Symptoms of Hypoglycemia in Children With IDDM

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OBJECTIVE — To examine the symptoms of hypoglycemia in children with insulin-dependent diabetes, from the perspective both of the child and of the child's parents, and to compare the symptom reporting of the diabetic children with that of adult diabetic patients.

RESEARCH DESIGN AND METHODS — Interviews were conducted with 100 parents and 43 of their children. The frequency and intensity of symptoms of hypoglycemia were documented using a structured interview and classified into groups using Principal Components Analysis (PCA).

RESULTS — Diabetic children and their parents showed close agreement concerning the relative frequency and the intensity of symptoms reported. PCA of the symptom reports showed that diabetic children and their parents identified the same distinct subgroups of hypoglycemia-related symptoms: behavioral disturbance and autonomic-neuroglycopenic subgroups.

CONCLUSIONS — Hypoglycemic symptoms in children with diabetes clearly differ from those experienced by insulin-treated adults and, in particular, include behavioral changes as primary features of a low blood glucose. These observations have important implications for parental education on hypoglycemia.

The symptoms of hypoglycemia that adults with insulin-treated diabetes experience have been allocated objectively into specific subgroups using multivariate statistical analyses of patients' reported symptoms (1–3). This has identified 11 key hypoglycemic symptoms, which segregate into three reliable and valid subgroups: autonomic (sweating, palpitations, shaking, and hunger), neuroglycopenic (confusion, drowsiness, odd behavior, speech difficulty, and incoordination), and nonspecific malaise (nausea and headache). These subgroups can be applied using the Edinburgh Hypoglycemia Scale (EHS) (3). It is not known whether hypoglycemic symptoms experienced by children with insulin-dependent diabetes mellitus (IDDM) conform to this classification. The present study examined the latent structure of hypoglycemic symptoms experienced by diabetic children and observed by their parents.

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EHS, Edinburgh Hypoglycemia Scale; IDDM, insulin-dependent diabetes mellitus; PCA, Principal Components Analysis.

RESEARCH DESIGN AND METHODS

— Parents of IDDM children (n = 100) were recruited during routine attendance at the pediatric diabetes clinic. The children's median (range) age was 10.3 (1.5–16.0) years with a diabetes duration of 4.0 (0.25–13.0) years, an insulin dose of 0.93 ± 0.32 U/kg (mean ± SD), and total glycated hemoglobin (HbA_1) of 10.4 ± 1.4%. Twenty-three recognized symptoms of hypoglycemia were compiled from published reports (1–7). One parent of each child was asked to indicate the symptoms that they usually observed in their child when they thought the child to be hypoglycemic and to estimate their usual intensity using a 7-point scale (1 = symptom not present, 7 = very intense). Two unrelated symptoms (itching and hiccups) were included in the questionnaire. Where it was practical, similar questions (excluding those of pallor and bed-wetting) were presented to the children, who were interviewed separately from their parents. Symptoms were described as experienced at the time of the study. The 43 children completing the symptom profile had a median age of 11.4 (range 3.0–16.0) years, diabetes duration of 4.5 (0.3–12.0) years, and an insulin dose of 1.0 ± 0.3 U/kg and total HbA_1 of 10.5 ± 1.4%.

Statistical analysis

The parents' and children's ratings of the frequency with which a symptom occurred and their relative intensities were compared using Spearman's rank correlation. Principal Components Analysis (PCA), followed by varimax rotation, was used to discover the latent structure within the hypoglycemia symptom reports of children and their parents. PCA allows an aggregation of those variables

Table 1—*Parental observations: frequency of individual symptoms reported, their mean intensity, and the correlation with the symptoms reported by the children*

Symptom	Frequency (%)	Mean intensity	r	P	FPC	Factors 1	2	3
Poor concentration	69	3.5	0.31	<0.05	**0.58**	**0.49**	0.30	0.12
Tearfulness	74	4.0	0.43	<0.05	**0.45**	**0.45**	**0.32**	−0.29
Tummy pain	43	2.5	0.55	<0.05	**0.38**	**0.53**	0.03	−0.18
Irritability	73	4.6	0.50	<0.05	**0.55**	**0.63**	−0.01	0.24
Argumentative	69	3.8	0.70	<0.05	**0.58**	**0.69**	−0.06	0.27
Naughty	40	2.4	0.49	<0.05	**0.53**	**0.65**	0.04	0.00
Nightmares	20	1.5	0.19	0.22	**0.36**	**0.38**	0.22	−0.22
Aggressive	64	3.8	0.47	<0.05	**0.67**	**0.64**	0.11	**0.40**
Confusion	60	3.2	0.23	0.14	**0.58**	**0.51**	0.23	0.19
Bed wetting	10	1.3	—	—	**0.42**	**0.47**	0.21	−0.25
Trembling	64	3.4	0.44	<0.05	0.30	0.02	**0.44**	0.09
Sleepiness	67	3.6	0.48	<0.05	**0.39**	0.15	**0.57**	−0.18
Dizziness	51	2.8	0.53	<0.05	**0.36**	−0.12	**0.59**	**0.39**
Weakness	64	3.2	0.41	<0.05	**0.47**	0.02	**0.74**	0.11
Sweating	77	3.2	0.60	<0.05	**0.42**	0.15	**0.56**	−0.09
Slurred speech	29	1.9	0.31	<0.05	**0.41**	0.06	**0.48**	**0.32**
Convulsion	16	1.3	0.46	<0.05	0.23	0.00	**0.37**	0.06
Pallor	88	5.3	—	—	**0.36**	0.21	**0.39**	−0.08
Double vision	11	1.3	0.17	0.27	0.30	0.05	0.17	**0.58**
Blurred vision	19	1.6	0.36	<0.05	0.20	0.02	−0.01	**0.71**
Headache	47	2.9	0.56	<0.05	**0.52**	**0.38**	0.16	**0.50**
Nausea	33	1.7	0.13	0.41	**0.40**	0.24	**0.31**	0.12
Hunger	69	3.8	0.60	<0.05	−0.09	−0.13	0.02	0.01

Factors derived from PCA with loadings >0.3 are shown in bold print. FPC, first principal component.

from a correlation matrix that tend to cosegregate (i.e., reduces a large number of variables into a few underlying factors) (2,8). The number of factors was determined using the Scree test (8). In this analysis, a symptom loading of ±0.3 on any factor is considered significant (a loading is the strength of a given variable's relationship with the underlying factor and may take a value from −1 to +1).

RESULTS — The prevalence (frequency) and mean intensity of each of the symptoms observed by the parents and reported by the children are shown in Tables 1 and 2. The correlation of frequency ranks between parents' and children's reports of hypoglycemic symptoms was substantial and highly significant (ρ = 0.65, $P < 0.01$). Moreover, children showed strong agreement with their parents (n = 43 of parent-child pairs) on ratings of symptom intensity (range of ρ corrected for ties, 0.13–0.70; Table 1). Symptom scores were then subjected to factor analysis. The first unrotated principal component indicates whether the variables are associated as a general factor. Most symptoms reported loaded significantly on this component (Tables 1 and 2) for both the parents and the children, suggesting that the symptoms were valid and representative of the experience of hypoglycemia. A three-factor solution was derived from varimax rotation of the parents' observed symptoms (Table 1). Factor 1 contained symptoms that predominantly indicate general behavioral disturbance. Factor 2 consisted principally of neuroglycopenic and autonomic symptoms. Factor 3 was largely associated with visual disturbance and headache. Some symptoms (convulsion, pallor, nausea, and hunger) had no substantial loading on any of these factors. Factor analysis of the children's reported symptoms produced a two-factor model (Table 2). The symptom clustering in factor 1 contains mainly neuroglycopenic and autonomic symptoms, whereas factor 2 suggests a behavioral disturbance. The factorial structure of the children's responses was compared with those of adults with IDDM by applying factor analysis to only those symptoms incorporated in the EHS (3). Three symptoms (palpitations, odd behavior, and incoordination) of the EHS were omitted in case the children might not understand them, and the terminology was modified so that "drowsiness" was replaced with "sleepiness" and "trembling" with "shaking." Three factors were extracted from this analysis (Table 2). Factor 1 combines neuroglycopenic and autonomic symptoms, factor 2 is a nonspecific malaise fac-

Table 2—*Children's reports: frequency of individual symptoms reported and their mean intensity*

Symptom	Frequency (%)	Mean intensity	FPC	Factors		Factors (EHS)		
				1	2	1	2	3
Headache	64	2.7	0.3	−0.05	**0.60**	−0.04	**0.84**	0.06
Sweating	63	3.6	**0.46**	**0.55**	0.01	**0.76**	−0.10	0.16
Confusion	60	2.7	**0.61**	**0.59**	0.22	**0.63**	**0.34**	−0.03
Trembling	72	3.6	**0.41**	**0.38**	0.16	0.36	−0.07	**0.66**
Poor concentration	67	3.3	**0.69**	**0.70**	0.21	—	—	—
Dizziness	70	3.6	**0.53**	**0.56**	0.07	—	—	—
Weakness	81	4.1	**0.59**	0.57	0.22	—	—	—
Hunger	65	3.9	**0.53**	**0.45**	0.28	**0.80**	−0.04	−0.18
Blurred vision	45	2.1	**0.59**	**0.73**	−0.02	—	—	—
Double vision	28	1.6	**0.63**	**0.77**	−0.01	—	—	—
Slurred speech	30	1.9	**0.44**	**0.58**	−0.07	**0.52**	0.21	**0.35**
Irritability	42	2.3	**0.48**	0.04	**0.78**	—	—	—
Aggressive	51	2.9	**0.66**	0.28	**0.75**	—	—	—
Argumentative	55	2.9	**0.44**	−0.08	**0.90**	—	—	—
Naughty	30	2.0	**0.39**	0.01	**0.68**	—	—	—
Sleepiness	67	3.3	0.23	0.13	0.21	0.25	−0.07	**−0.86**
Tearfulness	42	2.0	0.20	0.09	0.23	—	—	—
Tummy pain	45	2.2	−0.07	−0.14	0.08	—	—	—
Nausea	19	1.5	**0.43**	0.10	**0.63**	0.13	**0.86**	−0.03
Nightmares	7	1.1	**0.30**	−0.07	**0.66**	—	—	—

Factors derived from PCA of children's reports and of symptoms derived from the EHS. Loadings >0.3 are shown in bold print. FPC, first principal component.

tor, and factor 3 shows a high loading for trembling and a high negative loading for sleepiness.

CONCLUSIONS— In the present study, autonomic and neuroglycopenic symptoms reported by the children and their parents were cosegregated into a single factor. This is in contrast with adult IDDM patients, who are able to distinguish between these two symptom types (1–3). In children with IDDM, the coalescence of autonomic and neuroglycopenic symptoms may indicate that both symptom types are generated at similar glycemic thresholds. Both the parents and children reported a coherent cluster of symptoms related to behavioral change during hypoglycemia. Behavioral changes, though recognized to occur, have received little prominence as important premonitory signs of a low blood glucose (6,7). Behavioral disturbance in hypoglycemia occurred irrespective of the age of the child with no significant correlation demonstrable between total score on the behavioral factor and age for either the children's (Pearson's $r = -0.09$, $P = 0.55$) or the parents' observations (Pearson's $r = -0.04$, $P = 0.70$). Further studies are required to elucidate more fully the nature of behavioral symptoms associated with hypoglycemia. The effects of age and puberty and the transition from the child's to the adult's pattern of symptom reporting merit further examination. The nature and commonality of behavioral manifestations of hypoglycemia in IDDM children, demonstrated in the present study, should be emphasized when educating parents about the identification and treatment of hypoglycemia.

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