Neurology Asia 2019; 24(4) : 355 – 361

The validity and reliability of DDST II and Bayley III in children with language development delay

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Abstract

Objective: To analyze and compare the performance of the language sectors in the Denver Developmental Screening Test II (DDST II) and the Bayley Scales of Infant Development III (Bayley III) test with that of the Sequenced Language Scale for Infants (SELSI). *Methods:* Retrospective medical chart reviews including the Bayley III, DDST II and SELSI were conducted for 35 infants suspected to have delayed language development. More than 1 caution or fail in the DDST II-language sector (DLS) and Bayley III-language sector (BLS) score below 7were regarded as delayed language development. The sensitivity, specificity, positive predictive value, and negative predictive value of the DLS and BLS were analyzed. The degree of agreement between the Bayley III-receptive language sector (BRLS) or Bayley III-expressive language sector (BELS), DLS and SELSI was assessed by Cohen's kappa. Pearson's correlation between the Bayley III and SELSI was performed. *Results:* The DLS and BELS showed high sensitivity, while the BRLS showed low sensitivity. The BRLS showed very high specificity and the BELS showed high specificity; in contrast, the DLS showed low specificity. Cohen's kappa for the BRLS and DLS with the SELSI indicated moderate, while the value for the BELS indicated good agreement. The equivalent age as assessed by the BRLS or BELS was significantly associated with that assessed by the SELSI.
Conclusion: We propose that the DDST II is a useful screening test to identify infants with delayed language development. But the BLS cannot replace the SELSI in the evaluation of language development.

Keyword: Language development disorders, developmental disabilities, language development

INTRODUCTION

Infants and toddlers experience the greatest developmental changes throughout the human life, including the most significant changes in human behavior and physical, mental, and social development.[1] During this period, infants and toddlers begin to show independent behavior, adapt to their environment, and react appropriately. Moreover, they also begin to form relationships with others and their surroundings and experience rapid overall development. Regarding language development, newborns try to communicate through crying and gestures immediately after birth. When infants reach 12 months old, communication develops from primitive sounds to verbal communication, including the generation of meaningful words. By the age of two to three years, children are able to understand and express ideas using the basic grammar of their native language.[2] Delayed language development is a failure in children to develop language abilities according to the appropriate developmental timetable. Delayed language development is the most common developmental disorder of children aged between 2 to 4 years with a prevalence of 5 to 10% of all children and a higher incidence in boys than in girls.[3,4] Delayed language development may be due to neuropsychiatric or socio-developmental factors as well as physical disabilities such as hearing impairment, structural abnormalities related to pronunciation, and neurological impairment. Problems that manifest at the early stages of development such as gross motor and fine motor impairment are likely to develop into language disorders later on.[5-6] For this reason, language development is recognized as a useful developmental indicator reflecting a child's overall developmental status, including cognitive ability, and also as a reflection of the child's ability to adapt to school attendance.[7-9] Assessing the level of language development is an important factor

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in predicting the overall normal development of the child in the future and determining their potential need for treatment. Language skills are one of the most important parts because they are prominent in the infant's developmental process. Therefore, it is imperative to evaluate and treat infant language disorders at these critical times.[10] As a tool for assessing language development in Korea, the Korean version of the sequential language scale for infants (SELSI) has been used in many medical institutions as a standardized test.[11] The SELSI requires a relatively long test time of about 30 to 40 minutes and requires a specialized speech therapist to perform the test. Therefore, it is difficult to perform the test if the facility is not appropriately equipped. While it is theoretically important to screen for abnormal language development in infants and toddlers, in clinical practice this decision is often based on the subjective judgment of the clinician. It is very difficult to determine the degree of delayed language development using subjective judgment, especially in younger children whose normal development can vary widely.

The purpose of this study was to compare the SELSI with the language development sectors of the Denver Developmental Screening Test II (DDST II) and the Bayley Scales of Infant and Toddler Development 3rd edition (Bayley III) test which are commonly used to screen overall infant development in clinical practice. The validity of each test was calculated. The degree of agreement with the SELSI was analyzed to evaluate the reliability of the two tests and to test the accuracy of the test as a diagnostic test. In addition, we determined which test was more appropriate as an alternative screening test for the SELSI.

METHODS

This study was conducted on children younger than 36 months who visited Kosin University Hospital Department of Pediatrics and Rehabilitation Medicine between November 2012 and December 2016. The subjects were children who were suspected to have delayed language development clinically by a pediatric rehabilitation specialist who conducted the interview, physical examination and neurological examination. Children who completed SELSI, DDST II and Bayley III within 2 weeks were included and children with underlying central nervous system or genetic disorders were excluded. A total of 35 patients who were suspected to have delayed language development were reviewed. Thirty children were diagnosed with delayed language development and five were normal.

The protocol of this study was approved by the ethical review committee of bioethics and medical research ethics at Kosin University Hospital (IRB No. 2017-03-022).

Subjects underwent DDST II, Bayley III, and SELSI assessments on different dates. DDST II, Bayley III, and SELSI were performed on all subjects by a skilled occupational or speech therapist, respectively. The examiner performed the test without knowing the baseline history of the child.

Assessment for delayed language development

Denver developmental screening test II (DDST II)

The DDST II is a screening test for children with developmental delay or developmental problems. The age range for the test is from birth to 6 years. The test consists of 110 items in four developmental areas: personal - social development (22 items), fine motor and adaptation development (27 items), language development (34 items), and gross motor development (27 items). In addition, the examiner's subjective judgement is used to assess the overall behavior of the infant during the examination. Five items are assessed: daily behavior, level of compliance, environmental concern, fear level, and concentration. At examination, age classification is divided into monthly categories until the age of 2, after which the categories are 6-month periods from the ages of 3 to 6. In the DDST II, more than 2 cautions or 1 failure in the DDST II-language sector (DLS) was regarded as delayed language development.[12]

Bayley Scales of Infant and Toddler Development 3rd edition (Bayley III)

The Bayley III is a tool used to assess the overall development of infants 1-42 months of age. The test consists of cognitive, language (receptive/expressive), motor (fine/gross), active emotion, and adaptation behaviors, and was conducted according to manual guidelines. The original points of each item were converted into a scaled score ranging from 1 point to 19 points. On the Bayley III evaluation criteria, 10 points was the average score, 7 points was a score of -1SD, and 4 points was a score of -2SD. In the Bayley III, a scaled score below 7 in the Bayley III-language sector (BLS) was regarded as delayed language development.[13]

3) Sequenced language scale for infants (SELSI)

The SELSI test was designed to assess the overall language ability of infants younger than 3 years and can assess the infant's level of understanding and expression in semantic-cognitive, phonological, syntactic ability, and pragmatic competence terms. The SELSI test consists of 1,000 standardizations of 6 provinces nationwide and includes 112 items (56 in the receptive language test and 56 in the expressive language test). Each item consists of a question that can be answered "yes" or "no". If the patient answers yes to the question, they get 1 point. The sum of scores in each of the receptive and expressive sectors is compared by the percentile appropriate for the age. The scores of the receptive and expressive sectors are summed and compared again. Since the SELSI is assessed by the caregiver's report, the reliability of the test results can vary depending on how much time the caregiver spends with the child and how well the caregiver responds to the items on the test. Thus, evaluation by an expert, including detailed consultation, is required. In this study, delayed language development was diagnosed when the score was below 2 standard deviations (SDs) of the mean for each age group.[10]

Statistical analyses

In this study, the ability of the DDST II and Bayley III-language sector tests to diagnose delayed language development was examined by analyzing the sensitivity, specificity, positive predictive value, and negative predictive value of each test based on the SELSI. The degree of agreement between the DLS and SELSI was assessed by calculating Cohen's kappa value. Similarly, the degrees of agreement between the Bayley III-receptive language sector (BRLS)/ Bayley III-expressive language sector (BELS) and receptive/expressive language sector in the SELSI were also assessed. Correlations between the equivalent age according to the BRLS and BELS tests and the equivalent age in each language sector of SELSI were examined with Pearson's correlations. All statistical analyses were performed using SPSS ver. 18.0., P-values <0.05 were considered significant.

RESULTS

Among the 35 children with suspected delays in language development, 30 children were diagnosed with delayed language development on the SELSI test. The corrected ages ranged from 12 to 36 months and the mean corrected age was 25.3 months. There were 21 males and 9 females and the mean birth weight of the infants was 2630 ± 1121g (Table 1).

Compared with SELSI, the sensitivity of DDST II language sector (DLS) was high, 93.3%, and the specificity was as low as 60.0%. The positive predictive value was 93.3% and the negative predictive value was 60.0%. In addition, the agreement between the two tests was statistically significant with moderate agreement (Table 2, 3).

When compared with the expressive language sector of SELSI, Bayley III expression language sector (BELS) showed a high sensitivity of 93.1% and a high specificity of 83.3%. The positive predictive value was 96.4%and the negative predictive value was 71.4%. The agreement between the two tests was statistically significant with good agreement (Table 4, 5).

Sensitivity was low (71.4%) and specificity was high (100%) in Bayley III receptive language sector (BRLS) when compared to SELSI receptive language sector. The positive predictive value was 100% and the negative predictive value was 46.7%. In addition, the agreement between the two tests was statistically significant with moderate agreement (Table 6, 7).

The relationship between the equivalent age as shown in the appropriate area of each language sector in the SELSI and in the receptive/expressive language sectors of the Bayley III was next investigated by calculating Pearson correlations. The equivalent ages as assessed by the BRLS

Table 1: Demographic characteristics of the subjects (n = 30)

Mean corrected age (months)	25.3 ± 7.6
Mean gestational age (weeks)	36.6 ± 4.6
Gender	
Male (N)	21
Female (N)	9
Mean birth weight (g)	2630 ± 1121

Values are means±standard deviations (SDs), N: Number of cases.

Table 2: Comparison between DLS and SELSI

		DDST II-language		Total
		Normal	Delayed	
SELSI-language	Normal	3	2	5
	Delayed	2	28	30
Total		5	30	35

Kappa=0.533, p=0.002*

Table 3: Sensitivity, specificity, positive predictive value, and negative predictive value between DLS and SELSI

	DDST II-language
Sensitivity (%)	93.3 (76.5-98.8)
Specificity (%)	60 (17-92.7)
Positive predictive value (%)	93.3 (76.5-98.8)
Negative predictive value (%)	60 (17-92.7)

Values are presented as % (95% confidence interval).

Table 4: Comparison between BELS and SELSI expressive language sector

		Bayley II-expressive language		Total
		Normal	Delayed	
SELSI-expressive language	Normal	5	1	6
	Delayed	2	27	29
Total		7	28	35

Kappa=0.717, p=0.000*

Table 5: Sensitivity, specificity, positive predictive value, and negative predictive value between BELS and SELSI expressive language sector

	Bayley III-expressive language
Sensitivity (%)	93.1 (75.8-98.8)
Specificity (%)	83.3 (36.5-99.1)
Positive predictive value (%)	96.4 (79.8-99.8)
Negative predictive value (%)	71.4 (30.3-94.9)

Values are presented as % (95% confidence interval).

Table 6: Comparison between BRLS and SELSI receptive language sector

		Bayley III-receptive language		Total
		Normal	Delayed	
SELSI-receptive language	Normal	7	0	7
	Delayed	8	20	28
Total		15	20	35

Kappa=0.500, p=0.001*

Table 7: Sensitivity, specificity, positive predictive value, and negative predictive value between BRLS and SELSI receptive language sector

	Bayley III-receptive language
Sensitivity (%)	71.4 (51.1-86.1)
Specificity (%)	100 (56.1-100)
Positive predictive value (%)	100 (80-100)
Negative predictive value (%)	46.6 (22.3-72.6)

Values are presented as % (95% confidence interval).

and BELS both showed a statistically significant positive correlation with the equivalent age of each language sector of the SELSI(r=0.829, r=0.870, respectively, p<0.001, Figure 1).

DISCUSSION

Humans have the potential to communicate from birth and become more efficient in this communication over time, particularly through the use of language. Language develops intensively during critical developmental periods. In infancy and childhood, children learn basic speech concepts and various functions of language. As this basic language ability is formed, sentence structuring skills and vocabulary develop rapidly. The language skills developed in infancy and childhood form the basis for the future development of language during preschool and school. Delayed language development has been reported to be associated with cognitive impairments such as mental disability and autism spectrum disorder; thus, early assessment of language development problems and proper treatment have the potential to prevent or reduce problems such as language difficulties or learning disabilities that may occur later.[14] In particular, continuous evaluation of infants and children who are at higher risk of disability may help the appropriate interventions be applied in a timely manner.

In previous studies, children who visited the child development clinic with delayed language development were more likely to be diagnosed and corresponded to 41% of all cases.[15]However,it is more difficult to diagnose delayed language development in infants and toddlers than children of different ages because only one test or fragmentary observation is insufficient. Moreover, there is a lack of measures for early evaluation of language development in early childhood in Korea.

Tools have been described that can easily and effectively diagnose children with speech disorders in a timely manner. Chang *et al*. compared the Capute developmental test with the SELSI and confirmed the usefulness of the Capute developmental test as a screening test for delayed language development. In addition, Kim *et al*. found that the MacArthur-Bates Communicative Development Inventories (M-B CDI-K) short form test had high sensitivity and specificity as a screening tool for delayed language development.[16,17]

DDST II or Bayley III test is a system that

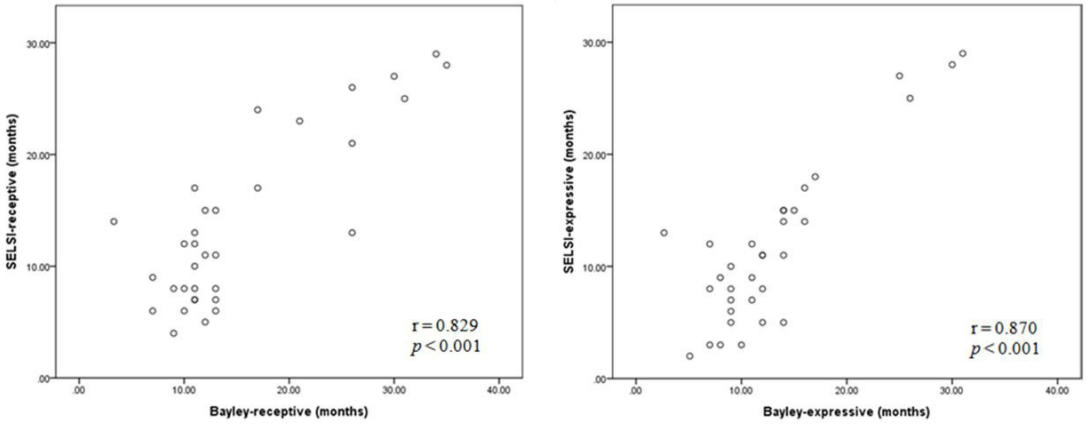

Figure 1. Correlations of equivalent age between Bayley III and SELSI

medical staff observe and examine children objectively based on given items. It has the advantage of being able to check quantified score and age corrected score compared to developmental screening tests such as Korean-developmental screening test (K-DST), Korean-Ages & Stages Questionnaires(K-ASQ), and SELSI. In addition, DDST II and The Bayley III tests are widely used as early developmental screening test and developmental disorder diagnostic test because they have the advantage of evaluating the developmental status of children, such as language, motor area, and cognitive domain. Therefore, in this study, we focused on the language sector of these two tests and confirmed the diagnostic value by comparing with SELSI.

Since the sensitivity of the DLS was as high as 93.3% based on the SELSI, the DLS may be useful for screening infants for delayed language development. However, the ability of the DLS to confirm diagnosis is somewhat limited because the specificity of the DLS was low (60%). The sensitivity of the BELS was high, whereas the sensitivity of the BRLS was lower. This finding suggests that the BLS may not be suitable to replace the SELSI test as a screening test for infants whose language development is suspected to be delayed. However, if interpretation is limited to the expressive language sector, the BLS may be useful as a screening test for expressive language disorder.

In addition, the high specificity of the BLS suggests that the Bayley III language developmental sector may be a suitable confirmatory test for delayed language development.

The positive predictive values of the DLS, BELS, and BRLS were all very high (93.3%, 96.4% and 100%), but the negative predictive values were low (60%, 71.4%, and 46.7%). This result may reflect the fact that among the enrolled patients, 30 of the 35 children (i.e. the majority) were diagnosed with delayed language development in the SELSI test, and only 5 children were identified to have normal language development. Therefore, future large-scale studies are needed to validate our results.

The BRLS and SELSI and the DLS and SELSI receptive language sector both exhibited moderate agreement. Moreover, the BERL and the SELSI expressive language sector exhibited good agreement. Since this result is consistent with the high sensitivity and specificity of the BELS, the Bayley III expressive language sector seems to be the most useful test for children suspected of delayed language development.

The equivalent ages shown in the equivalent areas of each language section of the SELSI and in the receptive/expressive language areas of the Bayley III showed statistically significant positive Pearson correlations. This result suggests that a finding of equivalent ages in the receptive and expressive language sectors implies that a Bayley III test should be conducted for a child with suspected language development delay.

The limitations of this study were as follows: First, only a small number of subjects were enrolled; second, the DDST II, Bayley III, and SELSI tests were performed only once, meaning that the condition of the child at the time of examination was not considered and the examiner error was not assessed. Third, in the SELSI test, the parent or caregiver familiar with the child's development was interviewed based on their usual observations of the child. Therefore, the test reliability may suffer due to memory errors in the interviewed caregivers, and due to errors caused by overestimation and underestimation of the child's abilities.

In this study, we analyzed whether the language sectors of the DDST II and Bayley III tests are useful for screening and evaluating children with suspected delayed language development. We found that DDST II had high sensitivity and was a potentially useful screening test. In contrast, the BRLS and BELS were not suitable replacements for the SELSI because of variations in their sensitivity, specificity, positive predictive value, and negative predictive value. Further studies of the DDST II and Bayley III with larger sample sizes including healthy children and children with various diseases are needed to validate our results.

DISCLOSURE

Financial support: None

Conflicts of interest: None

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