Original Article

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# Standardization of the Denver Developmental Screening Test for children in Seoul: a validity study

**Keun Lee**

Department of Pediatrics, Ewha Womans University College of Medicine, Seoul, Korea

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**Corresponding author**
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**Keywords**
Child; Denver Developmental Screening Test; Reproducibility of results; Seoul; Tokyo

**Objectives:** This study aimed to evaluate the applicability of the Denver Developmental Screening Test (DDST) for Korean children and to develop a Korean version reflecting the developmental characteristics of children in Seoul.

**Methods:** The DDST was administered to 2,140 children, aged 2 weeks to 6 years and 4 months, in Seoul between July 1985 and September 1986. Participants were recruited from the pediatric departments and counseling centers of several hospitals, excluding those with conditions affecting development. Certain test items were aligned with the Korean context. Inter-examiner reliability was evaluated based on 32 children, while validity was assessed with 30 children using standard developmental scales. The Probit method was employed for statistical analysis.

**Results:** Children from Seoul exhibited more rapid development than their counterparts in Denver and Tokyo across all four developmental domains: personal-social, fine motor-adaptive, language, and gross motor. Specifically, Korean children displayed earlier development for 10 items within the personal-social domain, eight within fine motor-adaptive, seven in language, and seven in the gross motor domain. This advanced development was consistent across age groups. Inter-examiner reliability averaged 97.3%, and validity tests demonstrated high concordance with established developmental scales.

**Conclusion:** The rapid development of Korean children may be attributed to close attention paid by parents and early exposure to educational materials. However, the potential role of genetic differences cannot be denied. The occupational distribution of the fathers in the sample did not differ significantly from that of the Seoul population; thus, these findings were applied to establish a standardized Korean DDST.

## Introduction

### Background

Early detection of developmental delays in children is crucial for evaluating their growth and development. Prompt identification of these delays and the implementation of appropriate interventions can either lessen their impact or address underlying causes to support normal development [1–4]. While accurate assessment of a child's developmental status typically requires

complex testing by highly trained specialists [5–7], such methods are too time-consuming and impractical for general pediatric practice. Simpler, time-efficient screening tests that can be easily administered by pediatricians are more useful in clinical settings [8–10]. The Denver Developmental Screening Test (DDST) [11,12] is the most widely used of these tests and is also employed in Korea. A pediatrician can conduct this test in about 20 minutes without special training. However, the DDST was developed based on children in Denver, a city in the United States, and may not be fully suitable for assessing the development of Korean children.

### Objectives

In this study, we administered the DDST to 2,140 boys and girls ranging in age from 2 weeks to 6 years and 4 months, all residing in Seoul. We compared the results with those obtained from children in Denver and Tokyo. Based on these findings, we developed a Korean version of the DDST.

## Methods

### Ethics statement

Neither institutional review board approval nor informed consent was obtained for this study. In 1985, systems for ethical oversight, such as ethics statements, were not yet established in Korea.

### Study design

This validity study was aimed at adapting a measurement tool originally developed in the United States for use in Korea.

### Setting

From July 1985 to September 1986, a period of approximately 14 months, the DDST was administered to 2,140 children, both boys and girls (Tables 1, 2). The DDST manual and test forms [13] were translated into Korean and underwent several revisions (Supplement 1). Examiners were thoroughly trained using the translated materials through repeated explanations, discussions, and demonstrations. After the test was administered to 32 children, inter-examiner reliability was established. To ensure the accuracy of the results, two examiners worked as a team: one administered the test while the other recorded the results.

### Participants

Children ranging in age from 2 weeks to 6 years and 4 months, as defined by the DDST, were included in the study. The participants were selected from those attending pediatric departments and child counseling centers at Ewha University Hospital, Red Cross Hospital, National Medical Center, Hanyang University Hospital, and Bangzi Hospital. In accordance with DDST guidelines, we excluded premature infants, twins, breech deliveries, adopted children, and children with visual or hearing impairments, central nervous system disorders, cleft palate, Down syndrome, or any acute or chronic illnesses. The team of examiners consisted of 15 individuals, including the researcher, medical students, pediatric residents, and students majoring in early childhood education.

### Variables

A total of 104 items from the DDST observer's checklist were used as variables.

**Table 1.** Distribution of sample by age

| Age (months) | Age range (days) | Number | Percent |
|---|---|---|---|
| 1 | 16–45 | 73 | 3.4 |
| 2 | 46–75 | 90 | 4.2 |
| 3 | 76–105 | 91 | 4.3 |
| 4 | 106–135 | 86 | 4 |
| 5 | 136–165 | 72 | 3.4 |
| 6 | 166–195 | 100 | 4.7 |
| 7 | 196–225 | 93 | 4.3 |
| 8 | 226–255 | 79 | 3.7 |
| 9 | 256–285 | 83 | 3.9 |
| 10 | 286–315 | 76 | 3.6 |
| 11 | 316–345 | 75 | 3.5 |
| 12 | 346–375 | 82 | 3.8 |
| 13 | 376–405 | 72 | 3.4 |
| 14 | 406–435 | 74 | 3.5 |
| 15 | 436–495 | 91 | 4.3 |
| 18 | 496–585 | 105 | 4.9 |
| 21 | 586–675 | 74 | 3.5 |
| 24 | 676–810 | 91 | 4.3 |
| 30 (2.5 y) | 811–990 | 97 | 4.5 |
| 36 (3 y) | 991–1,170 | 101 | 4.7 |
| 42 (3.5 y) | 1,171–1,350 | 90 | 4.2 |
| 48 (4 y) | 1,351–1,530 | 79 | 3.7 |
| 54 (4.5 y) | 1,531–1,710 | 90 | 4.2 |
| 60 (5 y) | 1,711–1,980 | 93 | 4.3 |
| 72 (6 y) | 1,981–2,340 | 83 | 3.9 |
| Total | | 2,140 | 100.0 (%) |

**Table 2**. Distribution of sample by sex

| Sex | Number | Percent |
|---|---|---|
| Male | 1,162 | 54.3 |
| Female | 978 | 45.7 |
| Total | 2,140 | 100 |

### Data sources/measurement

The testing materials used aligned with those specified in the manual. However, certain test items were modified, as follows.

In the language domain, "Uses plurals" was excluded because plural and singular forms are not distinguished in spoken Korean. For "Defines words," the passing criterion was adjusted from correctly defining six out of nine words to three out of nine. In "Object drawing," a child was

considered to pass if at least one of the three items was correct, rather than requiring all three to be correct. These modifications were based on preliminary studies that revealed differences in language expression among Korean children. Similar adjustments were made in the development of the Japanese version of the DDST [14].

Reliability and validity were evaluated. Prior to beginning the study, inter-examiner reliability was established. One examiner administered the test while another observed and independently recorded the results; then, the level of agreement was calculated. Overall, 32 children, ranging in age from 3 months to 5 years, were assessed to determine reliability. The inter-examiner reliability scores varied from 93.8% to 100%, with an average of 97.3%.

To assess validity, the DDST was administered to 30 children ranging in age from 3 months to 5 years. Subsequently, these children were evaluated using either the Bayley Scales of Infant Development or the Korea University–Binet Intelligence Test [15]. As shown in Table 3, all three children who scored an intelligence quotient of ≤75 or ≤69 on these respective tests were rated as either "questionable" or "abnormal" on the DDST, demonstrating high concordance despite the small sample size.

### Bias

Participants were selected after applying the exclusion criteria mentioned above. No additional selection bias was identified.

### Statistical methods

Statistical analysis was performed using the Probit method in SAS (SAS Institute, Cary, NC, USA).

## Results

### Participating children

The DDST was administered to a total of 2,140 boys and girls. Tables 1, 2 detail the distributions of their ages and sexes. The occupational distribution of the participants' fathers (Table 4) did not significantly differ from that of the general population in Seoul, as recorded in the 25th Seoul Statistical Yearbook, published in December 1985 (P>0.05).

### Main results

*Results of test items by city*

The ages at which 25%, 50%, 70%, and 90% of children passed each of the 104 test items

**Table 3**. Relationships among the results of the DDST, Binet Intelligence Scale, and Bayley Scales of Infant Development

| | Binet IQ | ≥92 | 76–91 | ≤75 |
|---|---|---|---|---|
| DDST | Bayley DQ | ≥90 | 70–89 | ≤69 |
| Normal | | 20 | 0 | 0 |
| Questionable | | 1 | 5 | 2 |
| Abnormal | | 0 | 1 | 1 |

DDST, Denver Developmental Screening Test; IQ, intelligence quotient; DQ, developmental quotient.


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**Table 4**. Occupations of fathers of participants compared with the general population of Seoul

| Occupation | Sample (%) | Seoul general population (%)[1)] |
|---|---|---|
| Administrative, managerial, or professional | 13.1 | 11.9 |
| Clerical and related workers | 40.4 | 22.7 |
| Commerce | 21.3 | 25.6 |
| Service | 4.3 | 8.7 |
| Agriculture, livestock, forestry, fishery | 0.6 | 0.7 |
| Production, transportation | 23.5 | 30.9 |
| Unknown, military, student, unemployed | 7.5 | 0 |

P>0.05.
[1)] The 25th Seoul Statistics annual report, published in December 1985.

(Supplement 2) were calculated. These findings were then compared with the results of children from Denver and Tokyo. A difference exceeding 20% was considered significant. The percentage difference was determined using the following formula:

[(Result of children in Seoul) − (Result of children in Denver)] / (Result of children in Seoul)] × 100

*Comparison between children in Seoul and Denver*

Test items exhibiting a difference of more than 20% are compared in Supplement 3.

Personal-social domain: For 10 of the 23 items, children from Seoul demonstrated more rapid development than their counterparts from Denver. Both 50% and 90% passing ages were earlier for four items: "Resists when a toy is taken away," "Plays peek-a-boo," "Attempts to reach distant toys," and "Plays ball." Only one item, "Easily separates from mother," was achieved earlier by the Denver children.

Fine motor-adaptive domain: Of the 30 items, relative to their counterparts from Denver, children from Seoul demonstrated faster development for eight. This was evident in both 50% and 90% passing ages for three items: "Regards raisin," "Picks up raisin with thumb and forefinger," and "Copies a square." Conversely, the Denver group exhibited more rapid development for three items.

Language domain: Of the 20 items, children from Seoul demonstrated faster development than the Denver children in seven. These items included "Says 'mama,' 'dada' (non-specific)," "Turns head to voice," and "Follows simple commands." The item "Defines words" was not included in the comparison due to changes in the scoring criteria.

Gross motor domain: For seven of the 31 items, children from Seoul demonstrated more rapid development than those in Denver. They reached both the 50% and 90% passing ages more quickly for "Bears weight on legs when held upright" and "Head lag disappears when pulled to sit." The Denver children did not exhibit faster development for any items.

*Comparison between children in Seoul and Tokyo (Supplement 4)*

Personal-social domain: Children from Seoul demonstrated faster development for 11 of the 23 items, reaching both the 50% and 90% passing ages more quickly for five of these items. The children from Tokyo outpaced their Seoul counterparts for only one item.

Fine motor-adaptive domain: Children from Seoul displayed faster development for 12 of the

31 items, reaching both the 50% and 90% passing ages earlier for three items. The Tokyo group exhibited more rapid development for one item.

Language domain: Children from Seoul exhibited faster development for 10 of the 20 items, reaching both the 50% and 90% passing ages earlier for two items. The Tokyo children displayed more rapid development for two items.

Gross motor domain: Children from Seoul demonstrated faster development for 14 of the 31 items, attaining both the 50% and 90% passing ages earlier for six items.

In Supplement 5, we superimposed the average ages of children from Seoul onto the original DDST chart to facilitate direct comparison with children from Denver. Dark shading on the left side of the bar indicates that the Seoul children achieved a milestone earlier, while shading on the right side signifies later achievement. As shown, the children from Seoul were ahead in many test items across all four domains and age groups.

Supplement 6 presents the Korean version of the DDST, developed based on the average data from the children in Seoul (Supplement 2). This version can replace the original DDST for the developmental screening of Korean children and should be used in conjunction with standardized testing materials and appropriate training. As explained, the Korean children demonstrated more rapid development for many test items across all domains and ages.

## Discussion

### Key results

In this study, the DDST was administered to 2,140 boys and girls ranging in age from 2 weeks to 6 years and 4 months, all residing in Seoul. When comparing the results with those from Denver and Tokyo, children from Seoul demonstrated more advanced development in multiple test items across all four developmental domains. Specifically, they were ahead in 10 out of 23 items in the personal-social domain, eight out of 30 items in the fine motor-adaptive domain, seven out of 20 items in the language domain, and seven out of 31 items in the gross motor domain. These differences were observed across all age groups.

### Interpretation/comparison with previous studies

Developmental delays in children can arise from various causes, including congenital or genetic disorders, complications during childbirth, and environmental factors after birth. Early detection is crucial for identifying the underlying causes and initiating interventions that can mitigate delays. Detection also enables parents to understand the delay and thus engage in more constructive childcare and educational practices [1–4,9].

Historically, a variety of methods have been developed to assess child development, each with advantages and disadvantages. Many of these methods are complex and time-consuming, rendering them impractical for use by general pediatricians [5–7]. Consequently, simple screening tests for developmental delays have been emphasized [8–10,16].

The DDST [11–13,17–19] is the most widely used screening tool. General pediatricians, nurses, or medical students can administer the DDST without specialized training, and it takes only 15–20 minutes to complete. This instrument was developed based on a population of children from Denver, and while it has been claimed to be applicable in other regions, studies have indicated differences among children from other countries [20–26], as detailed below.

Cardiff: A study by Bryant et al. [20] revealed that infants in Cardiff exhibited advanced development in the personal-social and language domains but delays in gross motor

development compared to their counterparts in Denver. Employing the original DDST could thus lead to the misclassification of normal gross motor development as delayed [27].

Tokyo: Ueda [26] observed that infants in Tokyo display relatively delayed gross motor development and preschool children exhibit delayed language development, which can be attributed to environmental factors such as childcare practices. For instance, Japanese infants are often not placed in a prone position, potentially leading to delays in the ability to lift the head or chest.

Hong Kong: A study by Fung and Lau [21] indicated that Chinese infants in Hong Kong exhibited delayed gross motor development, which normalized post-infancy. Contributing to this delay were cultural practices such as swaddling and a tendency towards overprotective parenting.

Differences stemming from childcare methods have also been observed in African [24,28] and Mexican infants [23]. Furthermore, economic factors can affect development; children from low-income families may exhibit delays in language and conceptual thinking tasks [29,30].

In this study, children from Seoul exhibited more rapid development across all domains compared to their counterparts in Denver and Tokyo. This trend was observed consistently among age groups. Two aspects of Korean childcare practices may contribute to this phenomenon. First, close physical contact is near-constant; Korean mothers often maintain close physical contact with their infants, frequently carrying or holding them, even during sleep. Sensory stimulation through skin-to-skin contact is known to facilitate development [4,31]. Second, a high value is placed on education. Korean parents emphasize educational achievement, providing educational materials at an early age and enrolling their children in preschools and academies. Nonetheless, genetic factors could also play a role in development, warranting further investigation.

Given the numerous test items for which Seoul children outperformed their counterparts, applying the original DDST to Korean children is unsuitable, as children with developmental delays could be misclassified as developmentally normal. The occupations of the fathers in our sample were comparable to those of the broader population of Seoul (Table 4), and the inter-examiner reliability was high. Validity tests demonstrated high concordance with established developmental scales (Table 3). Therefore, the establishment of a Korean version of the DDST based on our results is justified.

Accordingly, we developed the Korean version of the DDST (Supplement 6), tailored to the assessment of Korean children. Adequate training and standardized administration are essential for accurate results.

### Limitations

This study has several limitations. First, it was restricted to children visiting specific institutions in Seoul, which may not be representative of the broader pediatric population of the city. Second, children who visit hospitals and counseling centers might not fully reflect the health status of the general pediatric population, potentially impacting the generalizability of the findings. Third, the sample sizes for testing inter-examiner reliability (32 children) and validity (30 children) were relatively small, possibly affecting the statistical reliability of the results.

### Conclusion

Using the DDST, we examined the developmental progress of 2,140 children—both boys and girls—ranging in age from 2 weeks to 6 years and 4 months. The following results were obtained.

1. Overall advancement: Children in Seoul exhibited faster development than their counterparts in Denver and Tokyo across all domains and age groups.
2. Personal-social domain (23 items): Children from Seoul displayed slower attainment of only one item compared to both Denver and Tokyo children, while they exhibited faster development regarding 11 items.
3. Fine motor-adaptive domain (30 items): Compared to children in Denver, those in Seoul exhibited slower development regarding three items and faster development for eight. Compared to children in Tokyo, they were slower for one item and faster for 12.
4. Language domain (20 items): Children from Seoul displayed more rapid development for seven items compared to children from Denver. Relative to their counterparts in Tokyo, the Seoul group exhibited slower development for two items and faster attainment for 10.
5. Gross motor domain (31 items): Children from Seoul exhibited faster development for seven items compared to their counterparts in Denver and for 14 items compared to children from Tokyo.

The findings indicate that environmental factors and ethnic differences may contribute to the accelerated development observed in children from Seoul. To address these distinctions, we have developed and presented a Korean version of the DDST, which was informed by the study results. This research is anticipated to aid in the early detection of developmental delays and the implementation of appropriate interventions by offering an assessment tool tailored to the developmental evaluation of Korean children.

**ORCID**
Not applicable.

**Authors' contributions**
All work was done by Keun Lee.

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

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**Data availability**
Not applicable.

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Not applicable.

**Supplementary materials**
Supplementary materials are available from: https://doi.org/10.12771/emj.2024.e61.

Supplement 1. Korean translation of the Denver Developmental Screening Test (DDST)
Supplement 2. Age at which a given percentage of the Seoul sample passes various items
Supplement 3. Comparison of children from Seoul and Denver regarding the ages at which 50% and 90% of the sample pass various items

Supplement 4. Comparison of children from Seoul and Tokyo regarding the ages at which 50% and 90% of the sample pass various items
Supplement 5. Comparison of the original Denver Developmental Screening Test (DDST) with its Korean version
Supplement 6. The Korean version of the Denver Developmental Screening Test (DDST), developed using the average data of children from Seoul as shown in Supplement 2

### Editor's note

This secondary publication has been modified during the English translation process to align with the style and format of the *Ewha Medical Journal*. The abstract, which was originally quite short, has been expanded to approximately 250 words. An ethics statement has been incorporated; however, ethical approval and informed consent were not obtained, as Korea lacked an established system for such declarations in 1985. Nonetheless, this study posed no harm to children, as it was observational and involved no interventions. Additional sections on study design, variables, bias, key results, and limitations have been introduced. Reference number 17, which was not present in the main text of the original Korean article, has now been incorporated. Tables 5–7 from the original article were in Korean. Since the Korean texts of the items in these tables are meaningful, they have been moved to the Supplement without English translation. Throughout the translation and editing process, great care has been taken to preserve the core message of the original article.

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