Effectiveness Using of the Developmental Delay Screening Test in a Community, Korea

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Abstract

The purpose of this study is to examine the utility of developmental screening tests. I measured of developmental screening tests and compared with each test's validity. This study was conducted to investigate their developmental delay by four developmental screening tests - K-DIAL3, K-DDSTⅡ, K-CDI and K-ASQ. When a child was included in the developmental delay class through a latent class analysis, probability of being detected as developmental delay child was 82%, 70%, 67% and 56% in K-DIAL3, K-ASQ, K-CDI and K-DDSTⅡ respectively. Positive predictive values were 86%, 59%, 58% and 54% in K-DIAL3, K-ASQ, K-DDSTⅡ and K-CDI respectively and those of combination of two of them were 95%~78% respectively. As Developmental delay positive rates of screening tests were high, more active measures such as exact diagnosis and appropriate management were needed and it was suggested that to improve efficacy of developmental screening tests of detecting developmental delay children two or more than one be used.

Keywords: *Effectiveness of Developmental Screening Tests, Developmental delay, Child's Development*

1. Introduction

Since it is predicted that reduction of population of children will lead to reduction of production population, and reduction of national competitiveness, values of healthy children become prominent from the aspect of demographic economy. Interest in healthy children required changes of the government policy from treatment of diseases to prevention of diseases and from January 1, 2008, according to the regulation of article 47 of the 'National Health Insurance Act,' article 26 of the Enforcement Ordinance and article 14 of 'Medical Wage Law' health tests of infants & children under full six years old among the object people of health tests were carried out [1, 2].

Results of tests of children development enable early mediation by early diagnoses and mediatory approach during a stage when nervous system is not yet matured can alleviate problems of developmental delay or enhance the possibility to progress into normal development. In addition, if it is possible to diagnose causes of development delay accurately, it is possible to prevent so that no further delay is created and effects of stress reduction regarding disability among members of families and reduction of home economy and medical cost are very high [3, 4].

Therefore, screening test tools are being used importantly in children developmental screening tests as a standard for distinguishing children with potential delay of development or disabilities [5]. In consideration of the characteristics of developmental screening tests,

many researchers study and report validity, reliability and biological marker of test tools for effectively screening children with delay of development and are developing tools in compliance with the object people and the purpose of screening [6]. At present, in Korea, we use by translating or standardizing foreign developmental screening test tools and researches on developing Korean type developmental screening tests are being carried out but we need more time and verification for actual use [7].

There a lots of theories and clinical debates with regard to whether early evaluation of screening tests predicts development delay accurately or not and also researches whether sensitivity and specificity, over referral (false positive) and under referral (false negative) can predict development delay well or not are also continuing [8]. However, since reasonable prediction according to initial evaluation or without initial evaluation is not clear, researchers are reporting various research results individually and inconsistent research results are being suggested due to each different screening test and measurement condition [7, 8].

In order to increase utility of children developmental screening tests, each tool must be used in compliance with the object people of screening or purpose of screening while considering advantage & disadvantage of the test tools. In addition, tests must be carried out in consideration of sensitivity, specificity and errors of development test tools but since there are differences according to characteristic each tool has and also prediction is different regarding screening effect of development delay, as a method to increase screening effect, researches on feasibility and positive predictive value of test tools regarding use of screening test tools are being required. A latent class analysis is a statistical method which classifies potential classes with values of several observation variables and which finds out relations between each observation variable and potential classes and in this study, a latent class analysis was used for confirming utility regarding screening test tools [9].

This study carries out validity of developmental screening tests of 3-5 years old children in K-DIAL3, K-DDSTⅡ, K-CDI, and K-ASQ in consideration of characteristics of group of the object people before school ages and using a latent class analysis method, screening effects according to combination of screening tests and positive predictive values of screening tests were compared. These research results can be suggested as basic data for the prevention policy regarding infant-child health screening test projects.

2. Methods

2.1. Setting and Population

This study had 229 children of 3-5 years old (36 months-60 months), who were born from February 29, 2003 to February 29, 2005, as the object people. Finally recovered questionnaires out of guardians Q&A type questionnaires distributed to total 290 people were 235 and total 229 people of 120 male and 109 female were selected as final object people of the analysis by excluding six people due to inappropriateness of their answers.

Object organizations of the study were nurseries located in CheongJu city of Chungcheongbuk-Do and out of total 230 nurseries, we explained about research purpose, research goal, screening test, questionnaires and test methods and requested cooperation to 23 nurseries which were about 10% of the total number of nurseries and 16 nurseries decided to participate.

2.2. Data Source and Extraction

Data was collected papers were distributed before the survey under the consents of managers of nurseries which agreed to the purpose of the research and the papers were recovered later. With children, who received consent papers of their guardians, as the objects, surveyors visited children's homes and had interviews of K-DIAL3 and K-DDSTⅡ for the survey. K-CDI and K-ASQ, which are guardians Q&A type questionnaires, were also sent to homes and were collected later.

2.3. Measures

Evaluation tools used in this study are types of surveyors K-DIAL3 and K-DDSTⅡ were used. As Q&A type questionnaires for guardians, K-CDI and K-ASQ were used.

K-DIAL3 Is a Korean revision edition of Developmental Indicators for the Assessment of Learning-Revised (DIAL-R) and it was standardized with the object of 1,560 people to select five developmental fields required at the draft of revision law of 1997 the US Individuals with Disabilities Education Act (IDEA) [10]. K-DIAL3 was translated into Korean by Byeong-Un Chun and et al and the object age was full 3-6 years old [11]. Test-retest reliability of K-DIAL3 was 0.92~0.96 and internal consistency was 0.82. Total time required for the test was about 20-30 minutes [12].

K-DDSTⅡ is a revision edition of DDST developed in 1967 and was developed by Frankburg in 1990. DDSTⅡ is a tool used the most widely in the world currently and the object age was from full two weeks up to six years old. K-DDSTⅡ was developed by re-standardization research in 2002 and is composed of a total 110 questions. Test-retest reliability of K-DDSTⅡ was 0.90 and internal consistency was reported as 0.99 [13, 16].

K-CDI is a questionnaire developed to evaluate children between 15 months and six years old and is composed of 270 questions regarding social, self-help behavior, large muscle exercise, small muscle exercise, language expression, language understanding, letter and number fields and additional 30 questions regarding various senses, physical constitutions, exercise, and linguistic symptoms of young children. Implementation time of CDI questionnaires was about 20~30 minutes according to age and internal consistency regarding questions was 0.70 and test-retest reliability was from 0.81 to 0.96 [17, 18].

ASQ is a method parents prepare and was developed by Oregon University for judging infants & children. Development fields for evaluation are composed of total 30 questions in division of five fields such as communication, macro movement exercise, micro movement exercise, problems-solving, and individual-society. In Korea, Seoul Welfare Hall for Individuals with Disabilities has published and it was used and the use time was about 10-15 minutes and interpretation time of the result required about 2 minutes. Test-retest reliability of K-ASQ was 0.94 and standard error of measurement was 0.10 [19, 21].

2.4. Data Analysis

In this study, a latent class analysis was used in calculating positive predictive values of developmental screening tests. A latent class analysis is generally used in classifying respondent groups as a subcategory in multivariate scope data and is a method completed by Goodman in 1972 after it was first introduced by Lazasfeld in 1950 [7, 21]. A latent class analysis can be used additionally together with feasibility verification when we want to estimate diagnoses or positive rate accurately. In addition, it is appropriate when there is no standard test or an accurate diagnostic test and it also has advantage to suggest probabilistic

information about which potential class shall related objects belong based on observed categorical data [7]. Regarding development delay and normal children class established through a latent class analysis, a positive predictive value was obtained in finding out how effectively the results of each screening test can predict [21].

3. Results

3.1. Sample Characteristics

The age of the children who participated in the study was 36-41 months 42 (18.3%), 42-47 months 68 (29.7%), 48-53 months 53 (23.2%), 54-62 months 66 (28.8%) and subject's gender was mans 120 (52.4%), females 109 (47.6) (Table 1).

Table 1. Sample Characteristics

characteristics		No(%)
Age(months)	36-41	42(18.3)
	42-47	68(29.7)
	48-53	53(23.2)
	54-60	66(28.8)
Gender	Male	120(52.4)
	Female	109(47.6)
Birth order	First	119(52.0)
	Second	98(42.8)
	Third	12(5.2)
Total		229(100)

Family member of this study was frequently 4 ones 142 (62%), more 5 ones 50 (24.9%), 3 ones less than 30 (13.1%). Father ages was below 34 years old 97 (42.3%), above 35 years old 132 (57.7%), maternal ages were below 34 years old 159 (69.5%), above 35 years old 70 (30.5%). Parent's education was both highest above college and family income was the more above 3,000,000 won 105 (45.5%) (Table 2).

Table 2. Family Characteristics of Subjects

Family characteristics		No(%)
Family number	≤3	30(13.1)
	4	142(62.0)
	≥5	50(24.9)
Religion	Yes	113(49.3)
	No	116(50.7)
Age of father	≤34	97(42.3)
	≥35	132(57.7)

Age of mother	≤34	159(69.5)
	≥35	70(30.5)
Father's education	≤High school graduate	72(31.4)
	≥College graduate	157(68.6)
Mother's education	≤High school graduate	101(44.1)
	≥College graduate	128(55.9)
Family income (10,000 Won)	≤200	46(20.1)
	201-300	78(34.4)
	≥301	105(45.5)
Total		229(100)

3.2. Developmental Delay Positive Rate of Individual Screening Tests

Developmental delay positive rate of individual screening test were K-DIAL3 69 (30.1%), K-DDSTⅡ 70 (30.6%), K-CDI 90 (39.3%), and K-ASQ 86 (37.6%) (Table 3).

3.3. Positive Predictive Rate of Developmental Screening Tests Using Latent Class Analysis

As the result of implementing a latent class analysis using the results of four screening tests, it was found out that a model designating the potential classes into two was in a good conformity with the analyses. Probability to be classified as a delay of development class among the two potential classes was 0.32% and probability to be classified as a normal development potential class was 0.68%. When children belong to a delay class, the probability to be screened as a delay in each test was 82% in K-DIAL3, 70% in K-ASQ, 67% in K-CDI and 56% in K-DDSTⅡ. On the contrary, when children belong to a normal class, the probability to be screened as normal in the results of the test was in a sequent order of 94% in K-DIAL3, 81% in K-DDSTⅡ, 77% in K-ASQ and 73% in K-CDI (Table 4).

Table 3. Developmental Delay Cases of Subjects by each Tests

Test	Developmental area	Frequency N(%)	
		Delay	Normal
K-DIAL3(5%)	Motor	28(12.2)	201(87.8)
	Cognition	16(7.0)	213(93.0)
	Language	25(10.9)	204(89.1)
	Motor+Cognition+Language	18(7.9)	211(92.1)
	Self-care	19(8.3)	210(91.7)
	Social	21(9.2)	208(90.8)

	Total(delayed children)	69(30.1)	160(69.9)
K-DDSTⅡ(10%)	Social-personal	26(11.4)	203(88.6)
	Fine-motor	25(10.9)	204(89.1)
	Language	18(7.9)	211(92.1)
	Gross-motor	33(14.4)	196(85.6)
	Total(delayed children)	70(30.6)	159(69.4)
K-CDI(2%)	Social	55(24.0)	174(76.0)
	Self-help	20(8.7)	209(91.3)
	Gross-motor	20(8.7)	209(91.3)
	Fine-motor	10(4.4)	219(95.6)
	Expressive	41(17.9)	188(82.1)
	Comprehension	19(8.3)	210(91.7)
	Letters	19(8.3)	210(91.7)
	Numbers	13(5.7)	216(94.3)
	Total(delayed children)	90(39.3)	139(60.7)
K-ASQ(10%)	Communication	29(12.7)	200(87.3)
	Gross motor	21(9.2)	208(90.8)
	Fine motor	13(5.7)	216(94.3)
	Problem-solving	54(23.6)	175(76.4)
	Personal/social	10(4.4)	219(95.6)
	Total(delayed children)	86(37.6)	143(62.4)

Table 4. Class Probabilities Rate as the 2 Class Model

Result of tests\ Latent class		Delay[c]	Normal[d]
Latent class probabilities		0.32	0.68
K-DIAL3	Fail[a]	0.82	0.05
	Pass[b]	0.17	0.94
K-DDSTⅡ	Fail	0.56	0.18
	Pass	0.43	0.81
K-CDI	Fail	0.67	0.26
	Pass	0.32	0.73
K-ASQ	Fail	0.70	0.22
	Pass	0.29	0.77

x^2=10.625, df=6, p>.05.
[a]Fail: screening cases of tests results as delay,
[b]Pass: screening cases of tests results as normal,
[c]Delay: latent class of developmental delay,
[d]Normal: latent class of normal developmental.

Probability to be a development delay when it was screened as a delay in the results of the test was 86% in K-DIAL3, 59% in K-ASQ, 58% in K-DDSTⅡ and 54% in K-CDI. As the result, probability for a single result of K-DIAL3 to predict as a development delay was higher than K-DDSTⅡ, K-CDI and K-ASQ (Table 5).

Table 5. Probability of Being Included in Developmental Delay Class in a Single Test

Test	Delay[c] predict rate	
	Fail[a]	Pass[b]
K-DIAL3	0.86	0.07
K-DDSTⅡ	0.58	0.19
K-CDI	0.54	0.16
K-ASQ	0.59	0.14

[a]Fail: screening cases of tests results as delay,
[b]Pass: screening cases of tests results as normal,
[c]Delay: latent class of developmental delay.

As the result of screening as a delay in the results of the two tests of K-DIAL3 & K-DDSTⅡ and K-DIAL3 & K-ASQ, probability to be classified as a development delay was 95%, in K-DIAL3 and K-CDI it was 94%, in K-DDST & K-ASQ, it was 81%, in K-DDST & K-CDI and K-CDI& K-ASQ, it was 78% (Table 6).

Table 6. Probability of Being Included in Developmental Delay Class in a Two Type Tests

	Delay[c] predict rate	
Test 1 & Test 2	Fail& Fail[a]	Pass & Pass[b]
K-DIAL3 & K-DDSTⅡ	0.95	0.04
K-DIAL3 & K-CDI	0.94	0.03
K-DIAL3 & K-ASQ	0.95	0.03
K-DDSTⅡ& K-CDI	0.78	0.09
K-DDSTⅡ& K-ASQ	0.81	0.08
K-CDI & K-ASQ	0.78	0.07

[a]Fail: screening cases of tests results as delay,
[b]Pass: screening cases of tests results as normal,
cDelay: latent class of developmental delay.

4. Discussion

Diseases during the period of infants & children are difficult to cure and possibility of becoming children with disabilities in a long-term is high as the period of health examination is being delayed. And mediation must be taken at a proper period because of problems of scholastic achievements and education as well as problems of non-adaptation to the society[2]. For an effective approach from the aspect of cost efficiency of developmental screening tests, researches on the use of screening tests are being required.

As the results of reviewing validity by changing each test of K-DIAL3, K-DDST, K-CDI, and K-ASQ as a standard test, specificity of each test was higher than sensitivity. This result means that ratio to screen children screened as normal children is higher than ratio of screening children of actual delay of development among children screened as a development delay. A good development screening tool is a tool with sensitivity and specificity between 70-90% and the specificity for a single field such as language is over 80% [22, 23]. Eui-Sun Shin and et al have verified feasibility of K-DDST test based on Bayley Scales of Infant Development-II with the objects of children of 5 months-72 months who visit hospitals [14]. As the result, in the Bayley Scales of Infant Development-II test, sensitivity and specificity

with mental development index appeared as 0.87 and 0.62 and sensitivity and specificity with exercise index appeared as 0.83 and 0.51 and there were differences with this study [24]. However, as other data regarding sensitivity and specificity with Denver-II, request of diagnoses for children having suspicious results was very small number and since its validity appeared in a low sensitivity of 56% and a high specificity of 80% [25], it showed a similar result like this study. Developmental screening tests among many researches were to correctly distinguish a small number of infants & children among the object of infants & children and as the result, it was suggested that K-DDST has a problem in balance between sensitivity and specificity [21]. When below 2 standard deviation in the validity of K-ASQ was set as a cutoff point, it was reported that sensitivity was 75% and specificity was 68% and this is a result which has a little difference from the result of this study [15, 20]. In addition, as another research, in a research verifying feasibility of ASQ and CDI based on Battelle Development Inventory, sensitivity was 0.67 and 0.50 and specificity was 0.39 and 0.86 and the result for CDI was similar to the result of this study. In addition, as positive predictive values were 34% and 50%, they were relatively similar to the result of this study [25].

Positive predictive values of delay of development used a latent class analysis based on the results of each test [26]. By dividing children of delay of development and normal children into dependent variables, values screened as normal and delay in developmental screening test with the object people of each test were used as independent variables. As the result, probability to screen as a delay in case children are classified as a development delay in screening test was in a sequent order of K-DIAL3 (82%), K-ASQ (70%), K-CDI (67%), and K-DDST (56%). K-DDST had a lower prediction rate regarding children of delay of development and rather prediction rate (81%) regarding normal children was higher. This is the result that is not complied with the purpose that the developmental screening tests have to distinguish children of delay of development from normal children [27, 28].

In case of using a single developmental screening test, probability to predict development delay, when it was screened as a delay, was 86% only in K-DIAL3 and other tests predicted 54-59% [7]. In addition, in case of using a two test tools, all predicted development delays were over 90% except K-DDST and K-ASQ were 81%, K-DDST & K-CDI and K-CDI& K-ASQ were 78%. Therefore, in case of conducting development screening evaluations, it is predicted to screen development delay better when using more than two tests together than one test but efficient screening tool must be established in order to reduce cost according to the use of tests.

As limits of this study, first, there was a limit in recruiting the object people of the study because only children of 3-5 years old (36-60 months) visiting nurseries were selected as the object. Therefore, it is difficult to generalize by representing only 3-5 years old children. Second, since positive predictive values were obtained from the results of developmental screening tests of children of delay of development and normal children, it will be difficult to generalize the result. In addition, because the secondary diagnoses evaluation of children classified as a development delay was not carried out in this study, it was not investigated what diseases include development delay. Therefore, in the future researches, researches on prediction of obstacles diagnoses of children with development delay and a positive rate for general delay of development must be carried out continuously.

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