Original Article

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Performance of Activities of Daily Living in Typically Developing Children in Korea: Normative Value of K-MBI

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Objective: To determine the normative values of the Korean version of the Modified Barthel Index (K-MBI) score for typically developing children in Korea and assess its suitability for use in children.

Methods: Rehabilitation physicians and occupational therapists with children were invited through an online platform to participate in a survey assessing their children's performance of activity of daily living (ADL) using the K-MBI. The questionnaire encompassed queries on sociodemographic information of children and the assessment criteria outlined in the K-MBI. The standardized K-MBI scores by age were estimated using the nonlinear least squares method.

Results: The analysis incorporated responses from a total of 206 individuals. K-MBI total scores showed a rapid increase over the first 8 years of life, with 99% of children achieving a score of 90 or higher by age 8. Mobility scores exhibited a swift increase during early childhood, surpassing 90% of the maximum score at 3 years of age and nearing 100% at 7 years of age. In contrast, self-care scores demonstrated a more gradual advancement, achieving approximately 100% of the maximum score by the age of 10 years.

Conclusion: Age-specific normative values for K-MBI scores of typically developing children were established, which can be used as a reference in clinical care. While the K-MBI captured the overall trajectory of children's ADL development, it did not discern subtle differences across various developmental stages. There is a need for the development of more refined assessment tools tailored specifically to children.

Keywords: Activities of daily living, Child, Growth and development, Disability evaluation, Republic of Korea

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INTRODUCTION

Activities of daily living (ADLs) are fundamental skills required to fulfill basic needs in life. These are self-care tasks typically acquired at a young age and are also referred to as basic ADLs. Such activities comprise grooming/personal hygiene, dressing, toileting/continence, transferring/ambulating, and eating [1]. The performance of ADLs is an indicator of independence in life, and is widely used to assess the extent of assistance needed by the elderly, individuals with dementia, those affected with

diseases, and persons with disabilities [2-4]. Dependent ADL is associated with decline in quality of life, elevated healthcare costs, and increased risk of mortality [1]. The evaluation of ADLs enables healthcare providers to identify challenges in an individual's ADL performance, set goals, and plan interventions. Therefore, the measurement of an individual's ADL is essential component of disability assessment.

Numerous assessment tools have been developed to evaluate ADLs. Among standardized ADL measures, Functional Independence Measure (FIM™) and Barthel Index (BI) are the most extensively utilized in a variety of rehabilitation settings [5]. FIM™ is commonly used in North America, and the BI and the Modified Barthel Index (MBI) are popular in Europe and Asia [6,7]. The MBI is commonly selected to evaluate the extent of disability or dependence in ADLs among stroke survivors; however, it is also frequently employed for patients with a diverse range of disabilities [7-10].

The MBI comprises 10 distinct items: personal hygiene, bathing, feeding, toileting, stair climbing, dressing, bowel control, bladder control, ambulation, and chair/bed transfers. These items are scored on a scale divided into five levels, with each level assigned a different score depending on the area's importance. For instance, personal hygiene and bathing items are scored from 0 (unable) to 5 (independent), while feeding, toileting, stair climbing, dressing, bowel control and bladder control items are scored from 0 (unable) to 10 (independent), and ambulation and chair/bed transfers items are scored from 0 (unable) to 15 (independent). Total score is calculated by summing the scores for each of 10 items described above, with a maximum achievable score of 100 (100=independent, 91–99=minimal assistance, 75–90=mild dependence, 50–74=moderate dependence, 25–49=severe dependence, and 0–24=total dependence) [11]. The Korean version of the MBI (K-MBI) is a translation of the 5th version of the MBI tailored to reflect Korean culture and lifestyle [12]. The K-MBI is a standardized assessment tool with proven validity and reliability for evaluating ADLs in patients with stroke [12].

ADLs begin to be mastered in early childhood and become increasingly sophisticated and complex as the child grows. Therefore, when assessing ADL in children, it is essential to consider the child's developmental stages. Functional Independence Measure for Children (WeeFIM®) and Pediatric Evaluation of Disability Inventory (PEDI) are assessment tools for developed for pediatric population. The PEDI assesses children from 6 months to 7.5 years old, including older children with functional abilities under 7 years. WeeFIM® evaluates children from 6 months to 8 years old, with extension up to 18 years for children with developmental disabilities [13]. However, the utilization of WeeFIM® is limited, as it requires payment for copyright access and mandatory training. The application of PEDI for children in Korea is relatively infrequent, resulting in insufficient available data [8].

Currently, the K-MBI is a mandatory evaluation item for determining brain lesion disability in Korea, as per the Disabled Welfare Law, and it is also employed when assessing disability in children and adolescents. To assess the daily living performance of children and adolescents, age-specific reference data is crucial, yet data on the K-MBI is currently lacking. Consequently, there are limitation in objectively evaluating children and adolescents with disabilities. The aim of this study is to establish a standard range of K-MBI scores with respect to age in typically developing children in Korea, explore trends in children's ADL development using K-MBI, and evaluate its utility.

METHODS

Study subjects and setting

In July 2021, a web-based questionnaire survey was administered to parents of typically developing children aged 18 years or younger. The participants in this survey were restricted to rehabilitation medicine doctors and occupational therapists who possessed adequate knowledge of K-MBI. To gather data from typically developing children, we excluded children with disabilities as defined by the Disabled Welfare Law, those with congenital diseases such as genetic disorders or other neurological deficits, and individuals who had undergone treatments that could potentially impact their ADLs within the last three months. This exclusion criterion was communicated to the survey respondents.

The questionnaire included the K-MBI usage guidelines provided by the Korean Society for NeuroRehabilitation. These guidelines served as a reference for the evaluator to follow while assessing the child's ADL. Additionally, this questionnaire asked the following information about the subject: (1) relationship between the child and the respondent; (2) exact age of the child; (3) gender of the child; (4) current residence; (5) institution attended by the child (school, kindergarten, home daycare center, etc.); (6) birth record (full-term or premature birth).

Rationale of sample size estimation

Subjects were categorized into five age groups: 0 to 3 years old, 4 to 6 years old, 7 to 9 years old, 10 to 12 years old, and 13 years old and above. For this study, we aimed to enroll 30 participants in each of the five age groups, totaling 150 individuals. The sample size for each age group was determined by considering the minimum number of samples required to assume normality according to the central limit theorem.

Statistical analysis

The normality of the data was verified through the Kolmogorov–Smirnov test. To obtain the standard K-MBI score according to the age, the performance score of ADLs measured with K-MBI was estimated using nonlinear least squares. Participants' mean growth is a monotone increasing from 0 to 100, so the growth is assumed to follow a cumulative distribution function of a gamma distribution, where the parameters associated with the distribution are estimated to find the best fit for the data. With the estimated parameters, 95% and 99% lower bounds were used for the predictive distribution. The K-MBI questionnaire were divided into two categories for further analysis: "Self-care" activities (a total of 60 points including personal hygiene, bathing, feeding, toileting, dressing, bowel control, and bladder control) and "Mobility" activities (a total of 40 points including stair climbing, ambulation, and wheelchair/bed transfer). Percentages were calculated by dividing each score by its maximum score. Statistical analysis was done using IBM SPSS for Windows version 18.0 (IBM Corp.) and R for Windows software (R Foundation for Statistical Computing).

Ethics statement

The present study protocol was reviewed and approved by Institutional Review Board of St. Vincent's Hospital (IRB approval No. VC21QISI0133); it was conducted in compliance with the relevant ethics guidelines. Consent was obtained by clearly stating that the survey is for research purposes and requesting participation only from those who agree to be involved in the study.

RESULTS

Basic characteristics

From July 7 to 23, 2021, a total of 210 people participated in the survey. Among them, 206 responses were included in the analysis, while four were excluded due to missing questions or age discrepancies. Out of the 206 participants, 93.2% of children (192 out of 206) were born full-term, 54.9% (113 out of 206) were female children, and 65.5% (135 out of 206) of responders were mothers of the children.

Respondents were distributed across various regions as follows: Seoul (n=70, 34.0%); Incheon, Gyeonggi-do (n=55, 26.7%); Busan, Ulsan, Gyeongsangnam-do (n=30, 14.6%); Daejon, Sejong, Chungcheong-do (n=21, 10.2%); Jeju-do (n=15, 7.3%); Gwangju, Jeolla-do (n=12, 5.8%); Daegu, Gyeongsangbuk-do (n=3, 1.5%); and Gangwon-do (n=0, 0.0%). The institutions attended by the children included elementary school (n=82, 39.8%), daycare center (n=46, 22.3%), middle school (n=33, 16.0%), kindergarten (n=22, 10.7%), homeschooled (n=16, 7.8%), and high school (n=7, 3.4%).

Distribution of the K-MBI scores

In Fig. 1, the distribution of K-MBI total scores by age was depicted using the nonlinear least squares method, resulting in a sigmoid curve distribution. K-MBI total scores of children exhibited rapid increase from birth to age 5, after which the rate of increase diminished, eventually reaching a plateau around the age of 8. The median, 5th percentile, and 1st percentile values of the K-MBI total score by age are shown in Table 1. Ninety-nine percent of 7-year-old children obtained a total K-MBI score of 90 or above. Additionally, most children in Group V, aged 13 years and older, achieved a score of 100.

Fig. 2 displays the age-related shifts in scores for each K-MBI item, while Supplementary Table S1 provides detailed scores. Notably, at 2 years of age, the ambulation item achieved more than 90% of the maximum score, whereas most self-care items, except for feeding, remained at or below 20% of the maximum score. Among the self-care items, the feeding item displayed substantial improvement around the age of 2, while bladder and bowel control exhibited notable progress around the age of 3.

Fig. 3 presents the attainment levels of sub-scores categorized into self-care items (including personal hygiene, bathing, feeding, toileting, dressing, bowel control, bladder control) and mobility items (comprising stair climbing, ambulation, chair/bed transfer) expressed as percentages for each age group. Mobility scores reached 90% of the maximum achievable score at 3 years of age and attained a score close to 100% of the maximum at 8 years of age. In contrast, the self-care scores achieved 90% of the maximum score at the age of 7 and reached a score approximately equal to 100% of the maximum by the age of 10.

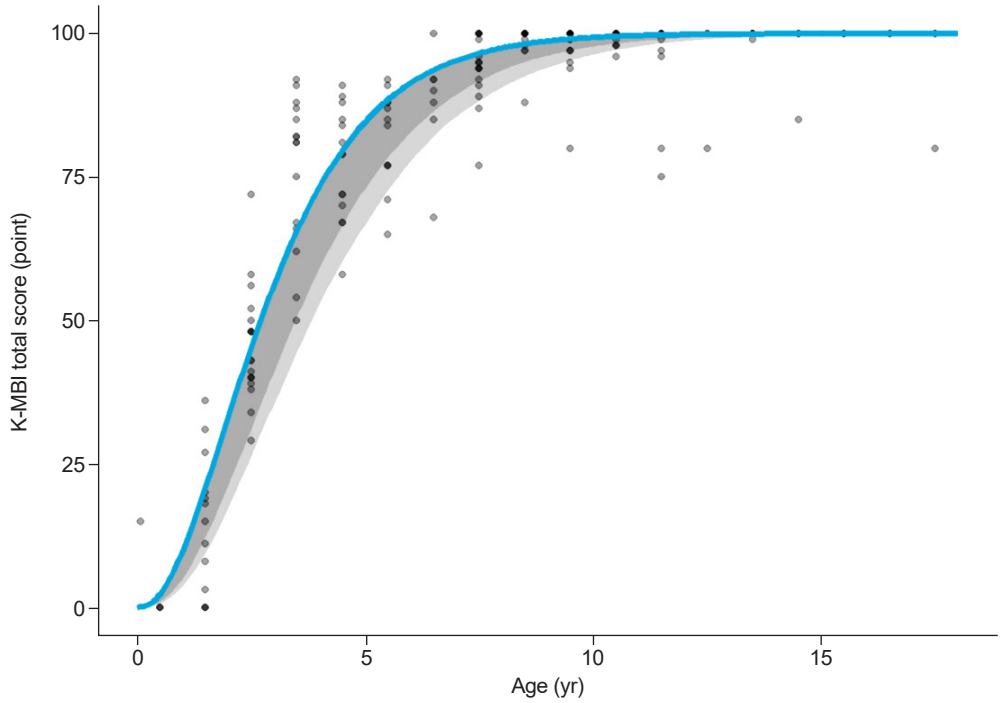

Fig. 1. The distribution of total scores of the Korean version of the Modified Barthel Index (K-MBI) according to age in typically developing children. The blue line depicts the standardized value of K-MBI total score. The dark grey area corresponds to the lower 5th percentile of K-MBI total score, and light grey area corresponds to the lower 1st percentile.

Table 1. Normative reference values of the K-MBI total score for each age (n=206)

Group (n, %)	Age (yr)	Total (n)	K-MBI total score		
			Median (point)	Lower 5th percentile (point)	Lower 1st percentile (point)
I (51, 24.8)	0	4	9.9	5.1	3.7
	1	13	33.3	21.3	17.3
	2	19	56.3	41.1	35.4
	3	15	73.4	59.1	52.8
II (33, 16.0)	4	14	84.7	73.1	66.7
	5	12	91.5	82.8	77.7
	6	7	95.4	89.4	85.5
III (48, 23.3)	7	19	97.6	93.6	90.6
	8	12	98.7	96.2	94.1
	9	17	99.3	97.8	96.3
IV (34, 16.5)	10	16	99.7	98.7	97.8
	11	15	99.8	99.2	98.7
	12	3	99.9	99.6	99.2
V (40, 19.4)	13	13	100.0	99.8	99.5
	14	10	100.0	99.9	99.7
	15	9	100.0	99.9	99.8
	16	4	100.0	100.0	99.9
	17	4	100.0	100.0	99.9

K-MBI, Korean version of the Modified Barthel Index.

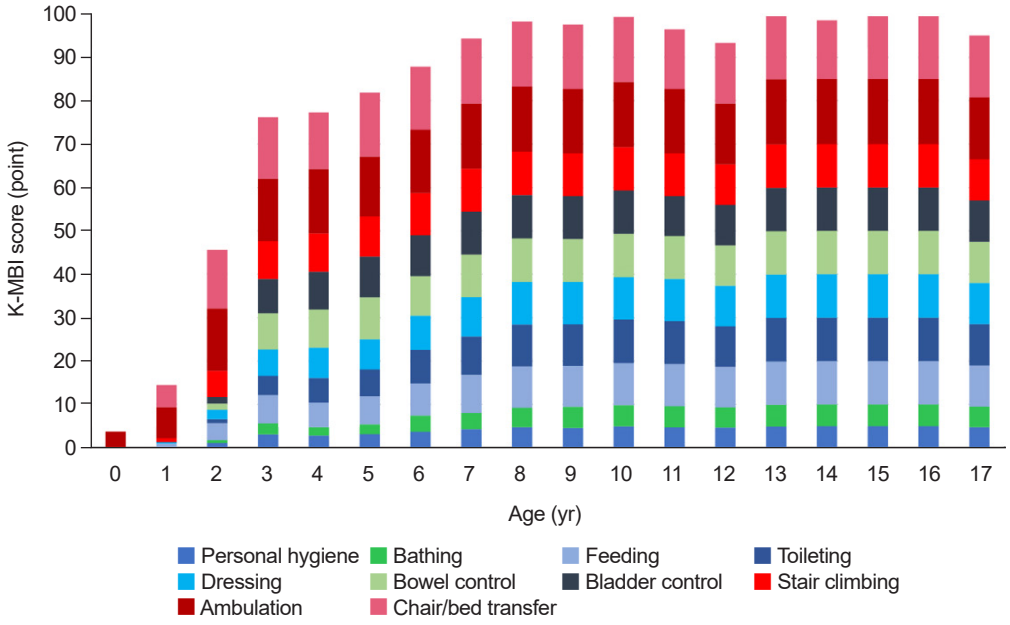

Fig. 2. Changes in scores by age for the 10 items of the Korean version of the Modified Barthel Index (K-MBI) evaluated in normally developing children (n=206). The blue and green series represents the self-care items (personal hygiene, bathing, feeding, toileting, dressing, bowel control, bladder control), and the red series represents the mobility items (stair climbing, ambulation, chair/bed transfer).

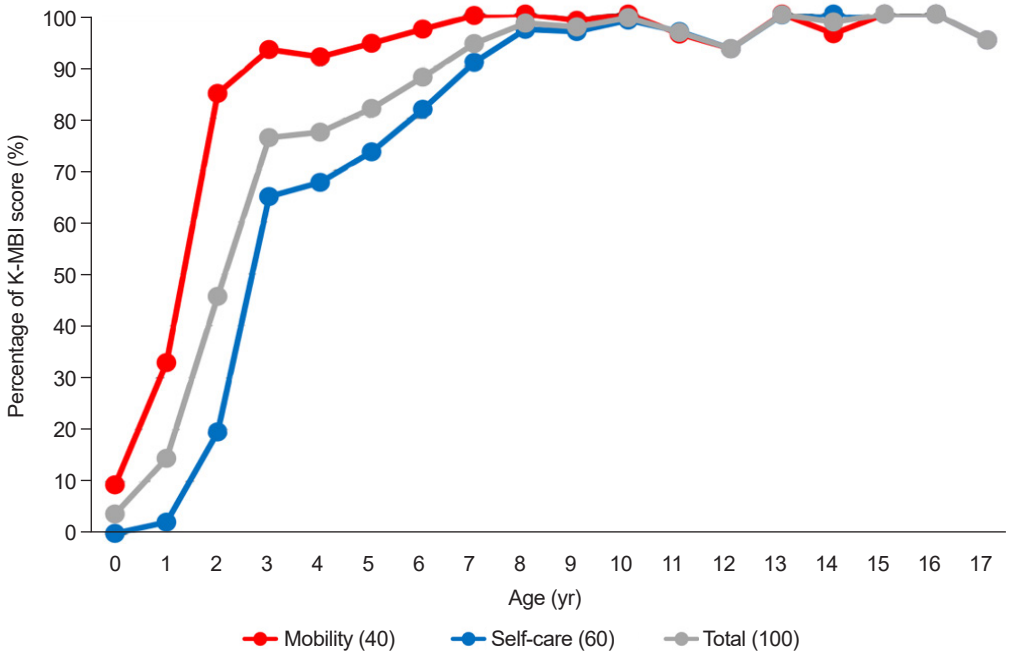

Fig. 3. Age-related changes in mobility scores and self-care scores on the Korean version of the Modified Barthel Index (K-MBI) (n=206). Percentages of sub-scores by age (n=206, %). The light grey line indicates the percentage of the total score, the red line represents self-care score percentage, and the blue line represents mobility score percentage. Percentages are calculated by dividing each score by its respective maximum value.

DISCUSSION

In this study, we provided the normative values in typically developing children for the K-MBI, a widely utilized assessment tool in Korea to assess ADL in children and adolescents. The K-MBI evaluation showed that the ADL performance of children and adolescents changes dynamically according to developmental age. The total K-MBI score exhibited rapid advancement up to the age of 5, after which the rate of increase decelerated, eventually plateauing around 8 years old, which reflects the nature of swift development in early childhood. Performance of mobility items were achieved rapidly before the age of 3, while progress in self-care items exhibited a more gradual trajectory thereafter.

To our knowledge, this study is the first to investigate the age-specific median, the lower 1% and 5% reference values of the K-MBI across a broad age spectrum among typically developing children and adolescents in Korea (Table 1). Despite the widespread use of K-MBI assessments in clinical settings involving Korean children and adolescents, comprehensive normative data based on developmental age has been lacking. The absence of this standard range complicates the precise evaluation of a child's deviation from the norms in ADL performance. Therefore, the findings from this study will be helpful in understanding the development of ADL according to the child's age and serve as essential reference material for clinical practitioners working with children who have developmental disabilities. A recent study has shown that the K-MBI presents good reliability and validity in evaluating children with congenital muscular dystrophy and Barth syndrome [14]. However, the reliability and validity of employing MBI in children with prevalent disabling conditions such as cerebral palsy have not yet been established and require further investigation.

The K-MBI assessment showed the typical trajectory of child development, marked by the rapid advancement of mobility in the early childhood and the progressive development of self-care skills as children grow. Mobility scores rapidly increased from a very young age, attaining 90% of the maximum score by the age of 3. In contrast, the self-care score exhibited a relatively gradual rise compared to the mobility score, reaching 90% of the total score at age 7. This distinction is attributed to the fact that self-care necessitates the development of dexterity and cognition, which typically mature later than the development of mobility skills [1].

Meanwhile, some components of the K-MBI appear inadequate in evaluating the distinctive ADL performance of children based on their developmental stage. When typically developing children were assessed with the K-MBI, their ambulation scores increased after 1 year of age. The K-MBI scores the ambulation item by focusing on independent walking and doesn't encompass the evaluation of movement methods besides walking, like crawling or rolling. Due to these limitations, the mobility score of K-MBI fails to capture the dynamic stages of gross motor development during the first year of life, making it challenging to accurately assess ADL performance related to motor skills in children under one-year old. Besides, respondents proposed refining the questions for assessing self-care items for more effective assessments of children. For example, it is not appropriate to ask young children about their ability to perform personal hygiene such as shaving or applying makeup. Accurate assessment of ADL in children, especially in younger age groups, requires the use of additional assessment tools. When evaluating a child's function to determine the degree of disability, it is important to understand both the level of development and ADL performance [15]. Comprehensive evaluation should be accompanied by neurodevelopmental assessment, especially for young children who inherently require assistance with ADL [15].

The present study has several limitations. Firstly, the recruitment was limited to children whose parents were rehabilitation medicine doctors or occupational therapists, potentially introducing selection bias. Secondly, the study involved a relatively small number of participants. According to the central limit theorem, when the sample size exceeds 30, the distribution of the sample mean tends to approximate a normal distribution. Although the sample size for each group surpassed 30 individuals, the number of subjects within each age category did not meet this threshold. Further research is needed with larger and more diverse populations to enhance the generalizability of our results. Additionally, as the study was conducted through an anonymous online survey, the possibility of typing errors exists. Unfortunately, due to the nature of the survey, we were unable to verify these potential errors. Consequently, data suspected to be the result of typing errors were excluded from the analysis. Another concern with this study is the large number of raters, which could potentially raise questions about the reliability of scoring. However, the MBI is known to have high inter-rater reliability [16]. The K-MBI also demonstrated robust inter-rater reliability, with Kendall's coefficient of concordance ranging from 0.93 to 0.98 [12]. Moreover, to enhance result reliability, we provided raters with the K-MBI usage guidelines issued

by the Korean Society for NeuroRehabilitation and instructed them to assess the child's ADL in accordance with these guidelines. However, despite these efforts, a few evaluators encountered challenges in objectively assessing their own children. Upon examining the scores for each item of the K-MBI (Supplementary Table S1), it was noted that the average score for 11- and 12-year-old children was marginally lower than that of 10-year-old children. It is presumed that a perfect score was determined based on how strictly the evaluator judged the child's level of daily living performance. This limitation is inherent in surveys relying on parental responses.

In conclusion, our study delineated the developmental patterns of ADL performance in typically developing Korean children through the K-MBI assessment and provided normative data. The identified cut-off values for K-MBI scores will serve as a basis for assessing ADL performance in children with developmental disabilities. Clinicians should understand the limitations associated with assessing children's ADL using the K-MBI and consider the use and development of alternative tools tailored for the children's developmental stage.

CONFLICTS OF INTEREST

Bo Young Hong is an Editorial Board member of Annals of Rehabilitation Medicine. The author did not engage in any part of the review and decision-making process for this manuscript. Otherwise, no potential conflict of interest relevant to this article was reported.

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AUTHOR CONTRIBUTION

Conceptualization: Hong BY, Lee J. Data curation: Paek S, Hong BY. Formal analysis: Hwang Y, Paek S, Yoon MJ. Investigation: Hong BY, Yoo YJ, Yoon MJ, Paek S. Methodology: Hong BY, Yoon MJ. Validation: Hong BY. Visualization: Paek S, Hwang Y. Writing – original draft: Paek S, Yoon MJ. Writing – review and editing: Yoon MJ, Hong BY, Kim JS. Approval of final manuscript: all authors.

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SUPPLEMENTARY MATERIALS

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