DEVELOPMENTAL NEURO-EPIDEMIOLOGIC STUDY ON CRITERIA OF NORMAL HIGH SCHOOL STUDENTS

—— A method of selecting "normal controls" by means of simple developmental indices.——

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Synopsis: The authors have already presented precise and yet simple criteria of normal children (6-12 years of age) from the neuro-developmental point of view. In this paper, the authors attempt to establish similar criteria for high school students (12-18 years of age)

The authors had followed, for the sake of convenience, their own criteria for normal high school students from the neuro-developmental point of view. These criteria were made up of 4 kinds of indices (group IQ., school achievement evaluation, school-health examination, and questionnaire to the parents on the developmental history), hence they are rather complicated. In addition, they have the disadvantage of having to use, as an index, data on the student achievement, etc., which are difficult for outsiders to obtain.

The purpose of the present study is to make more convenient criteria which are, nevertheless, almost as precise as the original criteria described above.

The authors utilized, as the index of the criteria of normal students, DE-Simplified Motor Function Test (DEMT) for the High School Students and DE-Group Bender Gestalt Test for High School Students (DE-BGT). Both of the two tests have been developed by the authors' research group as the screening tests for neuro-developmental disorders in high school students. It seems to the authors that the screening test for neuro-developmental disorders in students can be the screening test for normal students from the neuro-developmental point of view, if only the screening level is shifted to an appropriate level.

The screening level for normal students was placed at the level of 50 percentile of the standardization population (1502 cases) of the DEMT or DE-BGT.,respectively. In the case of screening the normal students according to the above criteria, only 0.1% of the normal students (screened by DEMT) had mental retardation, and 0.3% had epilepsy. Those having cerebral palsy or minimal brain dysfunction were not found among the normal students (screened by DEMT).

The results were almost the same for the normal students (screened by DE-BGT).

INTRODUCTION

What can be called "normal values" concerning the health indices (including simplified test) for children has been reported by many researchers.

On the other hand,"abnormal values" exists only in contrast to "normal value."The "normal value" refers

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to the value which the normal children possess. However, criteria of normal children are usually ambiguous, therefore it is very difficult to obtain a precise normal value.

What is urgently needed are objective and quantitative criteria of normal children. Even though they might be arbitrary criteria, we cannot avoid using them, because most pediatric researches in general, have constantly been utilizing arbitrary "make-shift-criteria" of normal children.

One important thing is to establish objective and quantitative criteria which are retestable by any researcher. The criteria of normal children which are so far based upon enriched experience of clinical pediatric experts seem to be, in a sense, acceptable, but these indices made by their experiences contain many ambiguous expressions. When it comes to use the criteria, some subjectivity is naturally incorporated into them.

For example, something like the following criteria are often indicated in pediatric researches: the children having, 1) no abnormal genetic history, 2) normal pregnancy, 3) normal delivery, 4) diagnosis of developmental normalcy by pediatritians. These criteria have vagueness and they sound like poetical expressions.

The authors do not attempt to present such philosophical problems of pediatrics as: "What is a normal child?" "What is a healthy child ?" etc. The authors consider it is necessary to show the objective and quantitative criteria of normal children as a practical pediatric problem.

Koizumi[1] stated that "normal value" should not be sought, but it should be set up. The authors agreed with his statement and considered that criteria of normal children do not exist but they should be set up according to the objective indices and viewpoints of criteria of normal children.

The criteria of normal children can naturally be defined by various kinds of viewpoints such as hematological, psychological, and neurological point of view. The purpose of this study is to present the simple criteria of normal children from the neuro-developmental viewpoint.

In general, there are two policies in dealing with the relationship between "normal" and "abnormal." One is based on the "average level" and the other is based on the "value level" according to Koizumi's theory.

In the methodological aspect, the criteria of normal student in this study are based on the "average level". But the authors tried to establish precise criteria of neuro-developmentally normal students so as to be able to exclude even minimal brain dysfunction syndrome.

The authors' research group has been developing a new field of pediatrics and advocating "Developmental Neuro-epidemiology[2)~15)]" (Mass-Neuropedatrics). The developmental neuro-epidemiology is a new subspeciality in pediatrics and it applies the method of epidemiology. Its purpose is not only to promote diagnosis and treatment of neuro-developmentally disordered children, but also to maintain and promote neuro-developmental health in all the children in the community. Therefore, developmental neuro-epidemiology is one of the subspecialities of child neurology and pediatrics.

The authors' research group has worked out simple developmental tests which are the core of their researches into developmental neuro-epidemiology and has made eight kinds of simplified developmental indices by the age groups shown in Table 1.

Through studying developmental neuro-epidemiology for a quarter century, the authors consider that the simple health indices have, in general, various functions as shown in Table 2, and one of the functions of the simple health indices is for them to be applicable as indices of simple and objective criteria for normal children.

Table 1 Simplified CNS Developmental Indices Developed by the Authors' Research Group

A. For Infants (6—12 months old)
1) DE—Simplified Motor Function Test for Infants.
2) MN—Developmental Screening Test for Infants (questionnaire)
B. For Children (1—2 years old)
3) DE—Simplified Motor Function Test for Children aged 1—2
4) MN—Developmental Screening Test for Children aged 1—2 (questionnaire)
C. For Children (3—6 years old)
5) DE—Simplified Motor Function Test for Children aged 3—6.
6) MN—Developmental Screening Test for Children aged 3—6 (questionnaire)
D. For Students (primary school, and high school) and Adults
7) DE—Simplified Motor Function Test for Students and Adults
8) DE—Bender Gestalt Test for Students and Adults

Table 2 Functions of Simple Health Indices (Simplified Tests)

1. As individual indices.
   (1) As a screening test.
   (2) Occasionally usable as one of the items in diagnostic criteria of the clinical diagnosis.
   (3) If the result of a simple test is available in advance, simple health indices will improve efficiency of the clinical test administered later.
1. As indices of the group.
   Example (1) Usable as a health index when searching the causative factors of diseases in the epidemiological studies.
   Example (2) Usable as indices of the community child health diagnosis, school health diagnosis, and community diagnosis.
   Example (3) If mass-screening of a disease by means of simplified health indices is widely carried out, mild and atypical cases of the disease will be detected and consequently the analysis of clinical picture including symptomatology will be improved.
   Example (4) Promoting the studies of pediatrics efficiently.
   a) Usable as objective and simplified criteria for normal children. (The simplified test can be the screening test for selecting the normal control children.)
   b) Usable as an index to control the quality of the subjects.
   c) Promoting the developmental studies efficiently based upon a large scale population survey.

SUBJECTS AND METHOD

This study is to present criteria of normal high school students from the neuro-developmental viewpoint by using two kinds of simplified developmental indices: 1) DE-Simplified Motor Function Test (DEMT) for High School Students, and 2) DE-Bender Gestalt Test for High School Students (DE-BGT).

Table 3 Subjects: High school students by age and sex in case of using DEMT as an index.

	age / sex	12	13	14	15	16	17	18	total
Normal student	boy	54	59	49	49	75	107	26	419
	girl	46	54	44	41	37	31	19	272
	total	100	113	93	90	112	138	45	691
Neuro-developmentally disordered student	boy	13	12	24	18	12	12	2	93
	girl	14	28	23	25	5	2	2	99
	total	27	40	47	43	17	14	4	192

DEMT (Developmental Epidemiologic Motor Function Test)

Subjects in case of using DEMT as developmental index (shown in table 3): 691 apparently normal high school students (aged 12-18, not completly by random sampling) and 192 students with neuro-developmental diesorders (aged 12-18); 71 cerebral palsy (CP), 46 mental retardation (MR), 48 epilepsy (EP), 22 borderline and minimal brain dysfunction (B+MBD), 5 others.

Subjects in the case of using DE-BGT as developmental index (shown in table 4): 1502 apparently normal students (aged 10-18, not completely random sampling), and 122 students with neuro-developmental diesorders (aged 10-18). They are as follows: CP; 81, MR; 36, EP; 67, B+MBD; 21, others; 16.

DEMT and DE-BGT shown in Table 1 being usable for screening neuro-developmentally disordered students, the authors considered they can also be used to screen normal students from the general population of students in the community or in schools. For this purpose a screening level should be shifted to another level. The authors have found that the screening level should not be fixed in order to use these developmental indices shown in Fig.1. For example, when the screening level is placed at the average value by age, according to the criteria, approximately 50%ile of the general population of children are judged normal. But it is very important to pay attention to the fact that the remaining 50% should not be judged as neuro-developmentally disordered. They are the students judged just "not-normal" by the above mentioned criteria. According to the aim of this study, it is not necessary to take those students into consideration who are not judged normal.

Table 4 Subjects : High school students by age and sex in case of using DE—BGT as an index.

	age / sex	10	11	12	13	14	15	16	17	18	total
Normal student	boy	89	107	150	116	122	54	76	110	26	850
	girl	81	87	118	110	120	50	37	30	19	652
	total	170	194	268	226	242	104	113	140	45	1502
Neuro-developmentally disordered student	boy	6	10	13	12	24	18	12	12	2	109
	girl	8	5	14	28	23	25	5	2	2	112
	total	14	15	27	40	47	43	17	14	4	221

DE (Developmental epidemiology) BGT (Bender Gestalt Test)

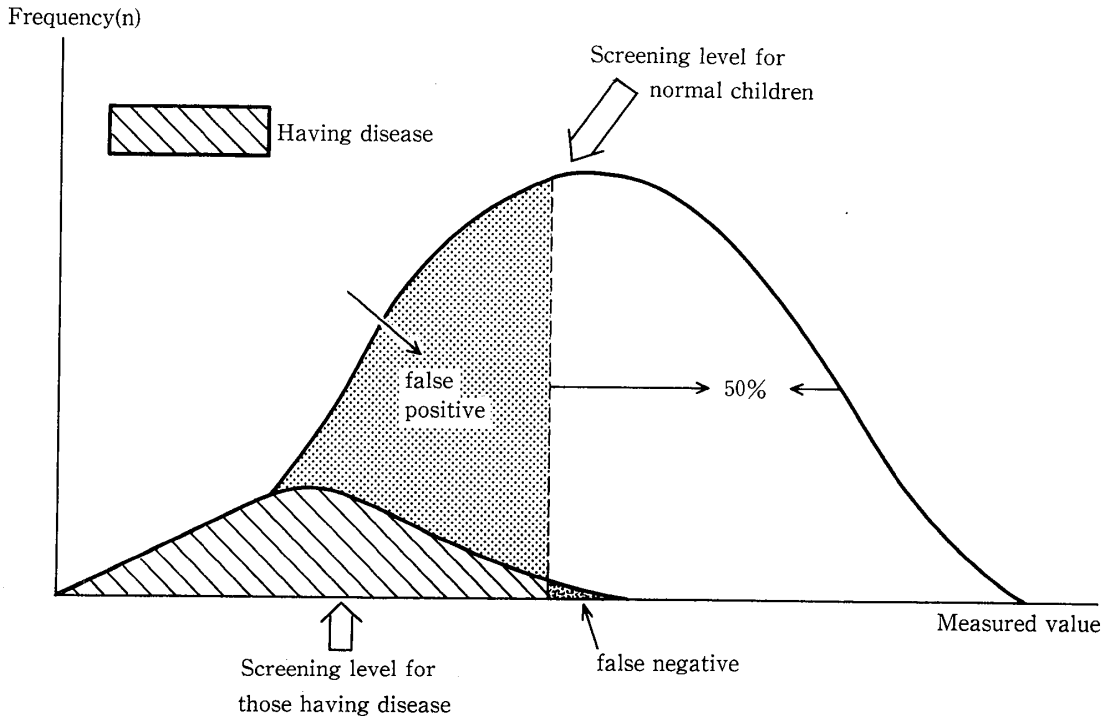

Fig. 1 Screening test for neuro-developmental disorders is also applicable as the one for normal children, if only the screenig level is shifted.

The authors would like to emphasize that this screening level to select normal children should not be fixed, but be shiftable to several levels. The important thing is to verify whether or not each screening level has validity as criteria of normal students.

The following procedures were employed to verify "criteria of normal students by means of these simple developmental indices."

1) To determine the percentage of the neuro-developmentally disordered and yet included among normal students according to the criteria. It is called false negative.

2) To determine error rate P; when the normal students are screened from the general population of students using the criteria, how many percent of selected normal students are neuro-developmentally disordered? This percentage was named "error rate P" by the authors.

By means of the following formula, the error rate p is determined

$$\text{Error rate P (\%)} = \frac{n \times m \times fn}{n \times sp} \times 100$$

n: (number of samples of the general population of students containing a few cases of neuro-developmentally disordered.

m: morbidity rate (%) of neuro-developmentally disordered among the general populations of students. Prior to conducting this study, the morbidity rate of neuro-developmental disorders was, as a matter of convenience, estimated at 0.2% for cerebral palsy (CP), 3.0% for mental retardation (MR), 1.0% for epilepsy (EP), and 16.0% for borderline plus minimal brain dysfunction (MBD). (For the sake of convenience borderline students and MBD students were summed up to one group (B+MBD).

fn: false negative (%)

sp: Specificity (%) (this means the percentage of the general population of students passing the test when screened by the criteria.)

If error rate P is small enough, the criteria of normal students are considered valid. In order to make the error rate P smaller, fn should be small enough and sp should be large enough in the above formula.

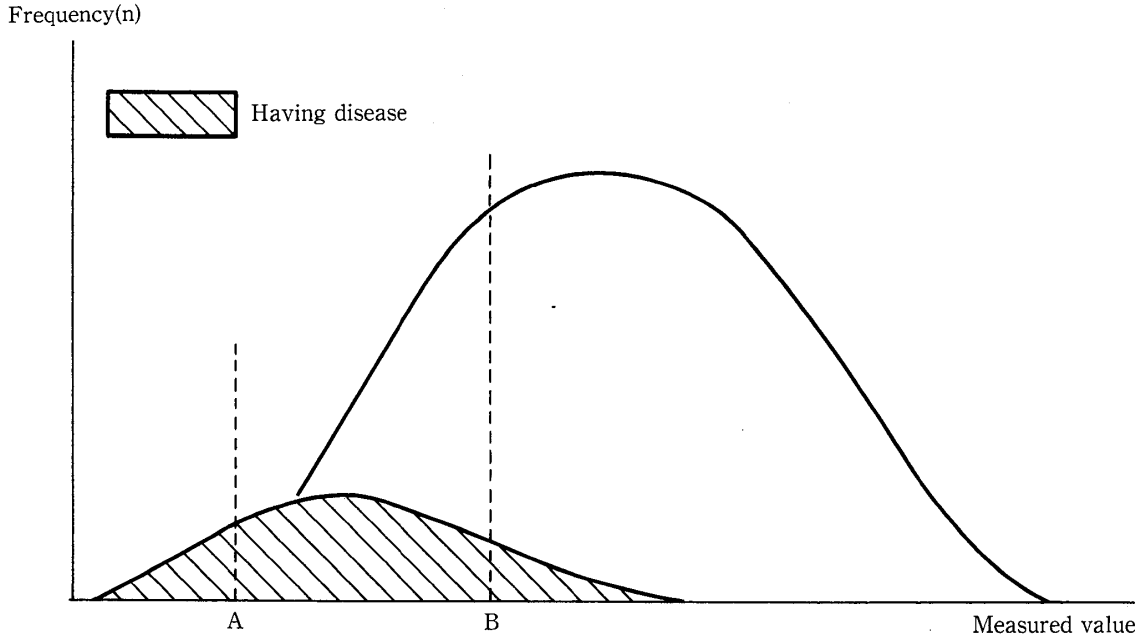

Fig. 2 The two mountains overlapping each other indicate the general population of the children. The part written in slant lines means children having disease, In other words, small number of children having disease is contained in the general population of children.

The authors consider tentatively that the morbidity rate of neuro-developmentally disordered students does not change. However, if you make fn smaller, sp also becomes smaller. For example (shown in Fig.2) if you place the screening level at A level, both fn and sp show higher percentage. However, when the screening level shifts from A to B. both fn and sp show lower percentage. Therefore, error rate P does not actually change very much even though the screening level is shifted (although moderate change of error rate P was observed).

The authors showed in this study how this error rate P would change when the screening level shifted to several levels.

In this study, DEMT for High School Students and DE-BGT for High School Students are used as indices.

The DEMT consists of 9 test items (each of them examines motor skills) and only 5-6 minutes are required to administer it to every three high school students. This test was developed by the authors' research group, and the validity and reliability have been verified.

Table 5 Changing criteria by different screening levels of DEMT for High School Students.

	age / pass or non pass / screening level	12		13		14		15		16		17		18	
boy		P	N	P	N	P	N	P	N	P	N	P	N	P	N
	50 percentile M−0 S.D.	7 or more	6 or less	7 or more	6 or less	8 or more	7 or less	8 or more	7 or less	8 or more	7 or less	8 or more	7 or less	9 or more	8 or less
	69.1 percentile M−0.5 S.D.	7	6	7	6	7	6	8	7	8	7	8	7	8	7
	84.1 percentile M−1.0 S.D.	6	5	6	5	6	5	7	6	7	6	7	6	7	6
	93.3 percentile M−1.5 S.D.	5	4	6	5	6	5	7	6	7	6	7	6	7	6
	97.7 percentile M−2.0 S.D.	5	4	5	4	5	4	6	5	6	5	6	5	6	5
girl		P	N	P	N	P	N	P	N	P	N	P	N	P	N
	50 percentile M−0 S.D.	7 or more	6 or less	7 or more	6 or less	7 or more	6 or less	7 or more	6 or less	7 or more	6 or less	8 or more	7 or less	8 or more	7 or less
	69.1 percentile M−0.5 S.D.	6	5	6	5	6	5	7	6	7	6	7	6	7	6
	84.1 percentile M−1.0 S.D.	6	5	6	5	6	5	6	5	6	5	7	6	7	6
	93.3 percentile M−1.5 S.D.	5	4	5	4	5	4	6	5	6	5	6	5	6	5
	97.7 percentile M−2.0 S.D.	4	3	5	4	5	4	6	5	6	5	6	5	6	5

When we attempted to shift screening level of DEMT, Table 5 was used. For instance, if you place the screening level at the level of (M−0.5 S.D.), a 13-year-old boy is judged neuro-developmentally normal if he gets 7 points or more.

Bender Gestalt Test originally was standardized by Bender[7] for diagnosis and prognostication of neuro-developmental disorders and has been used as a clinical visual motor function test. The authors have reformed this test to be applied as a simple developmental index of CNS of children. It is easily applicable to a mass of students.

The authors have standardized this test and named it DE (developmental epidemiology) Bender Gestalt Test

(BGT) for High School Students. (DE-BGT). Its validity and reliability have already been verified.

Table 6 Changing criteria by different screening levels of DE-BGT for High School Students.

	age / pass or non pass / screening level	10		11		12		13		14		15		16		17		18	
		P	N	P	N	P	N	P	N	P	N	P	N	P	N	P	N	P	N
boy	50 percentile M+0 S.D.	2 or less	3 or more	1 or less	2 or more	0 or less	1 or more	0 or less	1 or more	0 or less	1 or more	0 or less	1 or more	0 or less	1 or more	0 or less	1 or more	0 or less	1 or more
	69.1 percentile M+0.5 S.D.	3	4	2	3	1	2	1	2	1	2	1	2	1	2	1	2	1	2
	84.1 percentile M+1.0 S.D.	4	5	3	4	3	4	2	3	2	3	2	3	1	2	1	2	1	2
	93.3 percentile M+1.5 S.D.	5	6	4	5	4	5	3	4	3	4	3	4	2	3	2	3	2	3
	97.7 percentile M+2.0 S.D.	6	7	6	7	5	6	4	5	4	5	3	4	2	3	2	3	2	3
girl		P	N	P	N	P	N	P	N	P	N	P	N	P	N	P	N	P	N
	50 percentile M+0 S.D.	2 or less	3 or more	1 or less	2 or more	0 or less	1 or more	0 or less	1 or more	0 or less	1 or more	0 or less	1 or more	0 or less	1 or more	0 or less	1 or more	0 or less	1 or more
	69.1 percentile M+0.5 S.D.	3	4	2	3	1	2	1	2	1	2	1	2	0	1	0	1	0	1
	84.1 percentile M+1.0 S.D.	4	5	3	4	2	3	1	2	1	2	1	2	1	2	1	2	0	1
	93.3 percentile M+1.5 S.D.	5	6	4	5	3	4	2	3	2	3	2	3	2	3	1	2	1	2
	97.7 percentile M+2.0 S.D.	6	7	5	6	4	5	2	3	2	3	2	3	2	3	1	2	1	2

Table 6 was used as criteria, when the screening level was shifted. For example, if you place the screening level at the level of (M+0.5S.D.). a 13-year-old boy is judged neuro-developmentally normal, if he gets a score of 1 point or less. The result of DE-BGT is evaluated by "number of failure counting system" and a lower score is better.

RESULTS AND DISCUSSION

1. Criteria of neuro-developmentally normal high school students in the case of using DEMT as an index.

Table 7 shows 1) specificity of the general populatin of students, 2) false negative rate, and 3) error rate P. Five different levels of screening are indicated in the table.

The error rate P of each neuro-developmentally disordered group (except the B+MBD) was lower than 1.0% when the screening level was shifted to any level. The error rate P of B+MBD was not high either. When the screening level was placed at the level of 69.1 percentile, the error rate P of B+MBD indicated 0%.

Based upon the above mentioned data, the DEMT for high school students proved to be usable as a simple and objective index for the screening of neuro-developmentally normal students.

2. Criteria of neuro-developmentally normal high school students in the case of using DE-BGT for High School Students.

Table 8 shows 1) specificity 2) false negative rate, and 3) error rate P.

Five different levels of screening are also indicated in the table. Error rate P at any level of screening was

less than 1.0% except for B+MBD. In case of B+MBD, it fluctuates between 0% and 5.6% according to shifting screening level. When the screening level was placed at the level at which 69.1 percntile of general population of students pass the test, the error rate P even of B+MBD showed 0%.

Table 7 Changing percentages of error rate P (see below) when the screening level is shifted to various levels.

——In case of using DEMT as an index.——

screening level	specificity	Cerebral palsy(CP) n=71			mental retardation(MR) n=46			epilepsy(EP) n=48			borderline+minimal brain dysfunction(B+MBD) n=22		
		Pass	false % negative	error % rateP	Pass	false % negative	error % rateP	Pass	false % negative	error % rateP	Pass	false % negative	error % rateP
50 percentile M−0 S.D.	52.0	0	0	0	1	2.2	0.1	13	27.1	0.5	0	0	0
69.1 percentile M−0.5 S.D.	67.0	0	0	0	2	4.3	0.2	22	45.8	0.7	0	0	0
84.1 percentile M−1.0 S.D.	86.8	0	0	0	4	8.7	0.3	31	64.6	0.7	2	9.1	1.7
93.3 percentile M−1.5 S.D.	92.5	0	0	0	9	19.6	0.6	39	81.3	0.9	6	27.3	4.7
97.7 percentile M−2.0 S.D.	97.4	0	0	0	12	26.1	0.8	44	91.7	0.9	7	31.8	5.2

$$\text{Error rate P} = \frac{n \times m \times fn}{n \times sp} \times 100$$

n=number, m=morbidity rate among the normal students.

fn=false negative, sp=specificity

Morbidity rate : cerebral palsy(CP) 0.2%, mental retardation (MR) 3.0%, Epilepsy(EP) 1.0%, borderline plus minimal brain dysfunction(B+MBD) 16.0%

Table 8 Changing percentage of error rate P (see below) when the screening level is shifted to various levels.

——In case of using DE-BGT as an index.——

screening level	specificity	Cerebral palsy(CP) n=81			mental retardation(MR) n=36			epilepsy(EP) n=67			borderline+minimal brain dysfunction(B+MBD) n=21		
		Pass	false % negative	error % rateP	Pass	false % negative	error % rateP	Pass	false % negative	error % rateP	Pass	false % negative	error % rateP
50 percentile M+0 S.D.	39.9	0	0	0	0	0	0	15	22.4	0.6	0	0	0
69.1 percentile M+0.5 S.D.	68.2	1	1.2	0	0	0	0	25	37.3	0.5	0	0	0
84.1 percentile M+1.0 S.D.	82.0	8	9.9	0.2	2	5.6	0.2	36	53.7	0.7	1	4.8	0.9
93.3 percentile M+1.5 S.D.	92.5	23	28.4	0.1	3	8.3	0.3	51	76.1	0.8	5	23.8	4.1
97.7 percentile M+2.0 S.D.	95.5	29	35.8	0.1	5	13.9	0.4	56	83.6	0.9	7	33.3	5.6

$$\text{Error rate P} = \frac{n \times m \times fn}{n \times sp} \times 100$$

n=number, m=morbidity rate among the normal students.

fn=false negative, sp=specificity

Morbidity rate : cerebral palsy(CP) 0.2%, mental retardation (MR) 3.0%, Epilepsy(EP) 1.0%, borderline plus minimal brain dysfunction(B+MBD) 16.0%

DE-BGT also proved that it is an appropriate index usable as criteria for the screening of neuro-developmentally normal students. By shifting the screening level it will be possible to present fairly precise criteria of a normal students group. The term "normal students group" means it contains a very few neuro-developmentally disordered students.

Both DEMT and DE-BGT for High School Students were developed initially to screen the neuro-developmentally disordered students but in this study, it was proved that they were also good for use as indices to select normal students from a neuro-developmental viewpoint. The authors considered that the screening test for diseases can be used as the screening test for selecting normal children from the general population of children.

In general, three kinds of criteria of normal children are widely used by researchers: 1) etiological criteria of normal children (example: children having no abnormal prenatal, perinatal, and postnatal history are considered normal), 2) the criteria of normal children based upon the status praesens, or 3) criteria using both 1) and 2).

If the child has a problem on even one item of those criteria mentioned above , he is not considered as a normal child. However, it is almost impossible to survey the history of the child precisely and strictly. Therefore, ambiguous judgment of the history is a problem.

This study on criteria of normal children is based on the status praesens criteria.

Is it possible to determine the normal value of children with universal and ultra historical validity over time and place? Especially in the present changing society, it is clear that today's "normal value" may not be usable ten years later. Take the example of measured value of height and weight; there are great differences in the normal value between those measured in pre-war times and those measured in post war times. Therefore, it is important to keep the contemporary record of normal value to facilitate comparison between the present data and the future data.

This is a study on the methodology of research in pediatric neurology. It is natural for any pediatrician to show abnormal data of the children in comparison with the normal value , no matter what kind of test he administers. However, it is surprising to know that this normal value which should be based on the criteria of normal children often show ambiguities.

The authors admit that the method attempted in this study was arbitrary, but we proved that the criteria were fairly precice, objective, and quantitative excluding ambiguous expression. This study proved that the simple indices to screen the neuro-developmentally disordered are applicable as screening tests for selecting the normal control group efficiently from the general population of children without any extraneous procedures.

The authors consider that this is one of the developmental neuro-epidemiologic studies and that mass level medicine like this will contribute to such problems as setting up the criteria of normal children. Needless to say, the same kind of rsearch for younger children will become necessary.

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