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Usefulness of the Korean Developmental Screening Test for infants and children for the evaluation of developmental delay in Korean infants and children: a single-center study

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Purpose: To evaluate the usefulness of the Korean Developmental Screening Test (K-DST) for infants and children for developmental delay assessment.

Methods: This study was based on retrospective studies of the results of the K-DST, Preschool Receptive-Expressive Language Scale (PRES), Sequenced Language Scale for Infants (SELSI), Childhood Autism Rating Scale (CARS), Modified Checklist for Autism in Toddlers (M-CHAT), electroencephalography, magnetic resonance imaging, and extensive tests conducted in 209 of 1,403 patients, of whom 758 underwent the K-DST at the Korea University Guro Hospital between January 2015 and December 2016 and 645 were referred from local clinics between January 2015 and June 2016.

Results: Based on the K-DST results, the male children significantly more frequently required further or follow-up examination than the female children in most test sections, except for gross motor. The male children had notably lower mean scores than the female children. The PRES/SELSI results showed that when more further or follow-up evaluations were required in the K-DST communication section, significantly more problems in language delay or disorder emerged. When further or follow-up evaluation was required in the cognitive section in the CARS/M-CHAT, the possibility of autism increased significantly. A child tended to score low in the CARS test and show autism when further or follow-up evaluation was recommended in the K-DST.

Conclusion: This study demonstrated the usefulness of the K-DST as a screening test early in the development of infants and children in Korea. Data of normal control groups should be examined to determine the accuracy of this investigation.

Key words: Korean Developmental Screening Test, Screening test, Growth and development, Infant, Child

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Introduction

The Korean Developmental Screening Test (K-DST) is a recent screening test developed in September 2014 to verify whether infants in Korea have a standard development in the domains of gross motor, fine motor, cognition, communication, social interaction, and self-control[1].

A developmental delay, which is a disorder frequently discovered among 5% to 10% of the entire child population, including school-aged children[2,3], and 1% to 3% of infants under the age of 5 years[4-6], is one of the most important health issues among children. However, in cases where the developmental delay is not severe, it is difficult not only to detect such in early stages but also to diagnose the cause in advance. Because early interventions, such as

early education and rehabilitation service and treatment, can be provided if an exact cause is diagnosed in advance, it is crucial that an appropriate screening service is provided[6–11]. The Korean government also realized that an early detection of developmental delays among infants and children is crucial for a better prognosis and earlier rehabilitation therapy[1,5,12,13]. To achieve this purpose, the government has started a national health screening program for infants and children in Korea[1,14–16] and the K-DST has been used for developmental screening. Therefore, the usefulness of the K-DST was investigated via a cross-tabulation analysis between the K-DST results and those of other tests, such as detailed language tests (Preschool Receptive-Expressive Language Scale [PRES] and Sequenced Language Scale for Infants [SELSI]), Childhood Autism Rating Scale (CARS), Modified Checklist for Autism in Toddlers (M-CHAT), electroencephalography (EEG), and magnetic resonance imaging (MRI); further, the necessity of appropriate specific complete medical examination and follow-up evaluation was examined.

Materials and methods

1. Study participants

There were 758 infants and children who visited Korea University Guro Hospital for the National Health Screening Test between January 2015 and December 2016 and 645 who were referred to Korea University Guro Hospital between January 2015 and June 2016 from local clinics due to developmental problems. Among the 1,403 infants and children, 209 (127 boys and 82 girls) were included in this study; they required further evaluations after undergoing the K-DST.

2. Study design

According to the K-DST manual, we categorized the participants into 3 groups: the further evaluation, follow-up evaluation, and peer & high-level groups. A specific complete medical examination was selectively conducted on some patients among the further evaluation or follow-up evaluation group. A specific complete medical examination using an optimized version for each child was conducted on the patient group and was selectively chosen among tests, such as the PRES[17], SELSI[18], Korean Bayley Scales of Infant Development II, Korean-Wechsler Preschool and Primary Scale of Intelligence, Social Maturity Scale, auditory test, CARS, M-CHAT, MRI, EEG, and chromosome study. This study mainly focused on the PRES/SELSI, CARS, M-CHAT, MRI, and EEG.

The PRES/SELSI was conducted on a total of 34 infants and children. This group was categorized into 5 subgroups depending on the test results: relatively high in language development, normal, minor developmental delay, developmental delay, and language disorder. This categorization was cross analyzed using the Pearson chi-square test against the three stages of the K-DST: further evaluation, follow-

up evaluation, and peer & high-level groups. Thereafter, the result was further verified using the Fisher exact test.

The CARS test was conducted on a total of 24 infants and children. This group was categorized into 3 subgroups depending on the test results: no autism, mild to moderate autism, and severe autism.

The M-CHAT was conducted on a total of 24 infants and children. This group was categorized into 2 subgroups depending on the test results: no autism and autism suspected.

We reviewed the charts retrospectively and described the quantitative data of the discrete variables as frequencies with percentiles.

3. Statistics

Each categorization was cross analyzed using the Pearson chi-square test against the 3 stages of the K-DST. Thereafter, the result was further verified using the Fisher exact test. We used the IBM SPSS Statistics ver. 20.0 (IBM Co., Armonk, NY, USA) for the data processing.

Table 1. Number of cases according to age and sex (n=209)

Study group age	Age (mo)	Sex, n (%)		Total
		Male	Female	
1st (4–6 mo)	4–6	3 (75.0)	1 (25.0)	4
	6–7	3 (75.0)	1 (25.0)	4
	Total	6 (75.0)	2 (25.0)	8
2nd (9–12 mo)	8–9	4 (30.8)	9 (69.2)	13
	10–11	15 (48.4)	16 (51.6)	31
	12–13	13 (61.9)	8 (38.1)	21
	14–15	1 (50.0)	1 (50.0)	2
	16–17	1 (50.0)	1 (50.0)	2
	Total	34 (49.3)	35 (50.7)	69
3rd (18–24 mo)	18–19	8 (53.3)	7 (46.7)	15
	20–21	6 (66.7)	3 (33.3)	9
	22–23	2 (22.2)	7 (77.8)	9
	24–26	10 (71.4)	4 (28.6)	14
	27–29	3 (100)	0 (0)	3
	Total	29 (58.0)	21 (42.0)	50
4th (30–36 mo)	30–32	14 (87.5)	2 (12.5)	16
	33–35	7 (63.6)	4 (36.4)	11
	36–41	10 (66.7)	5 (33.3)	15
	Total	31 (73.8)	11 (26.2)	42
5th (42–48 mo)	42–47	8 (61.5)	5 (38.5)	13
	48–53	3 (75.0)	1 (25.0)	4
	Total	11 (64.7)	6 (35.3)	17
6th (54–60 mo)	54–59	8 (88.9)	1 (11.1)	9
	60–65	2 (66.7)	1 (33.3)	3
	Total	10 (83.3)	2 (16.7)	12
7th (66–71 mo)	66–71	6 (54.5)	5 (45.5)	11
Total		127 (60.8)	82 (39.2)	209

Table 2. Results of the K-DST for infants and children

Development level	Gross motor	Fine motor	Cognition	Communication	Social interaction	Self-control
Further evaluation	53 (25.4)	36 (17.2)	36 (17.2)	58 (27.8)	40 (19.1)	23 (17.3)
Follow-up evaluation	56 (26.8)	66 (31.6)	56 (26.8)	63 (30.1)	67 (32.1)	42 (31.6)
Peer and high	100 (47.8)	107 (51.2)	117 (56.0)	88 (42.1)	102 (48.8)	68 (51.1)
Total	209 (100)	209 (100)	209 (100)	209 (100)	209 (100)	133 (100)

Values are presented as number (%).
K-DST, Korean Developmental Screening Test.

Table 3. Checkpoint distribution of the K-DST level by sex

Category	Development level	Male	Female	Total, n (%)	P value
Gross motor	Further evaluation	29 (22.8)	24 (29.3)	53 (25.4)	0.597
	Follow-up evaluation	35 (27.6)	21 (25.6)	56 (26.8)	
	Peer & high	63 (49.6)	37 (45.1)	100 (47.8)	
	Total	127 (100)	82 (100)	209 (100)	
Fine motor	Further evaluation	29 (22.8)	7 (8.5)	36 (17.2)	0.028
	Follow-up evaluation	38 (29.9)	28 (34.1)	66 (31.6)	
	Peer & high	60 (47.3)	47 (57.4)	107 (51.2)	
	Total	127 (100)	82 (100)	209 (100)	
Cognition	Further evaluation	29 (22.8)	7 (8.5)	36 (17.2)	0.001
	Follow-up evaluation	39 (30.7)	17 (20.8)	56 (26.8)	
	Peer & high	59 (46.5)	58 (70.7)	117 (56.0)	
	Total	127 (100)	82 (100)	209 (100)	
Communi-cation	Further evaluation	51 (40.2)	7 (8.5)	58 (27.8)	<0.001
	Follow-up evaluation	39 (30.7)	24 (29.3)	63 (30.1)	
	Peer & high	37 (29.1)	51 (62.2)	88 (42.1)	
	Total	127 (100)	82 (100)	209 (100)	
Social interaction	Further evaluation	32 (25.2)	8 (9.8)	40 (19.1)	<0.001
	Follow-up evaluation	51 (40.2)	16 (19.5)	67 (32.1)	
	Peer & high	44 (34.6)	58 (70.7)	102 (48.8)	
	Total	127 (100)	82 (100)	209 (100)	
Self-control	Further evaluation	19 (21.6)	4 (8.9)	23 (17.3)	0.029
	Follow-up evaluation	31 (35.2)	11 (24.4)	42 (31.6)	
	Peer & high	38 (43.2)	30 (66.7)	68 (51.1)	
	Total	88 (100)	45 (100)	133 (100)	

K-DST, Korean Developmental Screening Test.

Table 4. Mean scores by sex and standard deviations based on the K-DST score

Category	Sex	Number	Mean±SD	P value
Gross motor	Male	127	15.38±6.36	0.572
	Female	82	14.87±6.43	
Fine motor	Male	127	15.64±5.90	0.001
	Female	82	17.99±4.57	
Cognition	Male	127	14.58±6.33	<0.001
	Female	82	18.17±4.70	
Communication	Male	127	11.39±7.33	<0.001
	Female	82	16.32±5.68	
Social interaction	Male	127	12.71±5.65	<0.001
	Female	82	17.46±4.76	
Self-control	Male	88	14.55±5.37	0.008
	Female	45	17.13±4.95	

K-DST, Korean Developmental Screening Test; SD, standard deviation.

1st (4–6 months), 2nd (9–12 months), 3rd (18–24 months), 4th (30–36 months), 5th (42–48 months), 6th (54–60 months), and 7th (66–71 months). According to the K-DST results, we divided the entire group into 3 categories: further evaluation, follow-up evaluation, and peer & high-level. Approximately half of the group was categorized into the peer & high-level group. The remaining children required further or follow-up evaluation (Table 2). The percentage of the patients who required follow-up evaluations was ~30% in all the six K-DST sections.

The proportion of the male patients who required further evaluation and follow-up evaluation was significantly high compared with that of the female patients in the areas of fine motor, cognition, communication, social interaction, and self-control (Table 3). For the ratio of patients who required further evaluations, the number of the male children was 4 to 7 (communication) times higher than that of the female children.

The scores of the female patients in the areas of fine motor, cognition, communication, social interaction, and self-control were significantly high compared with those of the male patients (Table 4). The average score of the female patients was 2 to 5 points (communication and social interaction) higher than that of the male patients.

In the K-DST and combined language in the PRES/SELSI, the grade of communication showed significant results in combined

4. Ethics statement

The study was approved by the Institutional Review Board of Korea University Guro Hospital (approval number: KUGH17041-001). Informed consent was waived by the board.

Results

Of the 209 patients, 127 (60.8%) were boys, and 82 (39.2%) were girls (Table 1). Each case was categorized into 7 groups by the national health screening program for infants and children in Korea:

language (Table 5) (*P*<0.05). Although not illustrating a significant result in combined language via the Fisher exact test, the grade of cognition showed a decreasing linear trend as a follow-up or further evaluation requirement was drawn on the basis of the K-DST results (*P*=0.103; Linear-by-Linear Association, 0.003).

In the K-DST and expressive language in the PRES/SELSI, the grade of communication showed significant results in expressive language (Table 6) (*P*<0.05). Although not illustrating a significant result in expressive language via the Fisher exact test, the grade of cognition showed a decreasing linear trend as a follow-up or further evaluation requirement was drawn on the basis of the K-DST results (*P*=0.143; Linear-by- Linear Association, 0.005).

In the K-DST and receptive language in the PRES/SELSI, the grade of cognition and communication showed significant results in receptive language (Table 7) (*P*<0.05).

In the CARS test, the grade of cognition showed a decreasing linear trend as a follow-up or further evaluation requirement was drawn on the basis of the K-DST results, without illustrating a significant result in the Fisher exact test (Table 8) (*P*=0.471; Linear-by-

Linear Association, 0.078).

The grade of social interaction showed a decreasing linear trend as a follow-up or further evaluation requirement was drawn on the basis of the K-DST results, without also illustrating a significant result in the Fisher exact test (*P*=0.464; Linear-by-Linear Association, 0.077).

The grade of cognition showed a significant result in the M-CHAT (Table 9) (*P*<0.05). The grade of social interaction showed a decreasing linear trend as a follow-up or further evaluation requirement was drawn on the basis of the K-DST results, without illustrating a significant result in the Fisher exact test (*P*=0.070; Linear-by-Linear Association, 0.038).

Eight children who underwent test showed abnormal EEG. Moreover, 5 out of 8 was diagnosed epilepsy and one with infantile spasm. Six children showed abnormal MRI, such as brain tumor or ventriculomegaly.

As for the patients who required detailed examinations due to abnormal findings, the implementation rate was very low (92 of 209) owing to follow-up loss. This may be because of the costs of the

Table 5. Cross-tabulation analysis between the grades in each test item in the K-DST and combined language

Category	Development level	Combined language, n (%)					Total	P value
		Relatively high	Normal	Minor developmental delay	Developmental delay	Language disorder		
Gross motor	Further evaluation	0 (0)	0 (0)	2 (50.0)	1 (25.0)	1 (25.0)	4 (100)	0.925
	Follow-up evaluation	0 (0)	2 (20.0)	2 (20.0)	5 (50.0)	1 (10.0)	10 (100)	
	Peer & high	1 (5.0)	2 (10.0)	5 (25.0)	9 (45.0)	3 (15.0)	20 (100)	
	Total	1 (2.9)	4 (11.8)	9 (26.5)	15 (44.1)	5 (14.7)	34 (100)	
Fine motor	Further evaluation	0 (0)	0 (0)	4 (28.6)	6 (42.9)	4 (28.6)	14 (100)	0.377
	Follow-up evaluation	0 (0)	2 (18.2)	3 (27.3)	5 (45.5)	1 (9.1)	11 (100)	
	Peer & high	1 (11.1)	2 (22.2)	2 (22.2)	4 (44.4)	0 (0)	9 (100)	
	Total	1 (2.9)	4 (11.8)	9 (26.5)	15 (44.1)	5 (14.7)	34 (100)	
Cognition	Further evaluation	0 (0)	0 (0)	4 (23.5)	8 (47.1)	5 (29.4)	17 (100)	0.103
	Follow-up evaluation	0 (0)	2 (22.2)	3 (33.3)	4 (44.4)	0 (0)	9 (100)	(0.003)*
	Peer & high	1 (12.5)	2 (25.0)	2 (25.0)	3 (37.5)	0 (0)	8 (100)	
	Total	1 (2.9)	4 (11.8)	9 (26.5)	15 (44.1)	5 (14.7)	34 (100)	
Communication	Further evaluation	0 (0)	1 (4.0)	6 (24.0)	13 (52.0)	5 (20.0)	25 (100)	0.007
	Follow-up evaluation	0 (0)	1 (16.7)	3 (50.0)	2 (33.3)	0 (0)	6 (100)	
	Peer & high	1 (33.3)	2 (66.7)	0 (0)	0 (0)	0 (0)	3 (100)	
	Total	1 (2.9)	4 (11.8)	9 (26.5)	15 (44.1)	5 (14.7)	34 (100)	
Social interaction	Further evaluation	0 (0)	1 (6.7)	3 (20.0)	7 (46.7)	4 (26.7)	15 (100)	0.403
	Follow-up evaluation	0 (0)	1 (9.1)	3 (27.3)	6 (54.5)	1 (9.1)	11 (100)	
	Peer & high	1 (12.5)	2 (25.0)	3 (37.5)	2 (25.0)	0 (0)	8 (100)	
	Total	1 (2.9)	4 (11.8)	9 (26.5)	15 (44.1)	5 (14.7)	34 (100)	
Self-control	Further evaluation	0 (0)	0 (0)	2 (20.0)	4 (40.0)	4 (40.0)	10 (100)	0.355
	Follow-up evaluation	0 (0)	1 (14.3)	2 (28.6)	4 (57.1)	0 (0)	7 (100)	
	Peer & high	1 (6.7)	3 (20.0)	5 (33.3)	5 (33.3)	1 (6.7)	15 (100)	
	Total	1 (3.1)	4 (12.5)	9 (28.1)	13 (40.6)	5 (15.6)	32 (100)	

K-DST, Korean Developmental Screening Test.
*Linear-by-Linear Association.

Table 6. Cross-tabulation analysis between the grades in each test item in the K-DST and expressive language

Category	Development level	Expressive language, n (%)					Total	P value
		Relatively high	Normal	Minor developmental delay	Developmental delay	Language disorder		
Gross motor	Further evaluation	0 (0)	0 (0)	2 (50.0)	1 (25.0)	1 (25.0)	4 (100)	0.961
	Follow-up evaluation	0 (0)	1 (10.0)	3 (30.0)	5 (10.0)	1 (10.0)	10 (10.0)	
	Peer & high	0 (0)	2 (10.0)	6 (30.0)	9 (45.0)	3 (15.0)	20 (100)	
	Total	0 (0)	3 (8.8)	11 (32.4)	15 (44.1)	5 (14.7)	34 (100)	
Fine motor	Further evaluation	0 (0)	0 (0)	4 (28.6)	6 (42.9)	4 (28.6)	14 (100)	0.448
	Follow-up evaluation	0 (0)	1 (9.1)	4 (36.4)	5 (45.5)	1 (9.1)	11 (100)	
	Peer & high	0 (0)	2 (22.2)	3 (33.3)	4 (44.4)	0 (0)	9 (100)	
	Total	0 (0)	3 (8.8)	11 (32.4)	15 (44.1)	5 (14.7)	34 (100)	
Cognition	Further evaluation	0 (0)	0 (0)	4 (23.5)	8 (47.1)	5 (29.4)	17 (100)	0.143
	Follow-up evaluation	0 (0)	1 (11.1)	4 (44.4)	4 (44.4)	0 (0)	9 (100)	(0.005)*
	Peer & high	0 (0)	2 (25.0)	3 (37.5)	3 (37.5)	0 (0)	8 (100)	
	Total	0 (0)	3 (8.8)	11 (32.4)	15 (44.1)	5 (14.7)	34 (100)	
Communication	Further evaluation	0 (0)	0 (0)	7 (28.0)	13 (52.0)	5 (20.0)	25 (100)	0.013
	Follow-up evaluation	0 (0)	1 (16.7)	3 (50.0)	2 (33.3)	0 (0)	6 (100)	
	Peer & high	0 (0)	2 (66.7)	1 (33.3)	0 (0)	0 (0)	3 (100)	
	Total	0 (0)	3 (8.8)	11 (32.4)	15 (44.1)	5 (14.7)	34 (100)	
Social interaction	Further evaluation	0 (0)	0 (0)	4 (26.7)	7 (46.7)	4 (26.7)	15 (100)	0.092
	Follow-up evaluation	0 (0)	0 (0)	4 (36.4)	6 (54.5)	1 (9.1)	11 (100)	
	Peer & high	0 (0)	3 (37.5)	3 (37.5)	2 (25.0)	0 (0)	8 (100)	
	Total	0 (0)	3 (8.8)	11 (32.4)	15 (44.1)	5 (14.7)	34 (100)	
Self-control	Further evaluation	0 (0)	0 (0)	2 (20.0)	4 (40.0)	4 (40.0)	10 (100)	0.180
	Follow-up evaluation	0 (0)	0 (0)	3 (42.9)	4 (57.1)	0 (0)	7 (100)	
	Peer & high	0 (0)	3 (20.0)	6 (40.0)	5 (33.3)	1 (6.7)	15 (100)	
	Total	0 (0)	3 (9.4)	11 (34.4)	13 (40.6)	5 (15.6)	32 (100)	

K-DST, Korean Developmental Screening Test.
*Linear-by-Linear Association.

detailed examinations and transfers to other medical institutes and nonmedical centers.

Discussion

The development of a child can be evaluated by assessing 5 major categories: physical development (gross motor and fine motor), language and communication, social interactions-emotions, cognition, and self-control (activities of daily living). This development is predictable and further progresses as follows: physical development to gross and fine motor training; language development to receptive and expressive language development; social interaction-emotion development to fine motor adaptive ability, overall communication ability, and cognitive function development; and cognitive development to visual-perception, visual-motor, and problem-solving ability development. Among these categories, language development is the basis of examining the overall cognitive development[19].

The patients among whom a problem was detected in the K-DST

and who were referred from other medical institutes visited Korea University Guro Hospital with distinctive issues according to their age. In early infancy, the patients mainly undergo a physical developmental delay. Among 2- to 3-year-old children, language development and social interaction delays are the most typical. In preschool stage, patients mainly come to hospitals with cognitive delay or activity problems[19-21]. As for the target subject of this study, language developmental delay and physical developmental delay were the most frequently observed.

The developmental screening test is very important in the early diagnosis of developmental delay[12-14,22,23]. Some of the developmental delays could resolve to an almost normal status with early interventions and rehabilitation programs[12-14,22,23]. Early detection of developmental delay needs comprehensive judgment of developmental status evaluation, medical history, and physical and neurological examination with a developmental screening test[12-15,22,23].

The Korean government launched the Korea National Health Screening Program for Infants and Children on November 2007[1,14-16]. The previous original screening tools were the K-ASQ and DDST

Table 7. Cross-tabulation analysis between the grades in each test item in the K-DST and receptive language

Category	Development level	Receptive language, n (%)					Total	P value
		Relatively high	Normal	Minor developmental delay	Developmental delay	Language disorder		
Gross motor	Further evaluation	0 (0)	0 (0)	3 (75.0)	0 (0)	1 (25.0)	4 (100)	0.437
	Follow-up evaluation	0 (0)	3 (30.0)	4 (40.0)	2 (20.0)	1 (10.0)	10 (100)	
	Peer & high	1 (5.0)	4 (20.0)	4 (20.0)	8 (40.0)	3 (15.0)	20 (100)	
	Total	1 (2.9)	7 (20.6)	11 (32.4)	10 (29.4)	5 (14.7)	34 (100)	
Fine motor	Further evaluation	0 (0)	1 (7.1)	5 (35.7)	4 (28.6)	4 (28.6)	14 (100)	0.449
	Follow-up evaluation	0 (0)	3 (27.3)	4 (36.4)	3 (27.3)	1 (9.1)	11 (100)	
	Peer & high	1 (11.1)	3 (33.3)	2 (22.2)	3 (33.3)	0 (0)	9 (100)	
	Total	1 (2.9)	7 (20.6)	11 (32.4)	10 (29.4)	5 (14.7)	34 (100)	
Cognition	Further evaluation	0 (0)	0 (0)	6 (35.3)	6 (35.3)	5 (29.4)	17 (100)	0.015
	Follow-up evaluation	0 (0)	3 (33.3)	3 (33.3)	3 (33.3)	0 (0)	9 (100)	
	Peer & high	1 (12.5)	4 (50.0)	2 (25.0)	1 (12.5)	0 (0)	8 (100)	
	Total	1 (2.9)	7 (20.6)	11 (32.4)	10 (29.4)	5 (14.7)	34 (100)	
Communication	Further evaluation	0 (0)	3 (12.0)	8 (32.0)	9 (36.0)	5 (20.0)	25 (100)	0.045
	Follow-up evaluation	0 (0)	2 (33.3)	3 (50.0)	1 (16.7)	0 (0)	6 (100)	
	Peer & high	1 (33.3)	2 (66.7)	0 (0)	0 (0)	0 (0)	3 (100)	
	Total	1 (2.9)	7 (20.6)	11 (32.4)	10 (29.4)	5 (14.7)	34 (100)	
Social interaction	Further evaluation	0 (0)	2 (13.3)	4 (26.7)	5 (33.3)	4 (26.7)	15 (100)	0.151
	Follow-up evaluation	0 (0)	2 (18.2)	3 (27.3)	5 (45.5)	1 (9.1)	11 (100)	
	Peer & high	1 (12.5)	3 (37.5)	4 (50.0)	0 (0)	0 (0)	8 (100)	
	Total	1 (2.9)	7 (20.6)	11 (32.4)	10 (29.4)	5 (14.7)	34 (100)	
Self-control	Further evaluation	0 (0)	1 (10.0)	2 (20.0)	3 (30.0)	4 (40.0)	10 (100)	0.407
	Follow-up evaluation	0 (0)	1 (14.3)	3 (42.9)	3 (42.9)	0 (0)	7 (100)	
	Peer & high	1 (6.7)	5 (33.3)	4 (26.7)	4 (26.7)	1 (6.7)	15 (100)	
	Total	1 (3.1)	7 (21.9)	9 (28.1)	10 (31.3)	5 (15.6)	32 (100)	

K-DST, Korean Developmental Screening Test.

II. The K-ASQ is a modified version of the Ages and Stage Questionnaires-II designed in America and is more convenient to use than the DDST II; therefore, most clinicians used the K-ASQ for screening[13,14,16,23]. However, this tool had a disadvantage in that it could not exactly reflect the Korean culture and infant care environments. Further, several questions related to problem-solving and personal-social sections were inappropriate[14]. The same questions were included in questionnaires in different age groups[16]. This caused a high false-negative rate, especially in the 60-month-old age group[13]. The last screening test age was 60 months, and children had a 1-year gap before entering elementary schools[13]. Moreover, the difficulty levels of some questions were not appropriate for suspicious developmental delay detection[1,13]. To compensate for these insufficiencies, a new screening tool, the K-DST, was designed in 2014, which was suitable for Korean infants and children[1,13,14,24].

Even though the K-DST has been adopted for the last 2 years, only few examinations on the adequacy of this screening test by correlating it with other types of detailed examinations have been conducted. This study focused on 758 infants and children who visited Korea University Guro Hospital for the National Health Screening Test (K-DST) between January 2015 and December 2016 and 645 infants and children referred to Korea University Guro Hospital between January 2015 and June 2016 from local clinics due to developmental problems. Of them, 209 (127 boys and 82 girls) were included; they required further examinations after undergoing the K-DST.

The significant result that male children underperform against female in each section of the K-DST, especially in communication area, may come from the fact that female children tend to develop faster, especially in language area, than male children in that age level or from the characteristic of research population.

The usefulness of the K-DST could be significantly verified via a cross-tablulation analysis of the results of the K-DST, CARS and M-CHAT, which aim to measure the autism degree, and PRES/SELSI, which is a detailed language test. No patients in peer and high group showed mild to moderate autism, severe autism, or suspicious autism in both the K-DST and CARS and the K-DST and M-CHAT. This result would imply that the K-DST can be viewed as a useful screening test.

Eight children who underwent test showed abnormal EEG. More-

Table 8. Cross-tabulation analysis between the grades in each test item in the K-DST and CARS

Category	Development level	CARS, n (%)			Total	P value
		Not autism	Mild to moderate autism	Severe autism		
Gross motor	Further evaluation	3 (75.0)	0 (0)	1 (25.0)	4 (100)	0.663
	Follow-up evaluation	3 (60.0)	2 (40.0)	0 (0)	5 (100)	
	Peer & high	7 (46.7)	5 (33.3)	3 (20.0)	15 (100)	
	Total	13 (54.2)	7 (29.2)	4 (16.7)	24 (100)	
Fine motor	Further evaluation	5 (41.7)	3 (25.0)	4 (33.3)	12 (100)	0.342
	Follow-up evaluation	4 (57.1)	3 (42.9)	0 (0)	7 (100)	
	Peer & high	4 (80.0)	1 (20.0)	0 (0)	5 (100)	
	Total	13 (54.2)	7 (29.2)	4 (16.7)	24 (100)	
Cognition	Further evaluation	5 (38.5)	5 (38.5)	3 (23.1)	13 (100)	0.471
	Follow-up evaluation	4 (57.1)	2 (28.6)	1 (14.3)	7 (100)	(0.078)*
	Peer & high	4 (100)	0 (0)	0 (0)	4 (100)	
	Total	13 (54.2)	7 (29.2)	4 (16.7)	24 (100)	
Communication	Further evaluation	8 (44.4)	6 (33.3)	4 (22.2)	18 (100)	0.681
	Follow-up evaluation	4 (80.0)	1 (20.0)	0 (0)	5 (100)	
	Peer & high	1 (100)	0 (0)	0 (0)	1 (100)	
	Total	13 (54.2)	7 (29.2)	4 (16.7)	24 (100)	
Social interaction	Further evaluation	4 (36.4)	4 (36.4)	3 (27.3)	11 (100)	0.464
	Follow-up evaluation	6 (60.0)	3 (30.0)	1 (10.0)	10 (100)	(0.077)*
	Peer & high	3 (100)	0 (0)	0 (0)	3 (100)	
	Total	13 (54.2)	7 (29.2)	4 (16.7)	24 (100)	
Self-control	Further evaluation	3 (37.5)	2 (25.0)	3 (37.5)	8 (100)	0.106
	Follow-up evaluation	4 (80.0)	0 (0)	1 (20.0)	5 (100)	
	Peer & high	6 (54.5)	5 (45.5)	0 (0)	11 (100)	
	Total	13 (54.2)	7 (29.2)	4 (16.7)	24 (100)	

K-DST, Korean Developmental Screening Test; CARS, Childhood Autism Rating Scale.
*Linear-by-Linear Association.

over, 5 out of 8 was diagnosed epilepsy and 1 with infantile spasm. Many of them showed an underperforming result in the K-DST in overall. Six children showed abnormal MRI, such as brain tumor or ventriculomegaly. Most of them showed an underperforming result in motor section of the K-DST. Based on the results of the cross-tablulation analysis with abnormal EEG and abnormal MRI, it could be concluded that if delay findings were reported on certain test sections in the K-DST, additional tests must be required.

Based on these results, it can be concluded that the K-DST is an appropriate screening tool; it is also important that an adequate treatment is provided and developmental delays are diagnosed in advance through detailed examinations when further evaluation and follow-up evaluation are recommended.

Since this study was based on retrospective data, identical tests were not applied among the patients; further, there were some follow-up losses, and a limitation exists in the statistical analysis owing to the small sample size; there can also be differences in the patient group characteristics and regional characteristics owing to the single-center analysis of this study. We also need to examine the data of normal control groups to determine the accuracy of the investigation.

Owing to frequent rotations of fosterer, mainly because of increased dual-career families, long usage hours of electronic devices, such as cell phones, and other reasons, attention to children's development and its importance are increasingly becoming significant. Because the K-DST is effective in detecting developmental issues, we should encourage its use in every infant and child in a timely manner.

Because children differ in speed and balance of their development, many develop normally even when a developmental delay is suspected; further examinations are then recommended. Therefore, an appropriate follow-up examination is essential based on the accurate analysis of experts. When detailed examinations are required, adequate early detection and intervention are very important for subsequent treatments. Since follow-up loss frequently occurs mainly owing to high examination costs and transfers to other institutes, setting up a standardized diagnostic tool, protocol, and official healthcare program can be effective in subsequent diagnoses and treat-

Table 9. Cross-tabulation analysis between the grades in each test item in the K-DST and M-CHAT

Category	Development level	M-CHAT, n (%) Not autism	M-CHAT, n (%) Suspicious autism	Total	P-value
Gross motor	Further evaluation	2 (50.0)	2 (50.0)	4 (100)	1.000
	Follow-up evaluation	2 (40.0)	3 (60.0)	5 (100)	
	Peer & high	8 (53.3)	7 (46.7)	15 (100)	
	Total	12 (50.0)	12 (50.0)	24 (100)	
Fine motor	Further evaluation	3 (25.0)	9 (75.0)	12 (100)	0.072
	Follow-up evaluation	5 (71.4)	2 (28.6)	7 (100)	
	Peer & high	4 (80.0)	1 (20.0)	5 (100)	
	Total	12 (50.0)	12 (50.0)	24 (100)	
Cognition	Further evaluation	3 (23.1)	10 (76.9)	13 (100)	0.009
	Follow-up evaluation	5 (71.4)	2 (28.6)	7 (100)	
	Peer & high	4 (100.)	0 (0)	4 (100)	
	Total	12 (50.0)	12 (50.0)	24 (100)	
Communi-cation	Further evaluation	7 (38.9)	11 (61.1)	18 (100)	0.160
	Follow-up evaluation	4 (80.0)	1 (20.0)	5 (100)	
	Peer & high	1 (100)	0 (0)	1 (100)	
	Total	12 (50.0)	12 (50.0)	24 (100)	
Social interaction	Further evaluation	3 (27.3)	8 (72.7)	11 (100)	0.070
	Follow-up evaluation	6 (60.0)	4 (40.0)	10 (100)	(0.038)*
	Peer & high	3 (100)	0 (0)	3 (100)	
	Total	12 (50.0)	12 (50.0)	24 (100)	
Self-control	Further evaluation	2 (25.0)	6 (75.0)	8 (100)	0.189
	Follow-up evaluation	4 (80.0)	1 (20.0)	5 (100)	
	Peer & high	6 (54.5)	5 (45.5)	11 (100)	
	Total	12 (50.0)	12 (50.0)	24 (100)	

K-DST, Korean Developmental Screening Test; M-CHAT, Modified Checklist for Autism in Toddlers.
*Linear-by-Linear Association.

ments and in tracing the results.

Conflicts of interest

No potential conflict of interest relevant to this article was reported.

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