

Interpreting skin prick tests in the evaluation of food allergy in children

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Background. Skin prick tests (SPTs) are utilized routinely in the evaluation of food allergy and several authors have discussed their utility. Efforts to standardize SPT reagents and procedures have been made, but the accuracies of different recording techniques have not been clearly defined. The aim of this study was to compare different SPT recording methods with the outcome of oral food challenge and determine whether they offer any advantage over the criteria proposed by Bock and May (1).

Patients and methods. Children suspected of IgE-mediated symptoms to any of five common food allergens (egg, milk, peanut, soy and wheat) were skin tested by the prick technique utilizing commercial extracts. The wheal reactions were recorded by two different methods: first by measuring the largest diameter of the wheal and the diameter orthogonal to it (mean wheal diameter), and second by recording the surface area of the wheal with a hand-held scanner. Wheal sizes above the 95% confidence interval of tolerant individuals were considered positive. The results of double-blind, placebo-controlled food challenges were considered the “gold standard” for diagnosis. Cut-off values were compared for positive responses in our study population (mean diameter/surface area of wheal): 4 mm / 16 mm² for egg, 5 mm / 29 mm² for milk, 6 mm / 40 mm² for peanut, 3 mm / 9 mm² for soy, and 3 mm / 7 mm² for wheat.

Results. Significant differences in wheal sizes were seen between individuals who were allergic or tolerant to egg ($P < 0.001$), milk ($P < 0.001$), wheat ($P < 0.005$), and peanut ($P < 0.05$). Reactivity to soy could not be predicted based on SPT results ($P = \text{n.s.}$). The sensitivities and the specificities of the two recording methods were similar. The predictive values were not significantly different from that of the commonly utilized method of grading SPTs (i.e. positive = mean diameter 3 mm or greater than the negative control).

Conclusions. Skin prick tests are a useful procedure for evaluating clinical reactivity to egg, milk, peanut and wheat, but not to soy. While the size of the SPT wheals may be interpreted utilizing mean diameter or surface area cut-offs, the predictive values of these measurement methods were no better than the commonly utilized grading method where a positive skin test was recorded as a mean wheal diameter 3 mm greater than the negative control.

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Double-blind, placebo-controlled food challenges (DBPCFC) are considered the gold standard for diagnosing food hypersensitivity. However, these challenges can be time consuming. Consequently, reliable screening tests are needed for the preliminary assessment of reactivity to food antigens and to provide guidance for selecting foods for DBPCFCs. Skin prick tests (SPTs) are routinely used for initial diagnostic screening in patients suspected of food allergies. Multiple SPTs can be performed rapidly and therefore recording methods that could provide high predictive accuracies for clinical reactivity would be extremely useful.

Standardization of skin prick testing methods has contributed to an increased reliability of this diagnostic procedure, now widely utilized in all age groups (1). However, the precision of SPTs is limited by an apparent variability of sensitivity and specificity to different food antigens, and by the low positive predictive accuracies when used as a screening test in a general allergic population (2, 3). Furthermore, several different methods of interpreting SPTs are employed and their value in predicting food allergic reactions remain to be determined. The results of food allergen SPTs are generally recorded as positive when the mean diameter of the wheal is 3

Table 1. Number of tolerant or clinically reactive patients with positive and negative SPT to the different foods tested.

	egg		milk		peanut		soy		wheat	
	-	+	-	+	-	+	-	+	-	+
	DBPCFC	DBPCFC	DBPCFC	DBPCFC	DBPCFC	DBPCFC	DBPCFC	DBPCFC	DBPCFC	DBPCFC
Mean diameter										
+ SPT	7	39	9	31	9	16	13	16	12	18
- SPT	11	1	19	4	8	2	13	9	10	3
		p < 0.001		p < 0.001		p = 0.05		p = n.s.		p < 0.001
Total	18	40	28	35	17	18	26	25	22	21
Surface area										
+ SPT	6	39	7	27	9	16	9	12	7	17
- SPT	12	1	21	8	8	2	17	13	15	4
		p < 0.001		p < 0.001		p = 0.05		p = n.s.		p < 0.005
Total	18	40	28	35	17	18	26	25	22	21

DBPCFC: Double-blind, placebo-controlled food challenge

mm or greater than the negative control. However, this method may not sufficiently reflect the actual size of wheals with irregular shapes and/or pseudopods. Other methods of reporting skin test results have been proposed, among them the measurement of the blood flow in the wheal by Laser Doppler flowimetry (4), or the measurement of wheal surface area by planimetry (5). The relative complexity of both these methods has limited their application primarily to research protocols. However, scanning the surface area of a wheal may represent a reliable and easy recording method which would better account for wheals with irregular shapes.

This study was designed to re-evaluate the reliability of SPTs to predict clinical reactivity to five common food allergens and to compare two methods of measuring skin tests for predicting clinical reactivity in a defined population: 1) measuring the largest diameter of the wheal and the diameter orthogonal to it or 2) recording the surface area of the wheal with a hand-held scanner.

Patients and methods

Design of the study

Data on SPTs for this case-control study were obtained from children with atopic dermatitis suspected of IgE-mediated allergies to egg, milk, peanut, soy, and/or wheat who were admitted to the Clinical Research Center for evaluation of food allergies between 1991 and 1995. Further characteristics of this population have been described previously (6). SPT data were obtained only from patients who had adequately recorded wheals. The number of children

skin tested to each antigen is presented in Table 1. Clinical reactivity to foods had to be confirmed either by a positive DBPCFC or a "convincing history" of a recent anaphylactic reaction.

Procedures

Most SPTs were performed by the same research nurse, reducing the risk of variations inherent the technique of different examiners. Skin prick tests were generally performed on the patient's back, but were occasionally placed on the volar surface of the forearm. Due to the large number of skin prick tests performed within a routine diagnostic procedure, the tests were not performed in duplicates. Glycerinated food extracts (1:20) (Greer Laboratories, Lenoir, NC) were pricked into the superficial layer of the skin with a bifurcated needle (Wyeth needle, Allergy Laboratories, Columbus, Ohio). A positive control with histamine (10 mg/ml), and a negative control were placed with each series of SPTs. Results of the skin tests were recorded after 15 minutes by outlining the edges of the wheal with a fine-tipped pen and transferring the line with adhesive tape onto paper for a permanent record. Two different techniques for measuring the size of the wheal were utilized. First, the mean diameter of the wheal was reported by measuring the greatest diameter of the wheal and the largest diameter perpendicular to it and then averaging the sum of the diameters (hereafter denoted as "mean diameter"). Second, the area of the wheal was determined by scanning the transferred record of the wheal with the New Genius Scanner 4500 (KYE Systems Corp., Taipei, Taiwan). Calculation of the area was performed by the

SPT Scan Software (7), with coefficient of variation of < 2%. The measurements are reported in square millimeters. The SPTs were interpreted as negative when the mean diameter or the surface area was less than the upper 95% confidence interval of subjects with negative DBPCFC to the study food. All wheal sizes greater than this cut-off point were interpreted as positive. The positive predictive accuracy was defined by the following formula:

$$v = \frac{sP}{sP + (1-f)(1-P)},$$

and the negative predictive accuracy by the formula:

$$g = \frac{f(1-P)}{f(1-P) + (1-s)P}$$

where s = sensitivity (true positives / total number of tests), f = specificity (true negatives / total number of tests) and P = prevalence.

DBPCFCs were performed as previously described (8). The challenges consisted of administering up to 8 to 10 g of dehydrated, powdered food camouflaged in juices or solid foods over a 60 to 90 minute period. A challenge was considered "positive" when objective cutaneous, upper or lower respiratory or gastrointestinal symptoms developed within 2 hours of the oral challenge. All negative DBPCFCs were confirmed by feeding the food openly in a usual portion under observation. According to guidelines, patients with a "convincing" history of an anaphylactic episode within the previous two years were not challenged to the incriminated food (2, 3). Positive challenges elicited skin symptoms in 76%, gastrointestinal symptoms in 50% and upper or lower respiratory symptoms in 44% of the patients. Based on these challenges, the prevalences of allergic reactivity to the challenge foods were as follows: egg, 69%; milk, 56%; peanut, 51%; soy, 49% and wheat, 49% (Table 1).

Statistical analysis

The Fisher's exact test was utilized for statistical analysis of wheal sizes in clinically reactive patients or tolerant control subjects. The predictive value for the two SPT recording methods were compared by the McNemar test for paired alternatives.

Results

The mean wheal size diameters are depicted in Figure 1, and the surface area in Figure 2. A wide range of wheal sizes was obtained to most foods with both

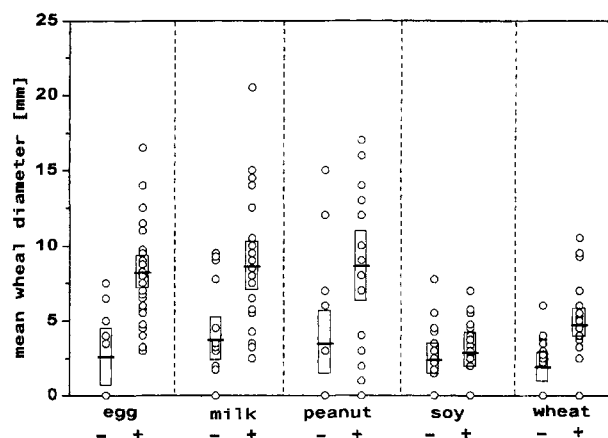


Fig. 1. Mean diameter of the wheal elicited by prick skin tests to five different food extracts in patients with or without clinical reactivity (challenge + or challenge -). The bars represent the means and the rectangles the 95% confidence intervals.

recording methods. As a result, the 95% confidence intervals were overlapping in patients with positive or negative DBPCFCs to soy and wheat. Positive SPTs were recorded in patients with negative DBPCFCs, and similarly negative SPTs in patients with positive DBPCFCs to peanut, wheat, or soy. For each test food, we defined the results of SPTs as positive only when the size of the wheal exceeded the upper 95% confidence interval for food-tolerant subjects. When the wheals were recorded utilizing the mean diameter, the positive cut-off levels were as follows: egg, 4 mm; milk, 5 mm; soy, 3 mm; wheat, 3 mm; and peanut, 6 mm. When the surface area was measured, the 95% confidence cut-off levels were as follows: egg, 16 mm²; milk, 29 mm²; soy, 9 mm²; wheat, 7 mm²; and peanut, 40 mm².

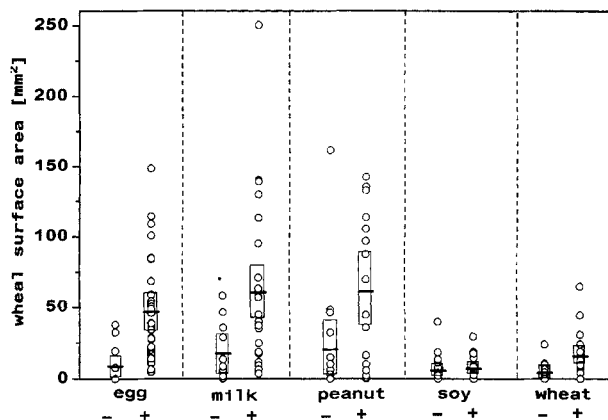


Fig. 2. Surface area of the wheal elicited by prick skin tests to five different food extracts in patients with or without clinical reactivity (challenge + or challenge -). The bars represent the means and the rectangles the 95% confidence intervals.

Table 2. Sensitivity, specificity and predictive indices calculated by recording prick skin tests to egg, milk, peanut, soy and wheat by the mean diameter of wheals, the surface area or by interpreting a mean diameter equal or superior to 3 mm as positive

Antigen (prevalence)	Statistical parameter	Wheal by mean diameter	Wheal by surface area	Wheal by diameter ≥ 3 mm
Egg (69%) n = 58	s	0.98	0.98	1.0
	f	0.61	0.67	0.61
	v	0.85	0.87	0.85
	g	0.93	0.94	1.0
Milk (56%) n = 63	s	0.89	0.77	0.94
	f	0.68	0.75	0.46
	v	0.78	0.80	0.69
	g	0.83	0.72	0.86
Peanut (51%) n = 35	s	0.63	0.71	0.80
	f	0.71	0.69	0.47
	v	0.69	0.70	0.61
	g	0.65	0.70	0.69
Soy (49%) n = 51	s	0.64	0.48	0.60
	f	0.50	0.65	0.53
	v	0.55	0.57	0.55
	g	0.59	0.57	0.58
Wheat (49%) n = 43	s	0.86	0.80	0.81
	f	0.45	0.68	0.64
	v	0.60	0.71	0.68
	g	0.70	0.78	0.78

s = sensitivity; f = specificity; v = positive predictive accuracy; g = negative predictive accuracy.

The number of true positive and true negative SPTs for each recording method were determined for each food in clinically tolerant or reactive patients according to the cut-off values determined in our study population (Table 1). Significant differences in SPT results were seen to egg, milk, peanut and wheat by both measurement methods ($P < 0.005$ for egg, milk, and wheat; $P < 0.05$ for peanut). However, neither recording method could discriminate positive responses to soy ($P = \text{n.s.}$).

Sensitivity, specificity, positive and negative predictive accuracies were calculated for both wheal size recording methods (Table 2). The measurement of the mean diameter provided the optimal sensitivity for all foods except peanuts. Sensitivities obtained with this method were greater than 0.85 for SPTs to egg, milk, and wheat. The specificity was slightly better utilizing the measurement of the surface area, but overall this method provided lower sensitivities to all foods except egg (below 0.80). Taken together, the sensitivities of SPTs by both recording methods were good to egg, milk and wheat and acceptable to peanut and soy, whereas the specificity of SPT results to all foods fell in a somewhat lower range (between 0.45 and 0.75). The predictive value was similar by both recording methods. However, the determination of positive and negative predictive accuracies depends upon the prevalence of

reactivity to a given food in the population studied, which in our population was high: egg (69%), milk (56%), peanut (51%), soy (49%), and wheat (49%). If the prevalence of food allergy in a more typical pediatric population was considered (approximately 2 to 5%), the positive predictive accuracies would be much lower (less than 5% for all foods).

The McNemar test for paired alternatives was used to compare the SPT recording methods. The methods were found to be comparable for evaluating five foods ($P = \text{n.s.}$), whereas the method of measuring the mean diameter was found to be more accurate in patients with clinical reactivity to egg ($P < 0.05$).

Discussion

Following the clinical history, skin testing is utilized as a first-line procedure in the evaluation of IgE-mediated food allergy. In this study, the value of SPTs in diagnosing allergy to five common food allergens was re-evaluated and the accuracies of two different methods of SPT interpretation were compared.

Skin prick testing has been utilized for many years to detect food sensitivity, although it is known that the results of SPTs frequently do not correspond to clinical expression of disease. In an effort to better correlate SPTs with clinical hypersensitivity, Bock, *et al.*, compared the results of SPTs with the outcome of DBPCFCs in patients with asthma and food allergy (1). Approximately one half of the patients who had a positive skin test to peanut or egg also had a positive DBPCFC. These authors concluded that results of SPTs had to be validated by DBPCFC, especially in younger children (9). Correlations between SPTs, specific IgE antibody measurements and the results of DBPCFCs to eight common food antigens were evaluated by Sampson, *et al.* in a population of children with atopic dermatitis and food hypersensitivity (3). The specificity was approximately 75% for both tests compared to the results of DBPCFCs. Notably, the accuracy of SPTs and RASTs varied slightly depending upon which food antigen was being studied. This study also indicated that although skin testing was a very reliable diagnostic procedure for excluding IgE-mediated food hypersensitivity, its positive predictive accuracy in children with food hypersensitivity was limited. Accepting these limitations, SPTs remain a useful screening procedure in food hypersensitivity (10, 11).

Efforts to improve the diagnostic accuracy of skin prick testing have focused mainly on the quality of the food extracts utilized and standardizing the technical aspects of skin testing. Another area to be addressed is the interpretation method employed in skin testing. Most investigators interpret the wheal

and flare results as positive when the diameter of the wheal exceeds that of the negative control by 3 mm. However, Lessof, *et al.* showed that this technique has its limitations, with the cut-off point for significance varying from 3 to 5 mm, according to the food tested (12). A value of 3 to 4 mm was found to be a reliable cut-off for milk and egg, while patients without reactivity to nuts had positive skin tests with a wheal diameter up to 4 mm. Similarly, some patients with wheals of 3 to 4 mm to fish had no history of reactivity to this food.

In this study, cut-off points for positivity were established as the upper 95% confidence interval calculated from the wheal size obtained in patients with negative DBPCFCs. When measuring the mean wheal diameter in this population, similar values to those reported by Lessof, *et al.* (12) were found: egg, 4 mm; milk, 5 mm; soy, 3 mm; wheat, 3 mm and peanut, 6 mm. No overlap was seen within the 95% confidence interval of SPT results between patients who were tolerant or allergic to egg, milk and peanut. It should be noted that these cut-off values are applicable only to patient populations similar to those in our study (young children with atopic dermatitis) and may differ in other populations. Furthermore, results are likely to vary depending on the quality of the extract used for skin prick testing. Statistical analyses confirmed that SPTs to soy could not predict reactivity in our patients. Similarly, a low predictive efficiency index of soy SPT extracts was found in previous studies (2). This finding re-emphasizes the need to develop better soy extracts for obtaining increased SPT reliability. Currently, a definite diagnosis of soy sensitivity must rely on DBPCFCs. The best discriminatory values of SPT results between tolerant and allergic patients were seen with milk ($P < 0.001$) egg ($P < 0.001$) and wheat ($P < 0.005$). Several patients tolerant to peanuts had quite large SPTs, probably due to cross-reactivity with other legumes (13), resulting in a lower discriminative value for SPTs to this food ($P < 0.05$). Skin prick test results to a food antigen which cross-react with members of the same family must be interpreted with caution, since false positive results are frequently observed. Similar observations have been noted in previous studies on legumes and fishes (14, 15). When SPTs with commercial extracts are negative despite a highly suggestive history of clinical reactivity, the prick-prick technique with fresh foods, or possibly other sources of commercial extracts, should be used (16).

The wide variety of SPT techniques prompted several allergy societies to recommend standardized testing procedures (17–21). Recommendations emphasized the importance of standard concentrations of antigen extracts, use of positive and negative controls, proper pricking techniques, and appropriate

reading times (22). Wheal size recording methods such as planimetry, or laser Doppler flowimetry have been demonstrated to be highly accurate, but are generally impractical in the clinical setting (4, 5). Recording the size of wheals with a hand-held scanner has been shown to be an accurate method of measuring SPT wheals (7, 23), but its usefulness in the interpretation of skin tests in food hypersensitivity needs to be demonstrated.

In this study, we recorded SPT results as mean wheal diameters (mean of the longest diameter and the diameter perpendicular to it) and as surface area of the wheal. The distribution of wheal sizes and the accuracies of SPTs to predict clinical reactivity to five common food antigens (egg, milk, peanut, soy, and wheat) by either method were similar for both methods (Figs. 1 and 2 and Table 1). Minor differences were seen when the sensitivity or the specificity of the SPT recording methods was calculated (Table 2). As reported previously, sensitivities were better than specificities, and again these parameters were best with egg, milk, and wheat extracts and acceptable with peanuts. The relatively good positive predictive accuracies reported here largely reflect the high prevalence of food allergy in our population. These values would be much lower in a general pediatric population where the prevalence of food allergy is much lower.

It is generally accepted that a mean wheal size 3 mm or greater than the negative control is suggestive of food allergy (1). Using this criteria, we compared the accuracy indices for this method with those of the two methods employed in our study population. The sensitivities of SPTs to most foods were comparable in all scoring methods. However, there was a slight increase in specificity to milk and peanut utilizing either measurement method (Table 2). Overall, the predictive values of either measurement method was no better than the standard method of interpreting positive skin tests as those with a mean wheal diameter greater than 3 mm. In milk allergic patients, the predictive value of the 3 mm cut-off gradation method was superior to either test method evaluated in this study ($P < 0.005$); versus the measurement of the surface area).

In conclusion, skin prick testing can be recommended only as a useful screening test for predicting clinical reactivity to egg, milk, wheat and peanut. For comparing methods of recording skin test results, cut-off values for positive responses were considered the value exceeding the upper 95% confidence interval of responses in tolerant subjects. These values were used in our study population to compare the different SPT recording methods, but might not be utilized in a different population to predict food sensitivity. Caution must be exercised when interpreting SPTs to peanut in patients with

allergies to other legumes, since SPTs may be falsely positive. This is likely true for SPT results to other potentially cross-reacting food allergens. Skin prick testing with soy extracts could not discriminate between tolerant and allergic patients and therefore DBPCFCs may be the only reliable procedure for diagnosing soy sensitivity. Finally, both recording methods (measurement of the mean diameter or scanning of the surface area) were found to be equally reliable, and provided similar predictive indices when compared to a commonly utilized method of interpretation. Therefore, these methods may be used for grading wheal sizes obtained by SPTs to foods.

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References

1. BOCK SA, BUCKLEY J, HOLST A, MAY CD. Proper use of skin tests with food extracts in diagnosis of hypersensitivity to food in children. *Clin Allergy* 1977; 7: 375-83.
2. SAMPSON HA. Comparative study of commercial food antigen extracts for the diagnosis of food hypersensitivity. *J Allergy Clin Immunol* 1988; 82: 718-26.
3. SAMPSON HA, ALBERGO R. Comparison of results of skin tests, RAST, double-blind, placebo-controlled food challenges in children with atopic dermatitis. *J Allergy Clin Immunol* 1984; 74: 26-33.
4. SERUP J, STABERG B. Quantification of wheal reactions with laser doppler flowimetry. *Allergy* 1985; 40: 233-7.
5. SUSSMAN GL, HARVEY RP, SCHOCKET AL. Evaluation of skin test response using two techniques of measurement. *Ann Allergy* 1982; 48: 75-7.
6. EIGENMANN PA, SAMPSON HA. An update on food hypersensitivity. *Fund Clin Immunol* 1994; 2: 121-33.
7. POULSEN LK, LIISBERG C, BINDSLEV-JENSEN C, MALLING HJ. Precise area determination of skin-prick tests: validation of a scanning device and software for a personal computer. *Clin Exp Allergy* 1993; 23: 61-8.
8. BOCK SA, SAMPSON HA, ATKINS FM, et al. Double-blind, placebo-controlled food challenge (DBPCFC) as an office procedure: A manual. *J Allergy Clin Immunol* 1988; 82: 986-97.
9. BOCK SA, LEE WY, REMIGIO LK, MAY CD. Studies of hypersensitivity reactions to foods in infants and children. *J Allergy Clin Immunol* 1978; 62: 327-34.
10. MÉNARDO JL, BOUSQUET J, RODIÈRE M, ASTRUC J, MICHEL FB. Skin test reactivity in infancy. *J Allergy Clin Immunol* 1985; 75: 646-51.
11. ATKINS FM, STEINBERG SS, METCALFE DD. Evaluation of immediate adverse reactions to foods in adult patients. I. Correlation of demographic, laboratory, prick skin test data with response to controlled oral food challenges. *J Allergy Clin Immunol* 1985; 75: 348-55.
12. LESSOF MH, BUISSERET PD, MERRETT J, MERRETT TG, WRAITH DG. Assessing the value of skin prick tests. *Clin Allergy* 1980; 10: 115-20.
13. EIGENMANN PA, BURKS AW, BANNON GA, SAMPSON HA. Identification of unique peanut and soy allergens with adsorbed human sera. *J Allergy Clin Immunol* 1996; 98: 969-78.
14. BERNHISEL-BROADBENT J, SCANLON SM, SAMPSON HA. Fish hypersensitivity. I. *In vitro* and oral challenge results in fish-allergic patients. *J Allergy Clin Immunol* 1992; 89: 730-7.
15. BERNHISEL-BROADBENT J, TAYLOR S, SAMPSON HA. Cross-allergenicity in the legume botanical family in children with food hypersensitivity. II. Laboratory correlates. *J Allergy Clin Immunol* 1989; 84: 701-9.
16. ORTOLANI C, ISPANO M, PASTORELLO EA, ANSALONI R, MAGRI GC. Comparison of results of skin prick tests (with fresh foods and commercial food extracts) and RAST in 100 patients with oral allergy syndrome. *J Allergy Clin Immunol* 1989; 83: 683-90.
17. DREBORG S. Skin tests used in type I allergy testing. Position paper. 2. Methods for skin testing. *Allergy* 1989; 44 Suppl 10: 22-30.
18. BERNSTEIN IL. Proceedings of the task force on guidelines for standardizing old and new technologies used for the diagnosis and treatment of allergic diseases. *J Allergy Clin Immunol* 1988; 82: 487-526.
19. POSITION STATEMENT. Skin testing and radioallergosorbent testing (RAST) for diagnosis of specific allergens responsible for IgE-mediated diseases. *J Allergy Clin Immunol* 1983; 72: 515-7.
20. THE COMMITTEE ON SKIN TEST STANDARDIZATION OF THE NETHERLANDS SOCIETY OF ALLERGOLOGY. Report on skin test standardization. *Clin Allergy* 1988; 18: 305-10.
21. BRUIJNZEEL-KOOMEN C, ORTOLANI C, AAS K, et al. Adverse reactions to food. European Academy of Allergology and Clinical Immunology Subcommittee. *Allergy* 1995; 50: 623-35.
22. DREBORG S. Skin tests in the diagnosis of food allergy. *Pediatr Allergy Immunol* 1995; 6 Suppl 8: 38-43.
23. PIJNBORG H, NILSSON L, DREBORG S. Estimation of skin prick test reactions with a scanning program. *Allergy* 1996; 51: 782-8.