RESPONSES TO THE POSTURAL CHANGE AND ORTHOSTATIC DYSREGULATION SYMPTOMS:

A Population Study on Japanese Junior and Senior High School Students

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A RATHER mild autonomic dysregulation syndrome with dizziness, fainting on standing and many other symptoms and complaints has been studied under the name of "orthostatic dysregulation (O.D.," mainly by European and Japanese pediatricians. The syndrome, studied first in children, may appear also in adults not infrequently. On the other hand, a rare, often fatal, disorder has been described by the name of "idiopathic orthostatic hypotension". The latter differs in various respects from O.D. and related affections, possibly belonging to another entity. All these, however, may clinically more or less overlap to each other and have been occasionally confused with each other.

Criteria for the diagnosis of O.D. are not always invariable among investigators. All partial symptoms of the syndrome can occur also in normal children. The patients are apt to respond more strongly than normals to postural change from supine to erect position with systolic blood pressure decrease, pulse pressure decrease and pulse rate increase. Such responses, however, may be physiological phenomena, frequently observable in normal subjects. Moreover, some patients are hyperresponsive to the postural

change but have few complaints and signs of other autonomic nervous dysfunction and others respond normally to the postural change but have numerous complaints.

Thus, it is difficult to draw a strict boundary between the O.D. patients and the normals. All these facts may suggest an importance of analyzing data on O.D. symptoms including sensitivity to the tilting test in the unselected general population, prior to an attempt of classifying persons into normal and affected groups.

We carried out the tilting test and obtained informations on autonomic dysregulation symptoms and complaints in 1,359 junior and senior high school students, 12 to 18 years of age. The results of analyses of the data are presented in this paper.

MATERIALS AND METHODS

Unselected 580 male and 779 female junior and senior high school students were subjected to the tilting test and informations on the complaints and symptoms in vegetative nervous system were taken by interviews.

The number and sex of the testees, the year of investigation, and testers in charge are listed in Table I. Of the 17 samples, some were examined twice at an interval of one year. Nearly all first- and second-year-class students of a junior high

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TABLE I MATERIALS

School	Sex	Year class	Age in years	Number	Year of examination	Tester in charge
A junior high school in Shimane Prefecture	Male	1*	12-13	111	192	1970
		2*	13-14	81		
		2**	13-14	112	217	1971
		3**	14-15	105		
	Female	1*	12-13	108	222	1970
		2*	13-14	114		
		2**	13-14	113	230	1971
		3**	14-15	117		
A senior high school in Tottori Prefecture	Male	1	15-16	52	171	1973
		2	16-17	62		
		3	17-18	57		
	Female	1*	15-16	54	167	1971
		2*	16-17	57		
		3	17-18	56		
		1	15-16	52	160	1972
		2**	16-17	53		
		3**	17-18	55		
	Total	Male	580	}	1359	
Female		779				

* and ** denote respectively the first (*) and the second (**) examinations of the almost same students at one year interval. Number of these two sets of testees are both included in the total number; that is, each of these testees is counted twice.

Of the listed students, several were excluded from subsequent analyses because of incompleteness of records.

school in Shimane Prefecture were examined in 1970 and almost the same samples were similarly examined in the next year. In 1971 and 1972 all girls in the nursing course of a senior high school in Tottori Prefecture were examined. Thus, the first- and second-year-class girls respectively in 1971 were almost the same as the second- and third-year-class girls in 1972. In the subsequent analyses, these two sets of data for almost the same populations were treated as if they were data on independent populations. The third-year-class girls in 1971 and the first-year-class girls in 1972 of the senior high school and all boys in a senior high school in Shimane Prefecture were examined only once.

Examinations and interviews were carried out using one and the same method and procedure

designed by Honda, the senior author.

In the examination, systolic and diastolic blood pressures and pulse rate were measured after 10 minutes lying supine and after 10 minutes active standing. In most occasions blood pressures were measured thrice at each posture, and the median values for each posture were used for analyses, with an exception of junior high school students in 1970, in whom blood pressures were measured only once in each posture. The pulse rate was counted once in each posture. The blood pressures were expressed by mmHg and the pulse rates were counted per minute.

Responses to the tilting test were evaluated by following three values:

- 1) systolic blood pressure decrease; that is, the systolic pressure in the lying minus

TABLE II INCIDENCE OF EACH SYMPTOM BY SCHOOL AND SEX IN PER CENT

Symptom or complaint	Junior high school		Senior high school	
	Boys (N=406)	Girls (N=457)	Boys (N=171)	Girls (N=325)
A	19.0	40.9	38.0	41.5
B	6.7	8.1	8.8	12.3
C	7.9	11.4	18.1	12.3
D	4.9	10.7	10.5	8.6
E	15.0	9.8	16.4	13.5
a	13.1	21.9	12.3	6.8
b	15.8	13.3	17.5	16.6
c	20.0	18.2	8.8	20.3
d	16.3	16.4	20.5	16.0
e	12.6	19.7	23.4	23.4
f	28.8	46.0	26.9	38.2
Mean	14.53	19.61	18.23	19.08
Number of symptom per child	1.60	2.16	2.01	2.10
S.D.	±1.49	±1.73	±1.75	±1.63

TABLE III TEST FOR NON-RANDOM DISTRIBUTION OF SYMPTOMS AND COMPLAINTS IN JUNIOR HIGH SCHOOL BOYS

Number of symptoms possessed by a testee	Observed number	Expected number calculated by		χ^2 of difference between observed and expected number by	
		Method I	Method II ($\bar{x}=0.1453$)	Method I	Method II
0	104	69.85	72.17	16.696***	14.038***
1	118	136.10	134.98	2.407	2.136
2	94	117.13	114.75	4.568*	3.752
3	53	58.85	58.53	0.582	0.523
4	20	19.15	19.91	0.038	0.000
5	7	4.33	4.74	27.970***	22.720***
6	4	0.67	0.81		
7	3	0.07	0.10		
8	3	0.006	0.01		
9	0	0.0004	0.0005		
10	0	0.0000	0.0000		
11	0	0.0000	0.0000		
Total	406	406.16	406.00		

Significance levels are shown by * (5%), ** (1%) and *** (0.1%)

- the one in the standing position,
- 2) pulse pressure decrease, or the difference between systolic and diastolic pressure in lying minus the difference between those in standing,

- 3) pulse rate increase due to postural change, and postural change in diastolic pressure was also recorded for reference. In the subsequent descriptions, positive values for postural change in blood pressures and pulse pressure signify

TABLE IV TEST FOR RANDOM DISTRIBUTION OF SYMPTOMS IN JUNIOR HIGH SCHOOL GIRLS AND SENIOR HIGH SCHOOL BOYS AND GIRLS ASSUMING EQUAL INCIDENCE OF ALL SYMPTOMS (METHOD II)

Number of Symptom	Junior high school girl			Senior high school boy			Senior high school girl		
	No. of children		χ^2	No. of children		χ^2	No. of children		χ^2
	Observed	Expected ($\bar{x}=0.1961$)		Observed	Expected ($\bar{x}=0.1823$)		Observed	Expected ($\bar{x}=0.1908$)	
0	63	41.41	11.256***	37	18.69	17.977***	50	31.67	10.609***
1	130	111.12	3.208	42	45.83	0.320	82	82.11	0.000
2	108	135.54	5.596*	34	51.08	5.711*	82	96.81	2.266
3	78	99.19	4.527*	30	34.17	0.509	56	68.48	2.274
4	29	48.39	7.770**	9	15.23	2.548	27	32.29	0.866
5	21	16.53	35.788***	11	4.75	28.166***	16	10.66	15.105***
6	18	4.03		5	1.06		8	2.51	
7	5	0.702		2	0.17		1	0.42	
8	3	0.086		1	0.02		2	0.05	
9	2	0.007		0	0.001		1	0.004	
10	0	0.000		0	0.000		0	0.000	
11	0	0.000		0	0.000		0	0.000	
Total	457	457.005		171	171.001		325	325.004	

Significance levels are shown by * (5%), ** (1%), and *** (0.1%).

amounts of the decrease and negative values those of the increase, while positive values for postural change in pulse rate imply amounts of increase.

Informations on presence or absence and severity or frequency of following 11 items of complaints and symptoms were obtained by interviews to the testees. These items have been chosen by the Japanese O.D. research group¹ for their availability as criteria of orthostatic dysregulation and autonomic dysfunction.

- A, dizziness;
- B, fainting on standing;
- C, queasiness at warm bathing, or at seeing or hearing unpleasant matters;
- D, palpitation or short breathing after slight body exercises;
- E, difficulty in getting out of bed, and/or laziness in the morning;
- a, pallor;
- b, poor appetite;
- c, abdominal pain;
- d, fatigability;
- e, headache; and
- f, car-sickness.

The symbols A-E and a-f will be used in the

present paper for abbreviation.

RESULTS

The 17 samples were collected into four groups by sex and by school (i.e., junior and senior high schools).

1) Distribution of symptoms and complaints

Proportions of students who have each symptom or complaint, disregarding their severity and frequency, are shown in Table II. The students have 1.60–2.16 symptoms in average.

Whether these symptoms occur randomly or not may be tested by the following analysis. If the 11 symptoms and complaints distribute randomly among students, numbers of students having 0, 1, 2, . . . symptoms ($n_0, n_1, n_2, \dots$), respectively, may be given by following formulae:

$$n_0 = N \prod_{i=1}^{11} (1 - x_i)$$

$$n_1 = N \sum_{i=1}^{11} \left\{ x_i \prod_{j=1}^{11} (1 - x_j) \right\} \quad i \neq j$$

$$n_2 = N \sum_{i=1}^{11} \left\{ x_i x_j \prod_{k=1}^{11} (1 - x_k) \right\} \quad i \neq j \neq k$$

TABLE V CORRELATIONS BETWEEN PRESENCE OR ABSENCE OF EACH TWO SYMPTOMS OR COMPLAINTS

<i>Junior high school boys</i>											
	A	B	C	D	E	a	b	c	d	e	f
A		-0.003	0.185***	0.093*	0.078	-0.020	0.153**	0.026	0.127**	0.196***	0.108*
B	0.112*		-0.041	0.122**	-0.085*	0.073	0.047	0.015	0.043	0.048	0.070
C	0.058	0.048		0.018	0.082	-0.032	0.049	0.037	0.045	0.110*	-0.004
D	0.143**	0.027	0.124**		0.064	0.047	0.089*	0.029	0.085*	0.120**	0.081
E	0.024	0.063	0.093*	0.075		-0.020	0.196***	0.066	0.226***	0.132**	0.143**
a	0.130**	0.153**	0.065	0.142**	0.020		0.013	0.026	0.107*	0.008	0.012
b	0.066	-0.022	0.167***	0.114*	0.108*	0.010		0.105*	0.212***	0.162***	0.053
c	0.127**	0.089**	0.049	0.149**	0.225***	-0.057	0.182***		0.064	0.127**	0.036
d	0.184***	0.125**	0.181***	0.209***	0.171***	0.137**	0.208***	0.144**		0.115*	0.014
e	0.215***	0.095*	0.244***	0.202***	0.169***	0.124**	0.145**	0.195***	0.286***		-0.028
f	0.010	0.032	-0.062	0.035	0.005	0.064	-0.039	-0.036	0.042	0.040	
<i>Junior high school girls</i>											
<i>Senior high school boys</i>											
	A	B	C	D	E	a	b	c	d	e	f
A		0.226**	0.257***	0.124	0.109	0.147*	0.082	0.183**	0.319***	0.279***	0.041
B	0.235***		0.069	0.096	0.030	0.010	0.020	-0.023	0.150*	0.122	0.045
C	0.064	0.116*		0.135*	0.202**	0.101	0.062	-0.092	0.100	0.063	0.125
D	0.142**	0.119*	0.119*		0.106	0.104	0.192**	0.028	0.251***	0.171*	0.050
E	0.068	0.071	0.043	0.071		0.075	0.004	0.030	0.128	0.091	0.195**
a	0.060	0.043	-0.030	-0.042	0.066		0.062	0.010	0.163*	0.046	0.014
b	0.084	0.012	0.113*	0.043	0.117*	0.041		-0.034	0.109	-0.001	-0.002
c	0.003	0.064	-0.006	0.087	0.021	0.097*	0.084		0.099	0.122	-0.095
d	0.101*	0.291***	0.088	0.191***	0.117*	0.106*	0.121*	0.228***		0.268***	0.019
e	0.183***	0.059	0.103*	0.089	0.164**	0.018	0.071	-0.012	0.130**		0.007
f	0.019	0.053	-0.063	0.052	0.152**	-0.069	-0.038	0.007	-0.038	0.090*	
<i>Senior high school girls</i>											

Significance levels of the correlation coefficients are shown by * (5%), ** (1%), and *** (0.1%) (One-sided test).

and so on,
where N denotes total number of students in the sample and $x_1, x_2, \dots, x_i, \dots, x_j, \dots, x_k, \dots, x_{11}$ proportions of students having the 1st, 2nd, ... and 11th symptoms, respectively.

Since these calculations are laborious, a more simplified method may be useful. If the 11 symptoms are assumed to occur in equal frequencies, number of children having 0–11 symptoms

may be given by the terms of the expansion of a following binomial:

$$N \left\{ (1 - \bar{x}) + \bar{x} \right\}^{11},$$

where $\bar{x}$ is the mean incidence of the 11 symptoms or $\bar{x} = (x_1 + x_2 + \dots + x_{11})/11$.

These two methods give quite similar expected numbers unless variation among x 's is too

TABLE VI RESULTS OF PRINCIPAL COMPONENT ANALYSIS

School	Junior high school								Senior high school							
	Boys				Girls				Boys				Girls			
Sex																
Principal component	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Eigen value	1.83	1.21	1.09	1.07	2.19	1.25	1.05	0.99	2.10	1.33	1.12	1.03	1.87	1.23	1.12	1.08
%	16.6	11.0	9.9	9.7	19.9	11.4	9.6	9.0	19.1	12.1	10.2	9.4	17.0	11.2	10.2	9.8
Factor loading																
A	0.51	-0.22	0.42	0.14	0.43	0.29	0.01	-0.17	0.68	-0.17	0.19	-0.03	0.49	0.18	-0.21	-0.08
B	0.11	0.67	0.34	0.00	0.28	0.41	0.34	-0.55	0.38	-0.07	0.14	-0.68	0.56	-0.06	-0.18	-0.42
C	0.31	-0.45	0.40	-0.05	0.44	-0.14	-0.52	-0.06	0.44	0.48	0.07	-0.01	0.33	0.02	-0.54	0.35
D	0.35	0.40	0.30	0.14	0.49	0.11	-0.15	0.31	0.51	0.04	-0.41	-0.02	0.46	0.08	-0.23	-0.24
E	0.53	-0.20	-0.48	0.25	0.40	-0.29	0.47	0.00	0.37	0.44	0.33	0.31	0.39	0.36	0.46	0.27
a	0.09	0.50	-0.19	-0.31	0.31	0.60	-0.18	-0.10	0.33	0.11	-0.24	0.48	0.18	-0.40	0.43	0.17
b	0.58	0.03	-0.20	-0.08	0.44	-0.43	-0.19	0.12	0.25	0.08	-0.72	-0.04	0.33	-0.12	0.05	0.64
c	0.30	0.03	-0.10	-0.28	0.46	-0.39	0.47	-0.10	0.19	-0.56	0.28	0.45	0.31	-0.50	0.35	-0.17
d	0.54	0.12	-0.38	-0.18	0.64	0.05	-0.05	0.08	0.65	-0.18	-0.09	0.05	0.64	-0.34	0.07	-0.16
e	0.53	-0.08	0.29	-0.34	0.65	0.04	-0.07	0.08	0.49	-0.39	0.18	-0.16	0.43	0.42	0.04	0.25
f	0.24	0.20	-0.05	0.80	0.03	0.42	0.36	0.72	0.17	0.60	0.29	-0.07	0.11	0.59	0.42	-0.31

TABLE VII MEANS AND STANDARD DEVIATIONS OF THE MEASUREMENTS AND THE RESPONSES TO THE TILTING TEST

	Junior High School				Senior High School			
	Boys (N=406)		Girls (N=457)		Boys (N=171)		Girls (N=325)	
	Mean	($\pm$ S.D.)	Mean	($\pm$ S.D.)	Mean	($\pm$ S.D.)	Mean	($\pm$ S.D.)
<i>In lying posture</i>								
1) Systolic pressure	108.87	(11.59)	106.64	(10.59)	117.94	(11.61)	117.22	(11.02)
2) Diastolic pressure	51.09	(17.59)	55.16	(14.06)	56.01	(16.13)	65.39	(10.08)
3) Pulse rate	75.86	(10.58)	78.67	(10.85)	71.47	(10.29)	77.04	(11.35)
<i>In standing posture</i>								
4) Systolic pressure	95.50	(13.24)	92.83	(11.43)	108.48	(12.27)	107.81	(11.55)
5) Diastolic pressure	52.59	(14.78)	51.46	(14.16)	67.15	(12.94)	65.29	(8.70)
6) Pulse rate	84.27	(12.37)	87.46	(11.54)	82.53	(10.48)	83.95	(12.12)
<i>Response to tilting test</i>								
7) Systolic pressure decrease	13.38	(10.87)	13.92	(10.54)	9.52	(9.51)	9.42	(9.34)
8) Diastolic pressure decrease	-1.44	(17.52)	3.73	(16.58)	-11.14	(15.58)	0.21	(9.40)
9) Pulse pressure decrease	14.88	(19.14)	10.05	(16.94)	20.66	(15.78)	9.15	(10.03)
10) Pulse rate increase	8.42	(9.07)	8.82	(9.75)	11.06	(8.26)	6.87	(9.12)

large.

For example, observed numbers of junior high school boys having 0–11 symptoms were compared with expected numbers calculated by two above mentioned procedures using χ^2 of the sample shown in Table II. The results are shown in Table III. Boys having no symptom and those having 5 or more symptoms are more numerous than the expected. The differences are highly significant. On the other hand, boys having 1, 2, or 3 symptoms are fewer than the expected and those having 4 symptoms are nearly equal in number to the expected. Thus, the symptoms and complaints does not distribute randomly, but have a tendency to accumulate in some individuals.

A quite similar trend is shown in the other 3 groups by analyses using Method II (Table IV).

Moreover, there are trends that some specific symptoms concur in the same individuals. As shown in Table V, presence or absence of each two symptoms or complaints is positively correlated in 193 (or 91.9%) of 220 comparisons. Eighty-nine or 46% of the positive correlations are significant (at the 0.1% level in 31, 1% in 28, and 5% in 30 comparisons). Whereas negative correlation is shown in 27 comparisons, of which only one is significantly correlated at the 5% level. The complaint d, fatigability, is most

frequently correlated with other symptoms. Number of significant positive correlation is recorded in the order d (28 of 40 comparisons), e (24), A (22), D (20), b (16), E (15), C (14), B and c (12), a (10), and f (5). On the other hand, negative correlations, though mostly insignificant, is found most numerous in symptom f, car-sickness (11), and nextly come C and c (8), a (7), and so on.

2) Results of principal component analyses

The fact that the symptoms and complaints accumulate in certain individuals suggests a possibility that a common factor or factors may be responsible for occurrence of several symptoms. However, results of the principal component analysis (Table VI) reveal that the first principal component can explain only 16.6–19.9% and total of four main components only 50% of the observed variations. Thus, many factors are obviously contributory to the occurrence of these symptoms.

The factor loadings of the first principal component, which correspond to correlation coefficients of the component with presence of symptoms or complaints, take positive signs in all symptoms in all the four groups classified by sex and school. This may suggest existence of a common factor or factors partially contributing to the occurrence of all symptoms. The first

TABLE VIII DISTRIBUTION OF MEASUREMENTS OF BLOOD PRESSURES AND PULSE RATES IN SENIOR HIGH SCHOOL GIRLS

	35-44	45-54	55-64	65-74	75-84	85-94	95-104	105-114	115-124	125-134	135-144	145-154
<i>In lying posture</i>												
1) Systolic pressure		1				3	34	92	119	62	14	2
2) Diastolic pressure	5	39	115	114	43	9		2				
3) Pulse rate		4	45	101	108	42	20	6				
<i>In Standing posture</i>												
4) Systolic pressure					2	37	102	99	64	17	4	1
5) Diastolic pressure	3	36	117	137	28	5	1					
6) Pulse rate		1	14	61	119	78	38	9	4	1	1	

TABLE IX DISTRIBUTIONS OF RESPONSES TO THE TILTING TEST IN SENIOR HIGH SCHOOL GIRLS

	-44~-35	-34~-25	-24~-15	-14~-5	-4~-4	5~14	15~24	25~34	35~44	45~54
7) Systolic pressure decrease	1	0	4	9	75	152	72	10	3	
8) Diastolic pressure decrease		6	12	64	155	70	17	3		
9) Pulse pressure decrease			3	20	84	132	66	18	4	
10) Pulse rate increase			3	12	136	122	39	10	1	2

component is correlated strongly with symptoms A, C, D, E, d and e, but only weakly with symptoms f and a. The latter two symptoms are correlated more strongly with the second or later components.

3) Distribution of measurements of blood pressures and pulse rate, and their responses to the tilting test

Values of the mean and the standard deviation of the measurements and responses to the tilting test are given in Table VII. The systolic blood pressures in lying as well as in erect posture are higher in average in senior than in junior high school students of both sexes and in boys than in girls of similar ages. The pulse rate shows an opposite trend to the blood pressures, that is, it is slower in older than in younger students and in boys than in girls of similar ages.

Of responses to the tilting test, the systolic pressure decrease is less pronounced in average in senior than in junior high school students, but shows no differences between sexes of similar ages. Change in the diastolic pressure due to the postural change is highly variable within each group, and shows no consistent trend among groups. The pulse pressure decrease is larger in boys than in girls, and much larger in older than in younger boys, whereas it is slightly smaller in older than in younger girls. The mean pulse rate increase is not different between sexes in junior high school students, while it is much larger in boys than girls of senior high school.

In all four groups, all measurements and responses show continuous, unimodal, approximately normal distributions. As a representative, data on senior high school girls are presented in Tables VIII and IX.

4) Correlations among measurements and responses

Correlations between each two values of measurements and responses of an individual show a common trend among groups (Table X). The systolic pressure decrease due to the postural change is correlated most strongly with the systolic pressure in erect posture (negatively) and less strongly with the systolic pressure in lying posture (positively) and the diastolic pressure in erect posture (negatively).

The diastolic pressure decrease is correlated most strongly with the diastolic pressure in the lying posture (positively), less strongly with the diastolic pressure in the erect posture (negatively). The pulse pressure decrease is correlated most strongly with the diastolic pressure in the

TABLE X CORRELATIONS AMONG MEASUREMENTS AND RESPONSES TO THE TILTING TEST

	School	Sex									
Supine posture											
1. Systolic	J	M									
blood	S	M									
pressure	J	F									
	S	F									
2. Diastolic	J	M	***								
blood	S	M	**								
pressure	J	F	***								
	S	F	***								
3. Pulse	J	M	***	-0.049							
rate	S	M	*	0.168	0.115						
	J	F	***	0.217	0.039						
	S	F	***	0.257	0.104						
Standing posture											
4. Systolic	J	M	***	***	***						
blood	S	M	***	***	*						
pressure	J	F	***	***	***						
	S	F	***	*	***						
5. Diastolic	J	M	***	***	-0.048	***					
blood	S	M	**	***	*	***					
pressure	J	F	***	***	0.068	***					
	S	F	***	***	**	***					
6. Pulse	J	M	***	-0.054	0.697	0.053	-0.041				
rate	S	M	0.016	0.004	0.684	0.015	0.126				
	J	F	0.065	-0.066	0.612	0.023	-0.006				
	S	F	0.119	0.042	0.699	0.129	0.078				
Response to test											
7. Systolic	J	M	***	-0.035	0.074	***	***	0.111			
pressure	S	M	***	0.108	-0.013	***	**	-0.001			
decrease	J	F	***	0.063	0.024	***	***	-0.002			
	S	F	***	0.190	-0.031	***	***	-0.007			
8. Diastolic	J	M	0.022	0.638	-0.012	-0.099	***	-0.022	**		
pressure	S	M	0.018	0.667	0.011	-0.206	***	-0.100	***		
decrease	J	F	0.055	0.579	-0.028	-0.174	***	-0.057	***		
	S	F	0.110	0.547	-0.054	-0.242	***	-0.052	***		
9. Pulse	J	M	**	***	0.060	***	***	0.094	***	***	
pressure	S	M	**	***	-0.018	***	***	0.098	***	***	
decrease	J	F	***	***	0.043	**	***	0.086	***	***	
	S	F	***	***	0.024	***	*	0.032	***	***	
10. Pulse	J	M	-0.089	-0.015	-0.215	-0.128	0.001	0.550	0.064	-0.015	0.057
rate	S	M	-0.189	-0.138	-0.378	-0.183	-0.003	0.417	0.015	-0.141	*
increase	J	F	-0.167	-0.112	-0.390	-0.178	-0.065	0.478	0.025	-0.035	0.053
	S	F	-0.152	-0.071	-0.316	-0.176	-0.095	0.456	0.038	0.000	0.018
			1	2	3	4	5	6	7	8	9

Significance levels are shown by * (5%), ** (1%), and *** (0.1%).

J and S denote respectively junior and senior high schools.

TABLE XI MEAN VALUES OF RESPONSES TO TILTING TEST IN JUNIOR HIGH SCHOOL BOYS WITH (+) OR WITHOUT (−) EACH SYMPTOM

Symptom or complaint	Systolic pressure decrease				Pulse pressure decrease				Pulse rate increase			
	(−)		(+))		(−)		(+))		(−)		(+))	
	Mean	(± S.D.)	Mean	(± S.D.)	Mean	(± S.D.)	Mean	(± S.D.)	Mean	(± S.D.)	Mean	(± S.D.)
A	12.98	(10.63)	15.05	(11.68)	14.51	(18.97)	16.45	(19.80)	8.08	(9.06)	9.90	(8.95)
B	13.30	(10.85)	14.48	(11.03)	14.64	(18.86)	18.30	(22.43)	7.97	(8.78)	14.74	(10.53)
C	13.46	(10.90)	12.38	(10.47)	15.23	(18.83)	10.78	(22.04)	8.23	(8.94)	10.69	(10.21)
D	13.18	(10.63)	17.20	(14.21)	14.47	(18.36)	22.80	(29.47)	8.35	(9.01)	9.90	(9.95)
E	12.74	(10.79)	16.95	(10.64)	14.23	(19.05)	18.56	(19.25)	8.19	(9.23)	9.74	(7.99)
a	12.84	(10.72)	16.98	(11.16)	14.93	(19.41)	14.58	(17.25)	8.32	(9.18)	9.09	(8.24)
b	12.99	(10.63)	15.44	(11.87)	14.50	(18.55)	16.94	(21.94)	8.29	(9.05)	9.13	(9.14)
c	12.93	(10.89)	15.17	(10.61)	15.55	(19.69)	12.21	(16.52)	8.34	(9.33)	8.77	(7.94)
d	12.74	(10.53)	16.64	(11.96)	14.11	(18.58)	18.83	(21.38)	8.04	(8.86)	10.42	(9.81)
e	13.08	(10.87)	15.45	(10.65)	14.97	(18.96)	14.25	(20.35)	8.37	(9.20)	8.78	(8.10)
f	12.61	(10.71)	15.28	(11.02)	13.55	(18.51)	18.18	(20.26)	8.12	(9.16)	9.17	(8.80)

TABLE XII MEAN RESPONSES TO THE TILTING TEST CLASSIFIED BY NUMBER OF COMPLAINTS (JUNIOR HIGH SCHOOL BOYS)

No. of complaints	No. of testees	Systolic pressure decrease		Pulse pressure decrease		Pulse rate decrease	
		Mean	(± S.D.)	Mean	(± S.D.)	Mean	(± S.D.)
0	102	11.26	(10.46)	12.01	(14.85)	7.24	(10.08)
1	121	12.32	(9.38)	15.77	(21.49)	7.69	(8.07)
2	94	13.64	(12.23)	16.36	(18.99)	8.82	(8.71)
3	51	15.41	(9.83)	13.00	(19.32)	9.00	(8.78)
4 or over	38	19.13	(12.04)	19.89	(23.02)	12.21	(9.88)
Total	406	13.38	(10.87)	14.88	(19.14)	8.42	(9.07)

lying posture (negatively) and less strongly with the diastolic pressure in the erect posture (positively), systolic pressure in the lying (positively) and that in the erect posture (negatively). These correlations are highly significant in most cases.

The pulse rate increase is correlated most strongly with the rate in the erect posture (positively) and less strongly with the rate in the lying posture (negatively). There are weak but statistically significant negative correlations between the pulse rate increase and the systolic pressures in the lying as well as the erect postures.

There are significant correlations among decreases in the systolic and diastolic pressures and the pulse pressure, but almost no correlation between each of these pressure changes and the

pulse rate increase.

5) Relationships between symptoms and responses to the tilting test

Mean values of responses to the tilting test were compared between children having and not having each symptom or complaint. Generally speaking, those having a symptom are likely to be more hyperresponsive in average than those not having the symptom. For example, data on junior high school boys are shown in Table XI.

The systolic pressure decrease due to postural change is greater in boys having a symptom than those not having the symptom in 10 of 11 symptoms, the pulse pressure decrease in 7, and the pulse rate increase in all 11. There are, however, many exceptions, and the differences in the

TABLE XIII CORRELATIONS BETWEEN NUMBER OF SYMPTOMS POSSESSED BY A CHILD AND MEASUREMENTS AND RESPONSES

Sex	Male		Female	
School	Junior	Senior	Junior	Senior
In lying posture				
1) Systolic pressure	-0.039	0.059	-0.071	-0.042
2) Diastolic pressure	-0.036	-0.017	-0.038	-0.060
3) Pulse rate	-0.049	-0.032	-0.011	-0.111*
In erect posture				
4) Systolic pressure	-0.192***	-0.050	-0.161**	-0.083
5) Diastolic pressure	-0.084*	-0.110	-0.040	-0.092
6) Pulse rate	-0.083*	0.109	-0.015	0.013
Responses to the test				
7) Systolic pressure decrease	0.194***	0.133*	0.097*	0.059
8) Diastolic pressure decrease	0.026	0.074	0.009	0.022
9) Pulse pressure decrease	0.081	0.007	0.063	0.020
10) Pulse rate increase	0.170***	0.179*	-0.013	0.151**

Significance levels are shown by * (5%), ** (1%), and *** (0.1%).

mean responses between children having and not having any one symptom are too small to be statistically significant.

6) Correlations between the number of the symptoms and the measurements or the responses (Tables XII and XIII)

The number of symptoms and complaints possessed by a testee is correlated with his or her measurements and responses to the tilting test.

The testees were classified into 5 classes by the number of complaints (0, 1, 2, 3, and 4 or over) and mean responses to the tilting test were compared among classes. Data on junior high school boys, for instance, are shown in Table XII. The systolic pressure decrease is the lowest in the class with no complaint and becomes more pronounced with the increase of the complaints. The pulse pressure decrease and the pulse rate increase are also in a similar trend. Correlation analyses disclosed (Table XIII) that with the increase in the number of complaints the systolic and diastolic pressures in both postures decrease, and the responses to the tilting test tend to increase. The number is correlated negatively with the pulse rate in the lying posture and positively with the rate in the erect posture.

These correlations are rather weak and mostly insignificant, but the trends are consistent among

four groups with a few exceptions.

DISCUSSION

Mathematical analyses of the data on symptoms and complaints and responses to the tilting test in unselected high school students confirmed previous authors' opinion¹⁻⁵ that there was no distinct boundary between the normal and the orthostatic dysregulation. However, there are significant tendencies that symptoms and complaints distribute nonrandomly among the testees; that is, those without symptoms and those with many symptoms are significantly more numerous than those expected from randomness.

Moreover, some specific symptoms and complaints apt to occur in clusters. For instances, "fatigability" correlates significantly with almost all symptoms excepting for "car-sickness". The latter correlates significantly with only one complaints, "difficulty in getting out of bed". On the other hand, "dizziness" correlates with "headache" at a high significance level, but only insignificantly with "difficulty in getting out of bed". Such detailed analyses may be useful for elucidating the aetiology of the manifold combinations of symptoms.

Doubtlessly, there exist a common factor or

factors responsible for these symptoms and complaints. As revealed by the principal components analysis, however, number of such factors seems rather large.

According to Brück and Oltmann⁴ of 36 O.D. patients only 8 responded positively to the tilting test in the pulse pressure decrease and 16 in the pulse rate increase. Oe et al.⁶ (1960) and Ishizawa⁷ (1961) claimed that positive responses to the tilting test are not more frequent in O.D. patients than in controls. Some others pointed out that positive pulse rate increase due to the postural change was more frequent in O.D. patients than in controls, but other responses occurred equally in the two groups (Mitani⁸ 1963, Kobayashi and Koizumi⁹ 1965). On the other hand, Okuni et al.¹⁰⁻¹³ (1958, 1960, 1961, 1962) Hamada¹⁴ (1961), Isoda and Kawada¹⁵ (1964) noticed differences in responses to the tilting test between the patients and the controls.

Some main problems in these controversies may be answered by the present study. In the unselected students, there is noticed a tendency that the more numerous symptoms and complaints an individual has, the stronger he or she responds to the postural change, suggesting that the common factors for various symptoms are contributing also to the hyperresponsiveness. And some individuals with a certain number or more symptoms or complaints including orthostatic hyperresponsiveness are diagnosed as the orthostatic dysregulation.

Analyses of family data revealed that number of symptoms and complaints and responses to the tilting test show significant correlations among relatives with rather high heritability. Incidence of orthostatic dysregulation among relatives of patients is significantly higher than that among relatives of controls. The data are not accord with the simple inheritance model, but with the polygenic or probably multifactorial model. Thus, the manifold symptoms and complaints including responses to the postural change in normal subjects as well as orthostatic dysregulation patients may be attributable to various combinations of these environmental and genetic factors. Details of the contribution of the genetic factors will be reported elsewhere (Tanaka, et al.¹⁶ 1976).

In the present study a majority of testees were examined twice at one year interval and these two sets of data for each testee were treated in the analyses as if they were on two different testees. Such a procedure may have an effect to

overestimate the statistical significance. The effect may be rather strong in measurements of the blood pressures and the pulse rate, occurrence of individual symptoms and complaints, and number of these symptoms, in which moderate or high correlations were observed, but the effect may be negligible in responses to the tilting test (especially in junior high school students) in which no or only low correlations were shown, as revealed in a study on reproducibility of the data (Tanimura, et al.¹⁷ 1977). Nevertheless, the general trend and conclusions of the present study may not be changed.

SUMMARY

Unselected 580 male and 779 female junior and senior high school students were subjected to the tilting test and informations on 11 autonomic dysregulation symptoms and complaints were taken by interviews. Results of the analyses of the data are summarized as follows:

1) Number of symptoms and complaints possessed by each individual distributes continuously but nonrandomly among testees; that is, individuals having no symptom and those having 5 or more symptoms are significantly more numerous than those expected from random distribution, indicating accumulation of the symptoms into some individuals.

2) Some specific symptoms tend to coincide with each other.

3) Principal component analyses disclosed that the first principal component can explain only 16–20% of the observed variation in the presence or absence of symptoms and complaints, suggesting that numerous factors are responsible for the occurrence of the symptoms.

4) Measurements of the blood pressures and the pulse rate, and their responses to the postural change show continuous, normal distributions, and significantly correlate to each other.

5) The responses to the tilting test are increased with the increase of number of symptoms and complaints possessed by the testees.

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