of the sample.

^dProtein content per cubic meter of air.

and specific occupational antigens. Sensitization to environmental antigens did not differ in workers as compared with controls when considering all subjects. A similar result was also obtained by Rees et al. [1998] who examined a group of 134 poultry workers in South Africa. In our series, RAST positivity to environmental allergens was significantly prevalent in controls, and was more frequent, though not significantly so, in atopic subjects.

Specific IgEs to occupational antigens showed a significant prevalence in workers when considering egg white and its proteins—ovomucoid and lysozyme—unrelated to atopic status. These two egg proteins represent, together with ovalbumin and ovotransferrin, 80% of the protein content of egg white. The lower prevalence of the IgE response to protein fractions of egg white than to whole albumen in our population could be due to sensitization to other proteins not analyzed, such as conalbumin [Bernstein et al., 1987].

In our study, the IgE determination for ovalbumin was negative. This protein has been shown to be a weak immunogen in inducing precipitins and IgG reactivity by inhalation, according to Berrens and Edwards [1987]. On the other hand, Bernstein et al. [1987] described a strong IgE response to ovalbumin and ovomucoid in four asthmatics with occupational sensitization to inhaled egg proteins. One of them also showed a response to lysozyme, which is an allergen of little importance in determining IgE responses [Langeland, 1982], although it may cause occupational asthma by inhalation in the workplace [Bernstein et al., 1993].

In our subjects, atopic status was not a risk factor in developing specific IgEs to occupational antigens; this observation is in agreement with other studies [Edwards et al., 1983; Bernstein et al., 1987; Smith et al., 1990].

The substantial prevalence of positivity in workers in the egg breaking area, where an elevated allergen concentration was found, shows that a higher level of exposure increases the risk of sensitization.

Precipitins

Precipitins were more frequently positive in workers; those directed against the environmental antigens *Lepidoglyphus* and *Glycyphagus* were significantly prevalent in the working group, suggesting that this workplace is a natural habitat for storage mites.

Precipitins to egg white and yolk, ovomucoid, lysozyme, chicken serum, and feathers were significantly prevalent in workers compared with the two control groups. This sensitization correlated with occupational exposure and was prevalent in the egg breaking area.

Elevated specific IgG responses to whole egg, lysozyme, and conalbumin had also been demonstrated in symptomatic and asymptomatic egg factory workers [Bernstein

et al., 1987]. The low reactivity to ovalbumin in our group was also observed by Edwards et al. [1983] and Berrens and Edwards [1987].

In our study, an appreciable number of workers showed precipitins to egg yolk, albumen, and chicken serum: the latter two antigens also gave rise to intense bands of precipitation. Considering the low prevalence of responses in rural controls (only two subjects), it would appear that non-professional exposure to these antigens does not induce precipitin production.

Various authors have found that a specific humoral response to egg yolk and feathers correlates with the presence of avian serum proteins in these components. Berrens et al. [1986] described inter-species cross-reactivity between pigeon serum proteins and water soluble proteins found in hen's egg yolk. Edwards et al. [1983] found subjects with precipitins to egg yolk, but negative to egg white, thus confirming different antigenic patterns in these components. Berrens et al. [1986] demonstrated the presence of antibodies to serum proteins in a group of pigeon breeders. A specific IgE response to hen's feathers, yolk, and serum proteins was found in a woman sensitized to a parrot kept as a household pet. This subject had specific IgE to egg yolk and avian serum, but was negative to egg white. Precipitin determination for these antigens yielded negative results [De Maat-Bleeker et al., 1985]. Other authors have also found a different pattern of specific IgE reactivity, thus distinguishing between a response to yolk and feathers, observed in adults with bird-egg syndrome, and egg white sensitization prevalent in children with food allergy without airway exposure [Szeffalusi et al., 1994].

In our findings, though IgE to chicken serum was not determined, the response to feathers and yolk was characterized by precipitins and 18 workers reacted to both serum and yolk, in agreement with previous observations [Berrens and Edwards, 1987].

Positive immunodiffusion tests for chicken litter were found in a large proportion of workers, but also in controls. These findings are in agreement with the results reported by Rees et al. [1998]. This may be due to the variety of proteins present in the birds' droppings, including bacterial contaminants [Thelin et al., 1984] and serum proteins; cross-antigenicity between sera of various avian species has, in fact, been demonstrated [Faux et al., 1971]. These components may account for the high frequency of immune reactivity to litter. Moreover, precipitins to lysozyme, a thermolabile component of egg white, were found in a large number of workers and controls, though the prevalence was significant only in the former. A similar response was also observed by Bernstein et al. [1987], and is probably due to the extensive use of this enzyme in various commercial products and as a food additive [Fremont et al., 1997].

In conclusion, our investigation shows that occupational exposure to avian proteins can lead to specific immune

responses to inhaled egg and poultry antigens in asymptomatic egg processing factory workers.

Environmental Monitoring

IgE positivity to egg white, ovomucoid and lysozyme, and the presence of precipitins to albumen, yolk, and chicken serum appear to be strongly related to professional inhalation. Atopic status and the local environment did not appear to be significant risk factors in developing sensitization, while specific antibody production seems to be favored by the kind of job held, being higher for egg breaking and separation of egg components where a greater dispersion of egg proteins was confirmed by environmental monitoring of antigen concentrations.

Although the precise predictive value of this positivity and the risk of developing occupational respiratory symptoms are not known, these results suggest that occupational antigenic concentrations in the workplace should be reduced by means of efficient exhaust ventilation or a closed-circuit work system, particularly in the egg breaking area. Thorough clinical monitoring by periodic evaluation of asymptomatic subjects, particularly those with specific IgE or high levels of precipitins to occupational antigens, is also advisable in order to detect any early signs of work-related disease.

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