Tzu Chi Medical Journal 27 (2015) 25–34

Contents lists available at ScienceDirect

Tzu Chi Medical Journal

journal homepage: www.tzuchimedjnl.com

Original Article

Update of the normative data for the Chinese Child Development Inventory for children over 3 years old

Hsin-Chi Wu [a, b], Chen-Chin Hsu [c], Bin-Han Huang [d], Shu-Hui Wen [e, *]

[a] Department of Physical Medicine and Rehabilitation, Taipei Tzu Chi Hospital, Buddhist Tzu Chi Medical Foundation, New Taipei, Taiwan
[b] Department of Medicine, College of Medicine, Tzu Chi University, Hualien, Taiwan
[c] Department of Psychiatry, Taipei Tzu Chi Hospital, Buddhist Tzu Chi Medical Foundation, New Taipei, Taiwan
[d] Department of Community Medicine, Taipei Tzu Chi Hospital, Buddhist Tzu Chi Medical Foundation, New Taipei, Taiwan
[e] Department of Public Health, College of Medicine, Tzu Chi University, Hualien, Taiwan

ARTICLE INFO

Article history:
Received 13 October 2014
Received in revised form
12 December 2014
Accepted 8 January 2015
Available online 28 February 2015

Keywords:
Child development
Chinese Child Developmental Inventory
Lambda-mu-sigma
Norm
Polynomial regression

ABSTRACT

Objective: The Chinese Child Developmental Inventory (CCDI) is a convenient screening tool to identify children with possible developmental delays. The purpose of this study was to update the CCDI norms using a contemporary sample of children, and to compare it with existing CCDI normative data.
Materials and methods: Five hundred fifty-two children, 36.5–75.5 months old, from 30 kindergartens located in three districts (Xindian, Jhonghe, and Yonghe) of New Taipei City, Taiwan were assessed using the CCDI. The updated normative data were compared with existing CCDI norms using a quadratic linear regression model. In addition, smoothed percentile curves (5^{th}–95^{th}) were estimated using the lambda-mu-sigma method.
Results: Among the eight CCDI developmental dimensions, the average scores for general development, comprehension-conceptual, fine motor, situation-comprehension and expressive language (at <50 months old) were higher than the scores of the existing norms that are based on data from 1978; however, the score of the gross motor dimension was slightly lower. No differences in the average scores for self-help existed between the updated and previous norms.
Conclusion: The updated CCDI normative data will provide valuable information for physicians and other professionals working to identify developmental delays at early stages.

1. Introduction

To identify children at risk of developmental delay at an early stage, physicians and professionals need to obtain all information related to the developmental profile of the children from their parents or main caregivers, or from developmental screenings [1–3]. An efficient developmental screening instrument should include precise and updated developmental normative data for the measured population, and it should be highly reliable, valid, and convenient to use [4]. In Taiwan, the Chinese Child Developmental Inventory (CCDI) is a very common screening instrument used in research and clinical practice for children 6–78 months old. The CCDI was derived from the Minnesota Child Development Inventory (MCDI) [5] and has been modified to eliminate specific cultural and socioeconomic attributes from the United States, and adapted to children living in northern Taiwan [6]. The CCDI includes 320 items of concrete behavioral descriptions in eight developmental dimensions: gross motor (GM), fine motor (FM), expressive language (EL), comprehension-conceptual (CC), situation-comprehension (SC), self-help (SH), personal-social (PS), and general development (GD). The CCDI has good reliability and validity, and has been used more than 30 years with normative data provided by Hsu et al [6]. Our recent study of the validity of diagnosis based on Hsu's norms found that this instrument still has a moderate to high level of specificity (57.6–95.1%), but the sensitivity of the EL for screening developmental language delay was only at an acceptable level (66%) [7]. Styles of rearing and parenting have changed over the past 30 years, and socioeconomic and

Conflict of interest: none.

* Corresponding author. Department of Public Health, College of Medicine, Tzu Chi University, 701, Section 3, Zhongyang Road, Hualien, Taiwan. Tel.: +886 3 8565301x2282; fax: +886 3 8564041.
E-mail address: shwen@mail.tcu.edu.tw (S.-H. Wen).

http://dx.doi.org/10.1016/j.tcmj.2015.01.001

environmental conditions are different, which could explain why the sensitivity of the CCDI has declined. In addition, previous studies have suggested that patterns of child development have also changed within this period [8,9]. Therefore, it is essential to reconstruct the normative data of the CCDI for screening purposes.

The CCDI normative data was recently updated using contemporary samples of children living in southern Taiwan in the Tainan area. The updated version has reliability and criterion validity, which confirms the potential of the CCDI in clinical use [9,10]. However, there is no evidence to show that the genetics, sociocultural background, and ways children are reared in Tainan are very similar to those in northern Taiwan. Thus, the main purpose of this study was to update CCDI normative data for children living in Taipei, and to compare these data with the data described by Ko et al [9] and Hsu et al [6] that were established more than 30 years ago using children living in northern Taiwan.

2. Materials and methods

2.1. Participants

Kindergarten children 36.5–75.5 months old were sampled using a stratified quota sampling method. Thirty kindergartens were proportionately recruited from three main areas—Xindian, Zhonghe, and Yonghe—in Taipei, Taiwan between June 2011 and April 2012. To compare these data with CCDI normative data from 1978, the children were classified into 26 groups according to sex by using the 3-month age groups defined by Hsu et al [6]. Inclusion criteria were the following: (1) age of 36.5 months to 75.5 months and (2) meeting sex by age stratification. To perform stratified quota sampling, we adopted a two-stage sampling framework to collect data on the sex and age of the children (Fig. 1). For the first step, the parents of 3539 kindergarten children from the selected kindergartens were approached to inquire whether they were willing to be contacted further for the study. The parents of 1252 children agreed to be contacted, and provided the sex and ages of their children. For the second step, we selected 789 children for sex and age group stratification by using the quota sampling method. In practice, only kindergarten teachers were allowed to meet these children and their parents. We then asked the teachers to collect the questionnaires. The research assistants initially explained the purpose of the study to the teachers of the selected kindergarten children. The teachers then delivered the questionnaires to the parents and asked the parents to return the questionnaires within 1 week. Parents were asked to complete an informed consent form and the questionnaire. The instructions for the questionnaire encouraged parents to telephone a trained assistant if they had any questions when filling out the questionnaire. A total of 664 questionnaires were returned with a response rate of 84.16%. We excluded 112 samples from the study because of unanswered

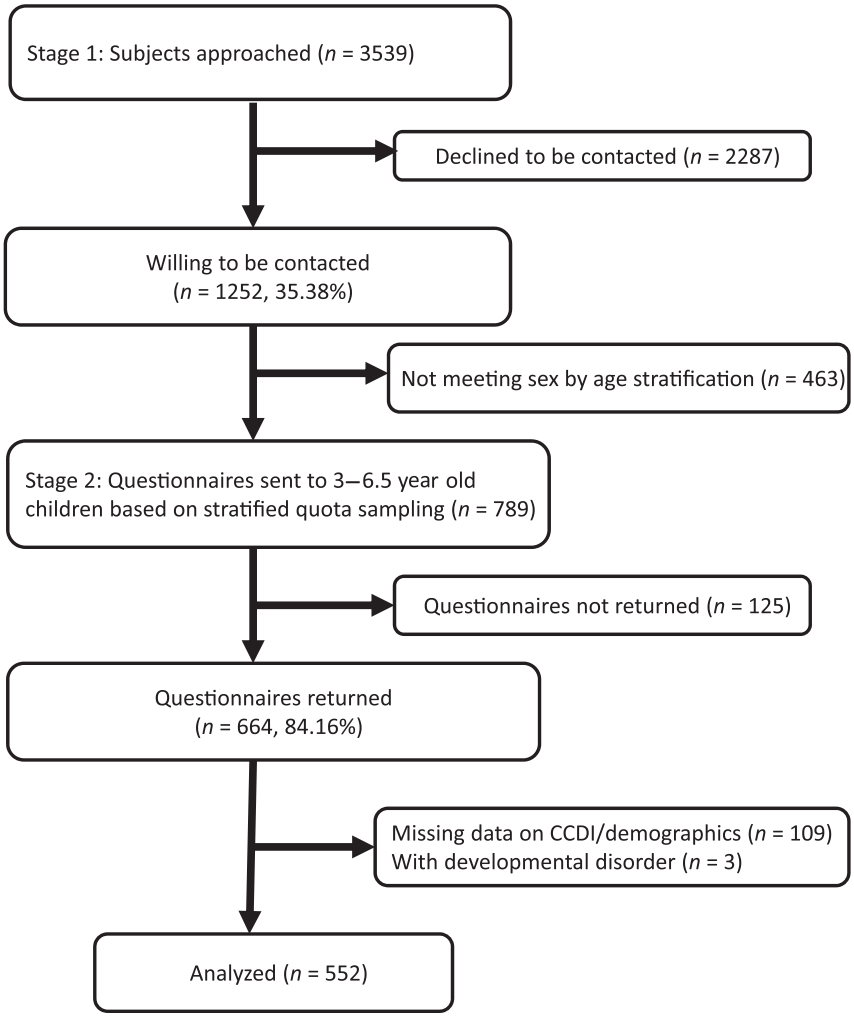

Fig. 1. Flowchart of the sampling framework. CCDI = Chinese Child Developmental Inventory.

questions or because the children had developmental disorders. Thus, 552 questionnaires were used for the analysis. The study was approved by the Institutional Review Board of the Taipei Tzu Chi Hospital (New Taipei, Taiwan). Informed written consent was obtained from all parents of the children involved.

2.2. Questionnaires

The CCDI was used to evaluate the eight dimensions of child development: GM (34 items); FM (44 items); EL (54 items); CC (67 items); SC (44 items); SH (36 items); PS (34 items); and GD (131 items). The GD domain combined seven new items with 124 items from the other seven domains. The CCDI is a parent report with 320 "Yes/No" items that measured the development of children from 6 months to 6.5 years old. In addition, demographic information was collected in relation to family background and social economic status.

2.3. Statistical analysis

The score for each CCDI dimension was obtained by summing up the number of "Yes" answers (1 point per "Yes" response) within each dimension. Descriptive statistics were presented as the mean and standard deviation for continuous variables and as the frequency and percentage for categorical variables. A possible ceiling effect was detected by calculating the percentage of scores presenting the maximum value (with >15% considered "substantial" [11]). To check for reliability, the Cronbach alpha coefficient was used to examine the internal consistency of each CCDI dimension. For comparison purposes, we constructed the norms by expressing the mean scores as a second-degree polynomial function of the mean age as follows: mean score $= \alpha + \beta \times age + \gamma \times age^2 + \varepsilon$, in which α, β, and γ are the regression coefficients and ε represents the error term. Furthermore, the lambda-mu-sigma (LMS) method by Cole and Green [12] was used to provide the reference percentiles for the CCDI. The LMS method is widely used for constructing growth charts for children such as head circumference and weight [13]. The method summarizes the changing distribution of the developmental scores as a function of age in three parameters that represent a Box-Cox power transformation of skewness (L), the median (M), and the coefficient of variation (S). The LMS percentiles were constructed with the VGAM package and implemented in the R language environment for statistical computing (v.2.9; R Development Core Team, R Foundation for Statistical Computing, Vienna, Austria, http://www.r-project.org/). All other analyses were performed using SAS 9.2 (SAS Institute Inc., Cary, NC, USA).

3. Results

3.1. Demographic characteristics of samples and reliability of the CCDI

Of the 552 children, 52.0% were boys. The male-to-female ratio was not significantly different from the ratio in Taiwan as a whole, which had a sex ratio of 1.074 from 2011 to 2012 ($p = 0.92$). The mean age of the children was 57.4 months (range, 37.0–75.5 months). Approximately 63.2% of the main caregivers spent at least 8 hours per day with their children, and only 8.6% of the main caregivers spent less than 4 hours with their children. The father's education ($p = 0.004$), maternal working status ($p < 0.001$), and the childrens ages ($p = 0.038$) were associated with time spent with children. However, there were no significant differences in the subdomains of the CCDI scores with various durations of time spent with the children (range of p, 0.089–0.627). Our sample did not differ from the official population data in Taiwan with regard to the number of children within one family and the mean age of the parents. Most (74.7%) fathers were educated at or above university level, and a similar figure (72.1%) was obtained for the mothers. Most (97.6%) fathers were employed, but that figure (68.6%) was only moderate for the mothers. In our study, the proportion of parents educated at or above university level and the number of working mothers were slightly higher than the proportion in the data from the whole of Taiwan. In our sample, the parents' education level was significantly associated with the CC, EL, and SH domains ($p < 0.001$); however, the domains accounted for a negligible amount of variance in these scores (R^2, 1.4%–2.3%). There was no significant association between maternal working status and developmental scores.

The Cronbach alpha coefficients for internal consistency were generally higher than or near 0.7, except for the dimensions of GM (0.62) and CC (0.66) (Table 1). The unsatisfactory Cronbach alpha coefficients may be attributed to either the low number of items or to more homogeneous samples because our samples were children aged older than 3 years in these domains. However, previous studies applied an acceptable reliability as a Cronbach alpha $\geq$0.6 [14,15]. All dimensions overall had an acceptable internal consistency. The mean scores for each dimension increased with age (Table 2). The children's ages and the mean scores were strongly correlated in that the correlation coefficients ranged from 0.862 to 0.986 ($p < 0.001$). Substantial ceiling effects (>15%) were observed in four dimensions: GM, FM, EL, and SC (Table 1). Through pairwise comparisons among the 13 age groups, we found that ceiling effects occurred at approximately 52–54 months for these dimensions.

3.2. Comparison with previous normative data of the CCDI

To compare our data with the previous normative data from Hsu et al [6] and Ko et al [9], we used the same analytical method, a quadratic linear regression model, to construct the updated normative data derived from this study. This is hereafter referred to as "the new model". To compare with the data from Ko et al [9], we reconstructed their quadratic linear regression model (hereafter referred to as "Ko's model") using their data from children 37–75 months old (Table 3). The age effect was statistically significant for each dimension and the adjusted R^2 was very large ($p < 0.001$, for all). Figs. 2 and 3 show the mean scores estimated from the normative data from Hsu et al [6] (hereafter referred to as "Hsu's model"), Ko's model, and the new model for each dimension. Our results show that the new model was quite similar to Ko's model,

Table 1
Descriptive statistics for each dimension of the Chinese Child Developmental Inventory ($n = 552$).

	GM	FM	CC	EL	SC	SH	PS	GD
Number of items	34	44	67	54	44	36	34	138
Mean	32.3	40.6	59.2	53	40.6	31.8	30.8	127.3
SD	1.6	3.5	6.5	1.6	3.3	3.6	2.5	8.9
Minimum	26	26	36	43	29	17	22	94
Percentiles								
25th	32	39	55	52.5	39	30	30	121
50th	33	42	60	54	41	33	31	129
75th	33	43	65	54	43	35	32	135
Percentage at ceiling (%)	**21.92**	**19.93**	11.96	**53.08**	**19.57**	13.04	14.49	6.34
Cronbach alpha (%)	62.15	81.88	66.15	89.84	78.27	80.87	68.58	92.24
Age group (mo)[a]	52 –54	52 –54	61 –63	46 –48	52 –54	58 –60	43 –45	—

CC = comprehension-conceptual; EL = expressive language; FM = fine motor; GD = general development; GM = gross motor; PS = personal-social; SC = situation-comprehension; SD = standard deviation; SH = self-help.
Bold font indicates a substantial ceiling effect.
[a] There is no significant difference of pairwise comparison among age groups older than the listed age groups for each dimension.

Table 2
Summary statistics for each developmental dimension of the Chinese Child Developmental Inventory ($n = 552$).

Age group	n	CCDI dimension															
		GM (34)		FM (44)		CC (67)		EL (54)		SC (44)		SH (36)		PS (34)		GD (138)	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
37–39	14	30.9	1.8	35.5	3.8	51.4	6.6	51.2	1.9	36.6	3.6	27.2	3.3	29.1	2.3	115.2	9.3
40–42	40	31.1	1.8	35.9	3.5	51.0	5.4	51.7	2.3	37.1	3.7	27.7	3.8	28.7	3.0	115.1	6.8
43–45	43	31.4	1.8	37.5	3.9	52.3	6.2	51.9	2.7	38.4	4.1	29.7	4.0	30.2	2.4	118.6	9.0
46–48	39	31.6	1.7	38.6	3.3	55.0	4.8	53.0	1.0	39.6	2.6	30.1	3.7	30.7	2.3	121.3	6.5
49–51	44	31.7	2.0	38.1	3.7	55.3	6.0	52.4	1.6	39.2	3.4	29.9	3.6	29.9	2.4	121.1	8.1
52–54	46	32.2	1.5	40.8	2.6	57.6	4.6	53.0	1.6	40.5	3.4	31.4	2.7	30.9	2.3	125.7	5.9
55–57	45	32.1	1.6	40.8	2.7	58.2	5.0	53.0	1.6	40.7	2.7	31.3	3.2	30.5	2.0	126.3	6.6
58–60	49	32.8	1.5	41.9	2.0	60.9	4.4	53.4	0.9	41.4	2.9	32.7	2.7	31.6	2.0	129.8	5.5
61–63	51	32.8	0.8	42.3	1.6	61.6	3.7	53.5	0.7	41.6	2.2	33.1	2.8	31.5	1.8	131.5	4.3
64–66	49	33.0	0.8	42.7	1.4	64.2	2.5	53.5	0.9	42.0	2.3	34.3	1.4	31.4	2.4	134.2	2.7
67–69	43	32.7	1.3	42.8	1.7	64.0	3.1	53.4	1.1	41.6	2.5	33.6	2.4	31.2	2.5	133.6	4.1
70–72	42	33.1	1.1	43.0	1.1	64.3	2.5	53.4	1.4	42.4	2.0	34.1	1.6	31.8	2.6	134.4	3.1
73–75	47	33.2	1.0	43.2	0.9	65.4	2.2	53.6	0.8	42.5	2.2	34.4	1.7	31.4	2.3	135.7	2.8

The age group presents a lower limit to upper limit in months. The number in parenthesis denotes the total number of items for the specific dimension of the CCDI.
CC = comprehension-conceptual; CCDI = Chinese Child Developmental Inventory; EL = expressive language; FM = fine motor; GD = general development; GM = gross motor; PS = personal-social; SC = situation-comprehension; SD = standard deviation; SH = self-help.

Table 3
Estimated regression coefficients of Ko's model and the new model, based on polynomial regression.

CCDI Dimension	Ko's model[a]				New model			
	R^2	$\hat{\alpha}$	$\hat{\beta}$	$\hat{\gamma}$	R^2	$\hat{\alpha}$	$\hat{\beta}$	$\hat{\gamma}$
GM	0.91	20.14	0.36	−0.002	0.95	25.53	0.18	−0.001
FM	0.98	8.79	0.87	−0.006	0.97	11.26	0.83	−0.005
EL	0.98	33.94	0.55	−0.004	0.91	42.04	0.34	−0.002
CC	0.99	10.06	1.26	−0.007	0.97	25.54	0.75	−0.003
SC	0.98	19.24	0.55	−0.003	0.97	18.63	0.63	−0.004
SH	0.97	10.32	0.63	−0.004	0.96	9.76	0.59	−0.003
PS	0.95	19.70	0.31	−0.002	0.80	19.19	0.35	−0.002
GD	0.99	43.02	2.08	−0.012	0.97	70.36	1.40	−0.007

Polynomial regression model can be expressed as mean score $= \hat{\alpha} + \hat{\beta}age + \hat{\gamma}age^2$.
[a] The coefficients are estimated by using data of the 37–75 months age group (Table 1 in Ko et al [9]).

even though their sample came from the general population of children in Tainan from 2000 to 2003. Our data and Ko's curves were quite similar for the FM, CC, PS, and GD dimensions; the mean difference (MD) among all age groups was within 0.36 (Figs. 2 and 3). The new model was slightly better than Ko's model at predicting the GM, EL, and SC scores for children under 48 months old; however, these differences were small (the MDs ranged 0.58–0.68). It is interesting that the new model in general had slightly lower values for the SH dimension (MD = 1.14) than Ko's model among all age groups. For children 3–6.5 years old, these two normative data curves were quite similar for GD, despite the fact that we only recruited kindergarten children.

To compare our data with the normative data in Hsu's model, we adopted the mean developmental age from the bar graphs of the CCDI in Hsu et al [6], which have been widely used for developmental screening in clinical practice (the dotted line in Figs. 2 and 3). The estimated mean scores were different in the seven

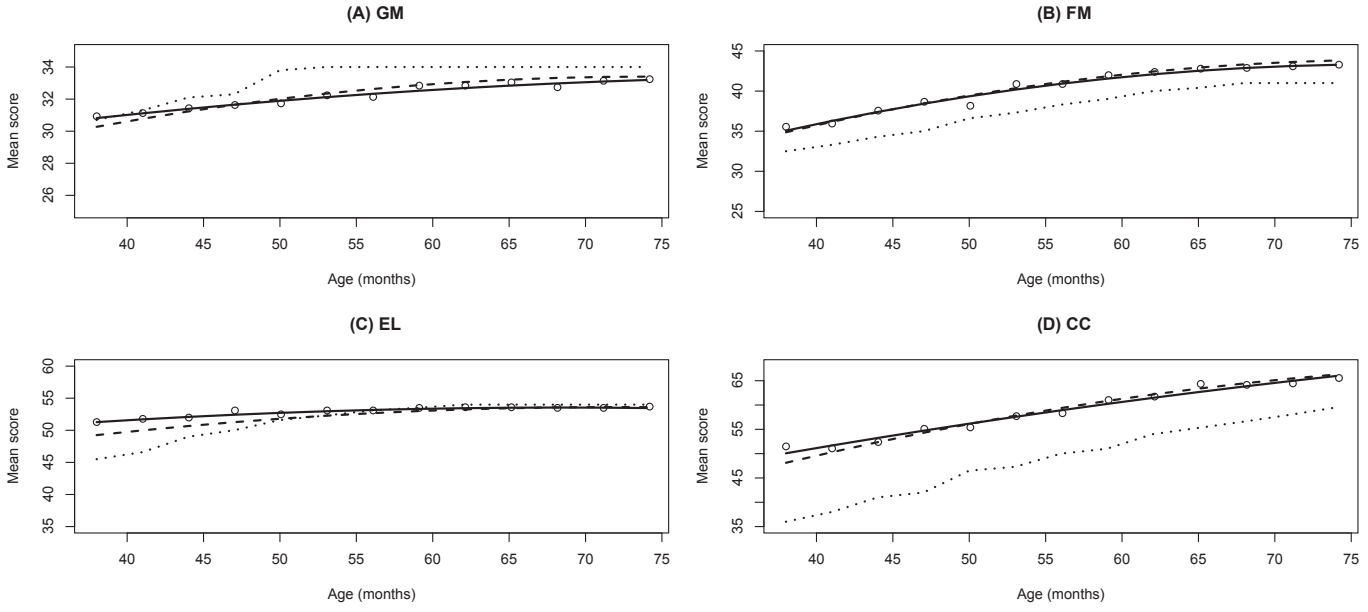

Fig. 2. Polynomial regression curves for the following dimensions: (A) gross motor (GM); (B) fine motor (FM); (C) expressive language (EL); and (D) comprehension-conceptual (CC). The bold lines represent the updated norms and the dashed lines represent the norms from Ko et al [9]. The dotted lines represent the mean developmental scores from Hsu et al [6].

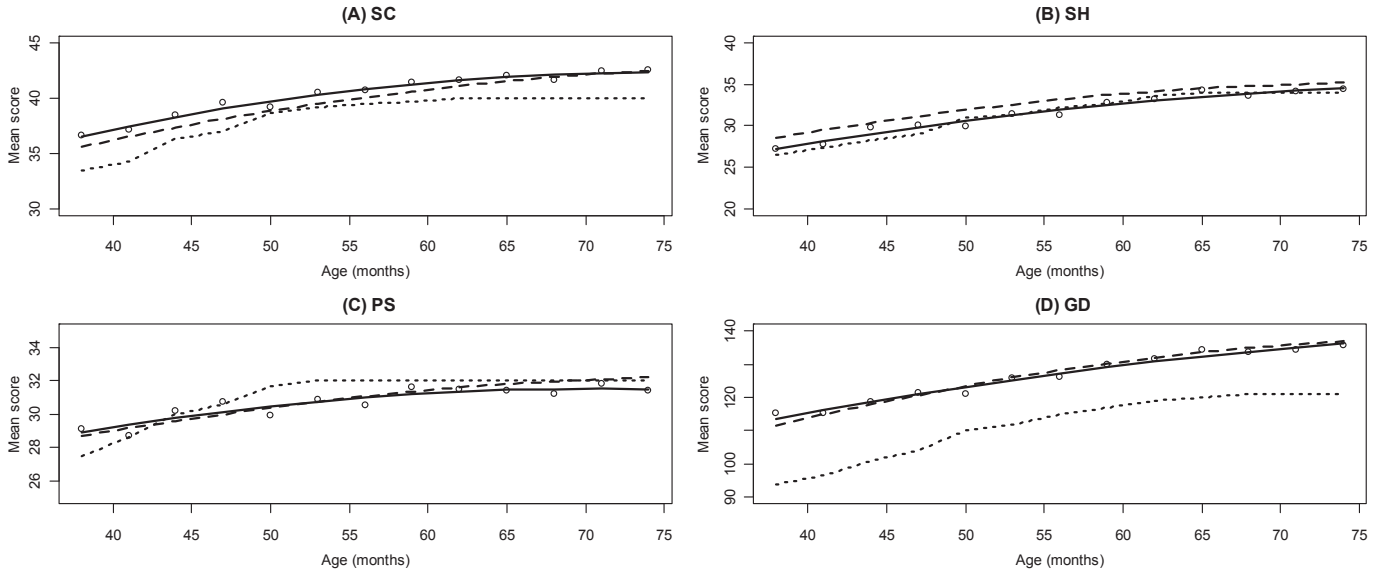

Fig. 3. The polynomial regression curves for the following dimensions: (A) situation-comprehension (SC); (B) self-help (SH); (C) personal-social (PS); and (D) general development (GD). The bold lines represent the updated norms and the dashed lines represent the norms from Ko et al [9]. The dotted lines represent the mean developmental scores from Hsu et al [6].

dimensions, except in the SH dimension (Figs. 2 and 3). Among all age groups, the new model indicated that the estimated mean scores were higher than those in Hsu's model for the GD dimension (mean MD = 14.69), followed by the CC dimension (mean MD = 9.7), the FM dimension (mean MD = 2.56), and the SC dimension (mean MD = 1.95). For EL, the difference between the two curves (Fig. 2) was observed at <50 months, whereas the difference was 3.5 higher on average in the new model. The better performance in the CC dimension would contribute to greater improvement in GD, compared to Hsu's model; however, the mean score of the GM dimension was lower than that in Hsu's model with a MD of 1.04. This indicates that the GM performance of the new model was slightly inferior than that of Hsu's model. The performance of SH, interestingly, tended to be quite similar between the two models, and the difference in the PS dimension between the models tended to be negligible (MD = 0.42). The new model revealed a sizable increase in GD, particularly in the CC dimension, during the past 3 decades for children 3–6.5 years old.

3.3. Updated reference CCDI curves

In this paper, we provide age-specific developmental percentile curves that can be used in clinical settings. Figs. 4 and 5 graphically present the age-specific percentile curves (the 5th, 25th, 50th, 75th,

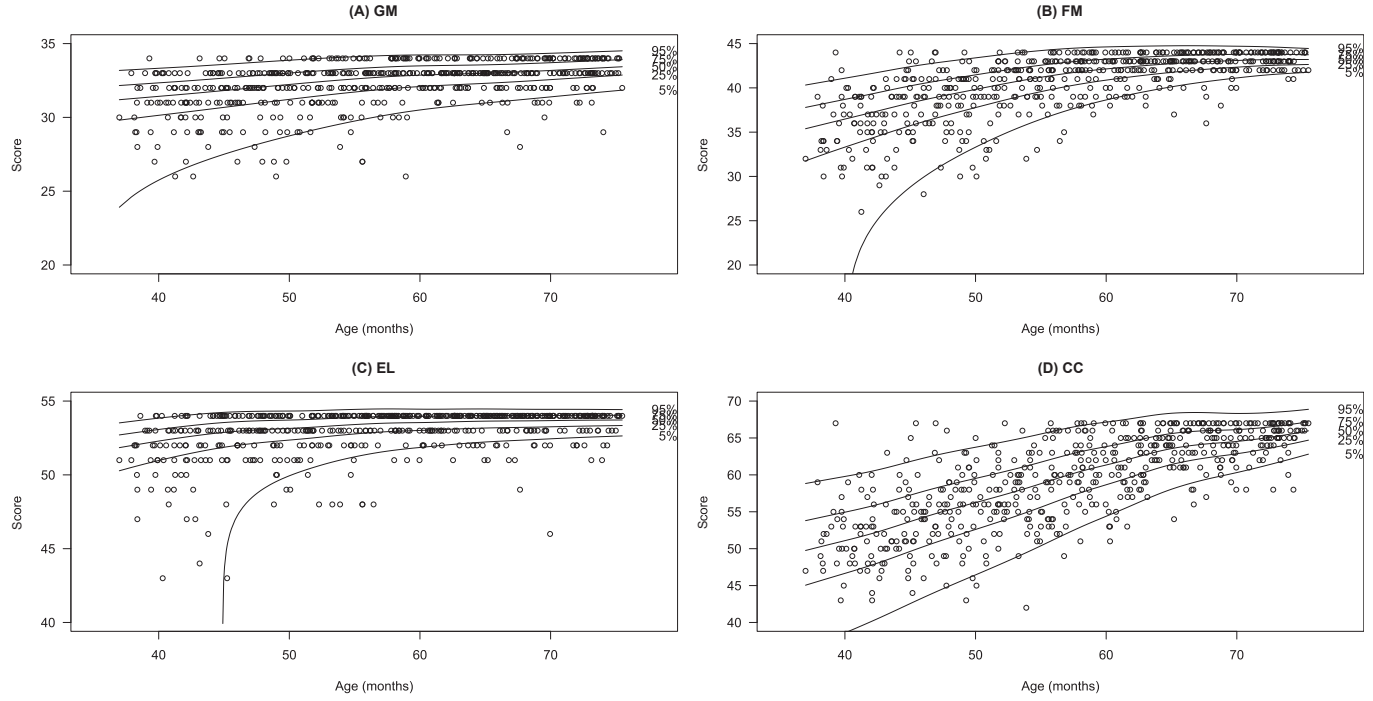

Fig. 4. The reference curves constructed using the lambda-mu-sigma (LMS) method for the 5th percentile, 25th percentile, 50th percentile, 75th percentile, and 95th percentile for the following dimensions: (A) gross motor (GM); (B) fine motor (FM); (C) expressive language (EL); and (D) comprehension-conceptual (CC).

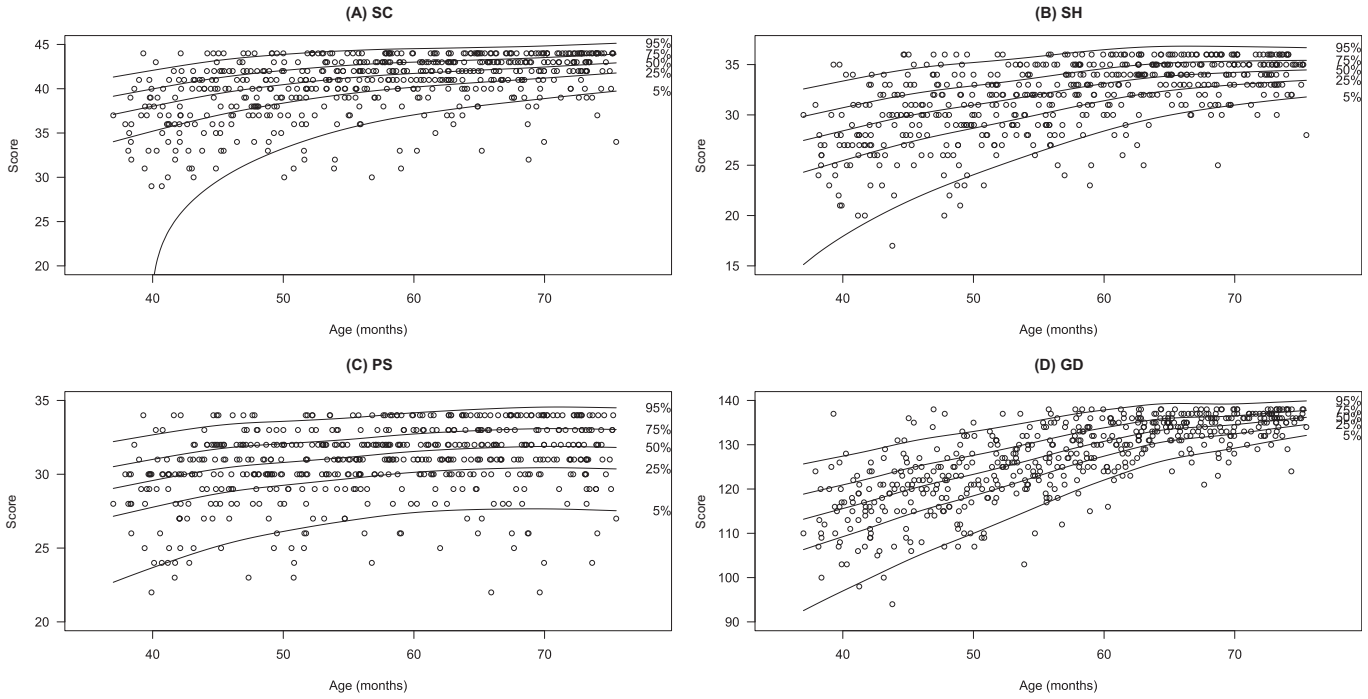

Fig. 5. The reference curves constructed using the lambda-mu-sigma (LMS) method for the 5th percentile, 25th percentile, 50th percentile, 75th percentile, and 95th percentile for the following dimensions: (A) situation-comprehension (SC); (B) self-help (SH); (C) personal-social (PS); and (D) general development (GD).

and 95th percentiles) of the raw scores for each CCDI developmental dimension. For each dimension, all percentile curves showed an increase with age. However, the curve reached a plateau for most dimensions after approximately 70 months of age. It is also noteworthy that the percentiles by age (90th and 95th) were quite similar at ages >65 months for each dimension. (The tabulated percentiles are available in Appendix A) In particular, there was little difference between the 5th and 95th percentiles (difference <3) in the GM, FM, and EL dimensions from 70 months of age onwards. This is consistent with the high percentage values at ceiling for the GM, FM, and EL dimensions, and indicates that the CCDI may fail to detect a meaningful difference in development for children over 70 months of age.

4. Discussion

In this study, we have established new CCDI developmental reference curves for children in Taipei, Taiwan, based on data from kindergarten children 3–6.5 years old. To the best of our knowledge, these are the first age-specific percentile figures of the CCDI developed for clinical use. The present study showed that, except for the SH dimension, the mean scores were similar to those of children living in Tainan (i.e., Ko's model). These similarities may be related to the fact that these two samples were relatively contemporary with shared properties such as the large proportion of children over 4 years old who attended kindergarten. It is worth noting that there were no differences in the SH dimension between the new model and Hsu's model. Both models used data from children living in northern Taiwan, which highlight possible differences in parenting styles between the southern and northern parts of Taiwan. The mean score curves of children in northern Taiwan were very different from those reported by Hsu et al [6]. In particular, we found a rather sizable increment in the number of items passed in the GD, FM, CC, EL (at age <50 months), and SC dimensions, compared to Hsu's model. The accelerated development in these divisions may have resulted from the increase in socioeconomic status (SES) over the past 30 years, which include increases in the parental educational level, higher maternal employment rate, lower fertility rate, and higher number of children attending kindergarten at an earlier age. Previous studies report that a higher SES may in fact accelerate language development [16,17]. Most Taiwanese mothers aged from 25 to 39 years old are employed outside their homes (the maternal employment rate increased from 40% in 1980 to 80% in 2010, based on 2011 data from the Taiwan Ministry of the Interior) [18]. Hence parents can afford to send their children to kindergarten at earlier ages. It is evident that the positive impact of schooling on children's cognitive development is achieved through playing actively with the peer group and daily teaching programs during the kindergarten years [19]. It seems that child development has overall accelerated in several development dimensions during the past 30 years.

On the contrary, our study found that children nowadays showed slightly lower mean scores in the GM dimension. Previous studies [20,21] indicated that home equipment is positively associated with the development of children's motor skills. For these reasons, we suspect that a lower GM score is correlated with outdoor playground limitations because of urbanization. Another plausible explanation is that the behavior items listed in the GM division may not be appropriate any longer because of sociocultural changes. For instance, the relatively low pass (29.2%) obtained nowadays for the task “riding a bicycle without training wheels” is probably because of a lack of suitable cycling spaces within and around residential areas in Taipei. In another example, the pass rate was 68.8% for “rubber band jumping”. This was a classic children's folk game between 1970 and 1990, but is not played any longer. Hence, this may lead to low internal reliability. Because these items are out-of-date, more research is needed to develop robust items that measure GM adequately. Apart from this, the pass rate was 26.6% for “walking/playing alone near the house” in the PS dimension, which reflects that parents usually forbid their children to play alone for security reasons. Hence, further revisions of the CCDI behavioral items are needed to ensure the adequacy and

appropriateness of these models for contemporary children. It is also notable that negligible changes existed in the SH and PS dimensions for the 3 decades. A possible explanation for this is that the child care context does not influence early social skills such as self-regulation and children's social skills [22,23]. Children's behavioral self-regulation ability may be mostly related to the degree of maturation. Self-regulation and social skills may be also neglected in classroom settings, compared to teaching programs specifically related to language and cognition.

Because the current CCDI scores in children were superior to the normative data from 1978, new reference curves for the CCDI were established to facilitate the interpretation of the relative status of a particular child. The smoothed percentile curves can serve as useful additional screening tools for physicians to understand a child's capability in the context of normal development at a particular stage. In addition, the adequacy of the reference norms is related to adequate sample size. As noted in previous studies [24,25], sample size determination depends on several factors such as the variability of measurements, margin of error, and statistical method used. As suggested by Zhu and Chen [26], a sample size of 50 individuals per age groups by year can be the lower bound to derive decent norms using the inferential method. In our study, we collected 40 children on average in each 3-month age group. The sample size was adequate to construct the reference norms. The precision was low at the end of the age range; hence, we fitted the norms for all ages and derived the reference percentiles for the age range of 40–72 months (Appendix A) [27]. In Hsu's and Ko's studies [6,9], the CCDI norms were not sex-specific. The differences in the developmental scores between boys and girls were very small in our sample, and we expected negligible differences between the sexes. The parents' education level was significantly correlated with the EL, CC, and SH dimensions, but the effect was small. This is consistent with previous findings in a Canadian study of new normative data for the MCDI [28]. There are certainly some essential biases in sample recruitment when collecting a community sample at a limited cost and within the restrictions on contact. However, our sample still represented a population with features more typical of contemporary children than Hsu's original sample. Therefore, the CCDI norms developed in this kindergarten sample can be generalized to kindergarten children more than 3 years old with a socioeconomic status similar to those in our study. However, the updated CCDI norms should not be generalized to children who are significantly different from the group such as children who have not attended kindergarten or children who are younger than 3 years old.

To understand the relationship between the threshold for the developmental quotient described in Hsu et al [6] and the cut-point for the percentile curves, we considered the SH dimension for comparison because this dimension had not changed during the past 30 years. According to the developmental quotient, a developmental age below 30% of chronologic age-level implies a "developmental delay". The threshold to consider a "delay" ranges between the 5^{th} and 10^{th} percentiles. However, further assessment is needed to determine whether these percentile figures can be adequately applied for screening criteria. Furthermore, the clinical validity of using the cut-off points of these percentiles also needs further study.

There were two main limitations in our study. We only recruited children older than 3 years; therefore, it is unclear whether these results could be generalized to children younger than 3 years old. The lack of children under 3 years old also limited our ability to examine floor and ceiling effects accurately. We found ceiling effects in most developmental dimensions. Similar to Ko's study, ceiling effects were evident among most CCDI dimensions. There are 320 behavioral items included in the CCDI, although it is still difficult to evenly distribute these items across all ages from 6 months to 72 months and all developmental dimensions. This may lead to undetected floor and ceiling effects. A previous study [29] using the data of children 15–72 months old showed a ceiling effect for children 5–6 years old in the French version of the Child Development Inventory, which was developed from the MCDI. Additional samples of children younger than 3 years old are needed. In the future, we hope to collect a representative sample of children under 3 years old to address these two issues.

The CCDI is one of the most commonly used comprehensive child developmental screening tools in Taiwan. Because of the current focus on children older than 3 years, we found that during the past 30 years, the GD of children has improved, particularly in language and in dimensions that require cognitive development. The progress observed in these dimensions may be related to factors such as a schooling effect, a rising SES, and a low fertility rate. Previous CCDI normative data should be interpreted very carefully and cautiously when used for screening contemporary children for developmental delays. In addition, we estimated percentile curves that could serve as appropriate references for clinical use, especially when screening for developmental disorders.

Acknowledgments

This work was supported by Taipei Tzu Chi Hospital, Buddhist Tzu Chi Medical Foundation (New Taipei, Taiwan; grant number TCRD-TPE-100-28).

Appendix A. The estimated percentile values of CCDI obtained from lambda-mu-sigma method for children older than 3 years.

Domain	Month	5^{th}	10^{th}	25^{th}	50^{th}	75^{th}	90^{th}	95^{th}
GM (34)	40	25.7	28.2	30.1	31.4	32.3	33.0	33.3
	41	26.2	28.4	30.2	31.5	32.4	33.0	33.4
	42	26.6	28.6	30.4	31.6	32.5	33.1	33.4
	43	26.9	28.8	30.5	31.7	32.5	33.2	33.5
	44	27.2	28.9	30.6	31.7	32.6	33.2	33.5
	45	27.5	29.1	30.7	31.8	32.7	33.3	33.6
	46	27.8	29.3	30.8	31.9	32.7	33.3	33.6
	47	28.0	29.4	30.9	32.0	32.8	33.4	33.7
	48	28.3	29.6	31.0	32.1	32.9	33.5	33.8
	49	28.5	29.8	31.1	32.1	32.9	33.5	33.8
	50	28.7	29.9	31.2	32.2	33.0	33.6	33.9
	51	29.0	30.1	31.3	32.3	33.1	33.6	33.9
	52	29.2	30.2	31.4	32.4	33.1	33.7	34.0
	53	29.4	30.4	31.5	32.5	33.2	33.7	34.0
	54	29.6	30.5	31.6	32.5	33.3	33.8	34.0
	55	29.8	30.6	31.7	32.6	33.3	33.8	34.0
	56	29.9	30.8	31.8	32.7	33.4	33.9	34.0
	57	30.1	30.9	31.9	32.7	33.4	33.9	34.0
	58	30.2	31.0	32.0	32.8	33.4	33.9	34.0
	59	30.4	31.1	32.0	32.8	33.5	34.0	34.0
	60	30.5	31.2	32.1	32.9	33.5	34.0	34.0
	61	30.6	31.3	32.1	32.9	33.5	34.0	34.0
	62	30.7	31.3	32.2	32.9	33.5	34.0	34.0
	63	30.8	31.4	32.2	32.9	33.5	34.0	34.0
	64	30.9	31.5	32.3	33.0	33.5	34.0	34.0
	65	31.0	31.5	32.3	33.0	33.6	34.0	34.0
	66	31.1	31.6	32.4	33.0	33.6	34.0	34.0
	67	31.1	31.7	32.4	33.1	33.6	34.0	34.0
	68	31.2	31.7	32.4	33.1	33.6	34.0	34.0
	69	31.3	31.8	32.5	33.1	33.7	34.0	34.0
	70	31.4	31.9	32.6	33.2	33.7	34.0	34.0
	71	31.5	31.9	32.6	33.2	33.7	34.0	34.0
	72	31.6	32.0	32.7	33.3	33.8	34.0	34.0

(*continued on next page*)

(*continued*)

Domain	Month	5th	10th	25th	50th	75th	90th	95th
FM (44)	40	NA	28.1	33.3	36.5	38.7	40.3	41.1
	41	21.1	29.1	33.8	36.8	39.0	40.5	41.3
	42	24.1	30.0	34.3	37.2	39.3	40.8	41.6
	43	26.0	30.8	34.8	37.6	39.6	41.1	41.9
	44	27.5	31.6	35.3	37.9	39.9	41.4	42.1
	45	28.8	32.3	35.7	38.3	40.2	41.6	42.4
	46	29.9	33.0	36.2	38.6	40.5	41.9	42.6
	47	30.9	33.6	36.6	38.9	40.8	42.1	42.8
	48	31.7	34.2	37.0	39.2	41.0	42.3	43.0
	49	32.6	34.8	37.4	39.5	41.2	42.5	43.2
	50	33.3	35.3	37.8	39.8	41.5	42.7	43.4
	51	34.0	35.8	38.2	40.1	41.7	42.9	43.6
	52	34.7	36.4	38.5	40.4	41.9	43.1	43.8
	53	35.3	36.9	38.9	40.7	42.2	43.3	43.9
	54	35.9	37.3	39.2	40.9	42.4	43.5	44.0
	55	36.5	37.8	39.6	41.2	42.6	43.6	44.0
	56	37.0	38.2	39.9	41.4	42.7	43.8	44.0
	57	37.4	38.6	40.2	41.6	42.9	43.9	44.0
	58	37.9	38.9	40.4	41.8	43.0	44.0	44.0
	59	38.3	39.3	40.7	42.0	43.1	44.0	44.0
	60	38.6	39.5	40.9	42.1	43.2	44.0	44.0
	61	39.0	39.8	41.1	42.3	43.3	44.0	44.0
	62	39.3	40.1	41.3	42.4	43.4	44.0	44.0
	63	39.6	40.3	41.4	42.5	43.5	44.0	44.0
	64	39.9	40.6	41.6	42.6	43.6	44.0	44.0
	65	40.1	40.8	41.8	42.7	43.6	44.0	44.0
	66	40.4	41.0	41.9	42.8	43.7	44.0	44.0
	67	40.6	41.1	42.0	42.9	43.7	44.0	44.0
	68	40.8	41.3	42.1	43.0	43.7	44.0	44.0
	69	40.9	41.5	42.2	43.0	43.8	44.0	44.0
	70	41.1	41.6	42.3	43.1	43.8	44.0	44.0
	71	41.3	41.7	42.4	43.1	43.8	44.0	44.0
	72	41.4	41.8	42.5	43.2	43.8	44.0	44.0
EL (54)	40	NA	46.9	51.0	52.3	53.1	53.6	53.8
	41	NA	48.0	51.2	52.4	53.2	53.7	53.9
	42	NA	48.7	51.4	52.5	53.3	53.8	54.0
	43	NA	49.2	51.5	52.7	53.4	53.8	54.0
	44	NA	49.7	51.7	52.8	53.5	53.9	54.0
	45	43.8	50.1	51.9	52.9	53.5	54.0	54.0
	46	47.3	50.4	52.0	52.9	53.6	54.0	54.0
	47	48.4	50.6	52.1	53.0	53.6	54.0	54.0
	48	49.1	50.8	52.2	53.1	53.7	54.0	54.0
	49	49.5	51.0	52.3	53.1	53.7	54.0	54.0
	50	49.9	51.2	52.3	53.1	53.7	54.0	54.0
	51	50.3	51.4	52.4	53.2	53.7	54.0	54.0
	52	50.5	51.5	52.5	53.2	53.8	54.0	54.0
	53	50.8	51.7	52.6	53.3	53.8	54.0	54.0
	54	51.0	51.8	52.7	53.3	53.8	54.0	54.0
	55	51.2	51.9	52.8	53.4	53.9	54.0	54.0
	56	51.4	52.1	52.8	53.4	53.9	54.0	54.0
	57	51.5	52.2	52.9	53.5	53.9	54.0	54.0
	58	51.7	52.2	52.9	53.5	54.0	54.0	54.0
	59	51.8	52.3	53.0	53.5	54.0	54.0	54.0
	60	51.8	52.4	53.0	53.5	54.0	54.0	54.0
	61	51.9	52.4	53.0	53.6	54.0	54.0	54.0
	62	52.0	52.5	53.1	53.6	54.0	54.0	54.0
	63	52.1	52.5	53.1	53.6	54.0	54.0	54.0
	64	52.2	52.6	53.1	53.6	54.0	54.0	54.0
	65	52.2	52.6	53.2	53.6	54.0	54.0	54.0
	66	52.3	52.7	53.2	53.6	54.0	54.0	54.0
	67	52.3	52.7	53.2	53.7	54.0	54.0	54.0
	68	52.4	52.7	53.2	53.7	54.0	54.0	54.0
	69	52.4	52.8	53.2	53.7	54.0	54.0	54.0
	70	52.4	52.8	53.3	53.7	54.0	54.0	54.0
	71	52.5	52.8	53.3	53.7	54.0	54.0	54.0
	72	52.5	52.8	53.3	53.7	54.0	54.0	54.0
CC (67)	40	38.6	41.9	46.7	51.1	54.9	58.1	59.8
	41	39.3	42.6	47.2	51.5	55.3	58.4	60.1
	42	40.1	43.2	47.7	52.0	55.8	58.8	60.5
	43	40.9	44.0	48.3	52.5	56.2	59.2	60.9
	44	41.7	44.7	49.0	53.1	56.7	59.7	61.3
	45	42.6	45.4	49.6	53.7	57.3	60.2	61.8
	46	43.4	46.2	50.3	54.2	57.8	60.6	62.3
	47	44.2	46.9	50.9	54.8	58.2	61.1	62.7
	48	44.9	47.6	51.5	55.3	58.7	61.5	63.1

(*continued*)

Domain	Month	5th	10th	25th	50th	75th	90th	95th
	49	45.7	48.2	52.0	55.8	59.1	61.9	63.4
	50	46.4	48.9	52.6	56.2	59.5	62.2	63.7
	51	47.2	49.6	53.2	56.7	59.9	62.6	64.1
	52	48.0	50.3	53.8	57.2	60.4	63.0	64.4
	53	48.8	51.0	54.4	57.7	60.8	63.3	64.8
	54	49.6	51.7	55.0	58.3	61.2	63.7	65.1
	55	50.4	52.5	55.6	58.8	61.7	64.2	65.5
	56	51.2	53.2	56.3	59.4	62.2	64.6	65.9
	57	52.1	54.0	56.9	59.9	62.7	65.0	66.3
	58	52.9	54.7	57.6	60.4	63.1	65.4	66.7
	59	53.7	55.4	58.1	60.9	63.5	65.7	66.9
	60	54.4	56.1	58.7	61.3	63.8	65.9	67.0
	61	55.1	56.7	59.2	61.8	64.2	66.2	67.0
	62	55.9	57.4	59.8	62.2	64.6	66.5	67.0
	63	56.7	58.1	60.4	62.7	64.9	66.8	67.0
	64	57.4	58.8	60.9	63.2	65.3	67.0	67.0
	65	58.1	59.3	61.4	63.6	65.6	67.0	67.0
	66	58.6	59.8	61.8	63.8	65.8	67.0	67.0
	67	59.1	60.3	62.1	64.1	65.9	67.0	67.0
	68	59.5	60.6	62.4	64.2	66.0	67.0	67.0
	69	59.9	61.0	62.6	64.4	66.1	67.0	67.0
	70	60.3	61.3	62.9	64.5	66.1	67.0	67.0
	71	60.7	61.6	63.1	64.7	66.2	67.0	67.0
	72	61.2	62.0	63.4	65.0	66.4	67.0	67.0
SC (44)	40	17.7	30.5	35.2	38.0	40.0	41.4	42.1
	41	23.3	31.2	35.6	38.3	40.2	41.6	42.3
	42	25.7	31.8	36.0	38.6	40.5	41.9	42.6
	43	27.3	32.4	36.3	38.9	40.8	42.1	42.8
	44	28.6	33.0	36.7	39.2	41.0	42.3	43.0
	45	29.6	33.5	37.0	39.4	41.2	42.5	43.2
	46	30.5	34.0	37.3	39.7	41.4	42.7	43.4
	47	31.3	34.5	37.6	39.9	41.6	42.9	43.5
	48	32.0	34.9	37.9	40.1	41.8	43.0	43.6
	49	32.7	35.3	38.1	40.3	41.9	43.1	43.8
	50	33.3	35.7	38.4	40.5	42.1	43.2	43.9
	51	33.8	36.0	38.6	40.6	42.2	43.4	44.0
	52	34.3	36.4	38.8	40.8	42.3	43.5	44.0
	53	34.7	36.7	39.0	40.9	42.4	43.6	44.0
	54	35.2	37.0	39.2	41.1	42.5	43.6	44.0
	55	35.5	37.3	39.4	41.2	42.6	43.7	44.0
	56	35.9	37.5	39.6	41.3	42.7	43.8	44.0
	57	36.2	37.8	39.8	41.5	42.8	43.9	44.0
	58	36.5	38.0	39.9	41.6	42.9	43.9	44.0
	59	36.8	38.2	40.1	41.6	43.0	44.0	44.0
	60	37.0	38.4	40.2	41.7	43.0	44.0	44.0
	61	37.3	38.6	40.3	41.8	43.1	44.0	44.0
	62	37.5	38.7	40.4	41.9	43.1	44.0	44.0
	63	37.7	38.9	40.5	42.0	43.2	44.0	44.0
	64	37.9	39.0	40.6	42.0	43.2	44.0	44.0
	65	38.1	39.2	40.7	42.1	43.3	44.0	44.0
	66	38.2	39.3	40.8	42.2	43.3	44.0	44.0
	67	38.4	39.5	40.9	42.2	43.4	44.0	44.0
	68	38.6	39.6	41.0	42.3	43.4	44.0	44.0
	69	38.7	39.7	41.1	42.4	43.5	44.0	44.0
	70	38.9	39.8	41.2	42.5	43.5	44.0	44.0
	71	39.0	40.0	41.3	42.5	43.6	44.0	44.0
	72	39.2	40.1	41.4	42.6	43.7	44.0	44.0
SH (36)	40	17.9	21.6	25.5	28.4	30.7	32.4	33.4
	41	18.7	22.1	25.8	28.7	31.0	32.7	33.6
	42	19.5	22.6	26.2	29.0	31.3	33.0	33.9
	43	20.1	23.1	26.6	29.3	31.5	33.2	34.1
	44	20.8	23.6	26.9	29.6	31.8	33.4	34.3
	45	21.4	24.1	27.3	29.9	32.0	33.7	34.5
	46	22.0	24.5	27.6	30.1	32.2	33.8	34.7
	47	22.5	24.9	27.9	30.4	32.4	34.0	34.9
	48	23.1	25.3	28.1	30.6	32.6	34.1	35.0
	49	23.6	25.7	28.4	30.8	32.7	34.3	35.1
	50	24.1	26.1	28.7	31.0	32.9	34.4	35.2
	51	24.5	26.4	28.9	31.2	33.0	34.5	35.3
	52	25.0	26.8	29.2	31.4	33.2	34.6	35.4
	53	25.4	27.2	29.5	31.6	33.4	34.8	35.5
	54	25.9	27.5	29.8	31.8	33.5	34.9	35.7
	55	26.3	27.9	30.0	32.0	33.7	35.1	35.8
	56	26.8	28.2	30.3	32.2	33.9	35.2	36.0
	57	27.2	28.6	30.6	32.5	34.1	35.4	36.0

(*continued*)

Domain	Month	5th	10th	25th	50th	75th	90th	95th
	58	27.6	29.0	30.9	32.7	34.3	35.5	36.0
	59	28.0	29.3	31.2	32.9	34.4	35.7	36.0
	60	28.4	29.6	31.4	33.1	34.6	35.8	36.0
	61	28.8	29.9	31.6	33.3	34.7	35.9	36.0
	62	29.1	30.2	31.9	33.5	34.9	36.0	36.0
	63	29.4	30.5	32.1	33.6	35.0	36.0	36.0
	64	29.7	30.7	32.3	33.8	35.1	36.0	36.0
	65	30.0	30.9	32.4	33.9	35.2	36.0	36.0
	66	30.2	31.1	32.6	34.0	35.2	36.0	36.0
	67	30.4	31.3	32.7	34.0	35.3	36.0	36.0
	68	30.6	31.5	32.8	34.1	35.3	36.0	36.0
	69	30.8	31.6	32.9	34.2	35.3	36.0	36.0
	70	31.0	31.8	33.0	34.2	35.3	36.0	36.0
	71	31.1	31.9	33.1	34.3	35.4	36.0	36.0
	72	31.3	32.0	33.2	34.3	35.4	36.0	36.0
PS (34)	40	23.7	25.5	27.8	29.6	31.0	32.1	32.7
	41	24.0	25.8	28.0	29.7	31.2	32.2	32.8
	42	24.3	26.0	28.2	29.9	31.3	32.4	33.0
	43	24.6	26.3	28.3	30.1	31.5	32.5	33.1
	44	24.9	26.5	28.5	30.2	31.6	32.6	33.2
	45	25.1	26.7	28.7	30.4	31.7	32.8	33.3
	46	25.4	26.9	28.8	30.5	31.8	32.8	33.4
	47	25.6	27.1	29.0	30.6	31.9	32.9	33.5
	48	25.8	27.2	29.1	30.7	32.0	33.0	33.5
	49	26.0	27.4	29.2	30.7	32.0	33.0	33.5
	50	26.1	27.5	29.3	30.8	32.1	33.1	33.6
	51	26.3	27.6	29.3	30.9	32.1	33.1	33.6
	52	26.4	27.7	29.4	30.9	32.2	33.1	33.7
	53	26.6	27.8	29.5	31.0	32.2	33.2	33.7
	54	26.7	28.0	29.6	31.1	32.3	33.2	33.8
	55	26.9	28.1	29.7	31.2	32.4	33.3	33.8
	56	27.0	28.2	29.8	31.2	32.4	33.4	33.9
	57	27.1	28.3	29.9	31.3	32.5	33.4	34.0
	58	27.2	28.4	30.0	31.4	32.6	33.5	34.0
	59	27.3	28.5	30.1	31.5	32.7	33.6	34.0
	60	27.4	28.6	30.1	31.5	32.7	33.7	34.0
	61	27.5	28.6	30.2	31.6	32.8	33.7	34.0
	62	27.5	28.7	30.2	31.7	32.8	33.8	34.0
	63	27.6	28.7	30.3	31.7	32.9	33.8	34.0
	64	27.6	28.7	30.3	31.7	32.9	33.9	34.0
	65	27.6	28.8	30.4	31.8	33.0	33.9	34.0
	66	27.6	28.8	30.4	31.8	33.0	33.9	34.0
	67	27.6	28.8	30.4	31.8	33.0	34.0	34.0
	68	27.7	28.8	30.4	31.9	33.1	34.0	34.0
	69	27.7	28.8	30.4	31.9	33.1	34.0	34.0
	70	27.7	28.8	30.4	31.9	33.1	34.0	34.0
	71	27.6	28.8	30.4	31.9	33.1	34.0	34.0
	72	27.6	28.8	30.4	31.9	33.1	34.0	34.0
GD (138)	40	97.0	102.2	109.2	115.6	120.9	125.1	127.4
	41	98.4	103.4	110.2	116.4	121.6	125.8	128.0
	42	99.8	104.6	111.2	117.2	122.4	126.4	128.6
	43	101.2	105.8	112.2	118.1	123.1	127.1	129.3
	44	102.6	107.0	113.2	119.0	123.9	127.8	130.0
	45	104.0	108.2	114.2	119.8	124.7	128.5	130.6
	46	105.3	109.3	115.1	120.6	125.3	129.1	131.2
	47	106.5	110.4	116.0	121.3	125.9	129.6	131.7
	48	107.7	111.4	116.8	122.0	126.5	130.1	132.1
	49	108.8	112.4	117.6	122.6	127.0	130.6	132.6
	50	110.0	113.4	118.5	123.3	127.6	131.1	133.0
	51	111.2	114.5	119.3	124.0	128.2	131.6	133.5
	52	112.4	115.6	120.2	124.8	128.8	132.1	134.0
	53	113.6	116.6	121.1	125.5	129.4	132.7	134.5
	54	114.9	117.7	122.0	126.3	130.1	133.2	135.0
	55	116.1	118.9	123.0	127.1	130.8	133.8	135.5
	56	117.4	120.0	123.9	127.9	131.4	134.4	136.0
	57	118.6	121.1	124.9	128.7	132.1	134.9	136.6
	58	119.8	122.2	125.8	129.4	132.7	135.5	137.0
	59	121.0	123.2	126.6	130.1	133.3	136.0	137.5
	60	122.0	124.1	127.4	130.8	133.8	136.4	137.8
	61	123.1	125.1	128.2	131.4	134.3	136.8	138.0
	62	124.1	126.0	129.0	132.0	134.8	137.2	138.0
	63	125.1	126.9	129.7	132.6	135.3	137.6	138.0
	64	126.0	127.7	130.3	133.1	135.7	137.9	138.0
	65	126.7	128.3	130.9	133.5	136.0	138.0	138.0
	66	127.3	128.8	131.2	133.8	136.1	138.0	138.0

(*continued*)

Domain	Month	5th	10th	25th	50th	75th	90th	95th
	67	127.8	129.2	131.5	134.0	136.2	138.0	138.0
	68	128.3	129.6	131.8	134.1	136.3	138.0	138.0
	69	128.7	130.0	132.1	134.3	136.4	138.0	138.0
	70	129.2	130.5	132.5	134.5	136.5	138.0	138.0
	71	129.8	130.9	132.8	134.8	136.7	138.0	138.0
	72	130.3	131.4	133.2	135.1	137.0	138.0	138.0

Because the precision of the percentile values is lower at the extremes of the age range, we only list percentile values for the ages of 40–72 months. The number in parentheses after the domain denotes the total number of items for the specific dimension of the CCDI.

CC = comprehension-conceptual; CCDI = Chinese Child Developmental Inventory; EL = expressive language; FM = fine motor; GD = general development; GM = gross motor; NA = not available (because of the small sample size); PS = personal-social; SC = situation-comprehension; SD = standard deviation; SH = self-help.

References

[1] Glascoe FP, Dworkin PH. The role of parents in the detection of developmental and behavioral problems. Pediatrics 1995;95:829–36.

[2] Lung FW, Shu BC, Chiang TL, Lin SJ. Efficient developmental screening instrument for 6- and 18-month-old children in the Taiwan Birth Cohort Pilot Study. Acta Paediatr 2008;97:1093–8.

[3] Lung FW, Chiang TL, Lin SJ, Lee MC, Shu BC. Child developmental screening instrument from six to thirty-six months in Taiwan birth cohort study. Early Hum Dev 2010;86:17–21.

[4] Frankenburg WK. Preventing developmental delays: is developmental screening sufficient? Pediatrics 1994;934:586–93.

[5] Ireton H, Thwing E. The Minnesota Child Development Inventory in the psychiatric-developmental evaluation of the preschool-age child. Child Psychiatry Hum Dev 1972;3:102–14.

[6] Hsu CC, Su S, Shao SJ, Lin CC, Soong WT, Chang C. Chinese child developmental inventory: a tentative normative data. Acta Paediatr Sin 1978;19:142–57.

[7] Wu HC, Hsu CC, Chiu V, Yeh YJ, Wen SH. Diagnostic validity of the Chinese Child Development Inventory in screening children with developmental language delay. Tzu Chi Med J 2013;25:228–32.

[8] Chen C, Li I, Chien L. Developmental status among 3 to 5-year-old preschool children in three kindergartens in the Peitou District of Taipei city. J Nurs Res 2003;11:73–81.

[9] Ko HC, Chu PY, Lu WM, Kao CC, Kung IS, Chiu YW, et al. Chinese Child Development Inventory: an updated normative data. Psychological Testing 2008;55:313–40.

[10] Chu PY. Diagnostic validity of Chinese Child Development Inventory in screening children with developmental delay [Master thesis; in Chinese]. Tainan, Taiwan: National Cheng Kung University; 2007. Available at:, http://etds.lib.ncku.edu.tw/etdservice/view_metadata?etdun=U0026-0812200914015341 [accessed 09.02.15].

[11] Hou WH, Yeh TS, Liang HW. Reliability and validity of Taiwan Chinese version of lower extremity functional scale. J Formos Med Assoc 2014;113:313–20.

[12] Cole TJ, Green PJ. Smoothing reference centile curves. The LMS method and penalized likelihood. Stat Med 1992;11:1305–19.

[13] WHO Growth Reference Study Group. WHO Child Growth Standards: head circumference-for-age, arm circumference-for-age, triceps circumference-for-age and sub-scapular skinford-for-age: methods and development. Geneva, Switzerland: World Health Organization; 2007.

[14] Sim J, Wright C. Research in health care: concepts, designs and methods. Cheltenham, United Kingdom: Stanley Thornes Ltd; 2000.

[15] Strugnell C, Renzaho A, Ridley K, Burns Cate. Reliability and validity of the modified child and adolescent physical activity and nutrition survey (CAPANS-C) questionnaire examining potential correlates of physical activity participation among Chinese-Australian youth. BMC Public Health 2014;14:145.

[16] Le Normand MT, Moreno-Torres I, Parisse C, Dellatolas G. How do children acquire early grammar and build multiword utterances? A corpus study of French children aged 2 to 4. Child Dev 2012;84:647–61.

[17] Vasilyeva M, Waterfall H, Huttenlocher J. Emergence of syntax: commonalities and differences across children. Dev Sci 2008;11:84–97.

[18] Ministry of the Interior (Taiwan). Women's marriage, fertility and employment survey. Mar 31, 2014. Available at: http://eng.stat.gov.tw/ct.asp?xItem=17761&CtNode=1662&mp=5 [accessed 09.02.15].

[19] Skibbe LE, Connorb CM, Morrisonc FJ, Jewkesd AM. Schooling effects on preschoolers' self-regulation, early literacy, and language growth. Early Child Res Q 2011;26:42–9.

[20] Barnett L, Hinkley T, Okely AD, Salmon J. Child, family and environmental correlates of children's motor skill proficiency. J Sci Med Sport 2013;16:332–6.

[21] Saccani R, Valentini NC, Pereira KR, Muller AB, Gabbard C. Associations of biological factors and affordances in the home with infant motor development. Pediatr Int 2013;55:197–203.

[22] NICHD Early Child Care Research and Network. Multiple pathways to early academic achievement. Harv Educ Rev 2004;74:1–29.
[23] Administration for Children and Families. Head start impact study: first year findings. Washington, DC: U.S. Department of Health and Human Services; 2005.
[24] Bellera CA, Hanley JA. A method is presented to plan the required sample size when estimating regression-based reference limits. J Clin Epidemiol 2007;60:610–5.
[25] Altman DG, Ohuma EO. Statistical considerations for the development of prescriptive fetal and newborn growth standards in the INTERGROWTH-21st Project. BJOG 2013;120(Suppl. 2):71–6.
[26] Zhu JJ, Chen HY. Utility of inferential norming with smaller sample sizes. J Psychoeduc Assess 2011;29:570–80.
[27] Bellera CA, Foster BJ, Hanley JA. Calculating sample size in anthropometry. In: Handbook of anthropometry: physical measures of human form in health and disease; 2012. p. 3–27. http://dx.doi.org/10.1007/978-1-4419-1788-1_1.
[28] Byrne JM, Backman JE, Bawden HN. Minnesota Child Development Inventory: a normative study. Canadian Psychol 1995;36:115–30.
[29] Duyme M, Zorman M, Tervo R, Capron C. French norms and validation of the Child Development Inventory (CDI): Inventaire du Développement de l'Enfant (IDE). Clin Pediatr 2011;50:636–47.