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Original Article

The relationship between child development and small for gestational age among preschool children

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Abstract

Objectives: This study aimed to assess the impact of small for gestational age (SGA) on the development of Taiwanese preschool children using the Chinese Child Developmental Inventory (CCDI). **Materials and Methods:** A total of 982 children were enrolled in this study between June 2011 and December 2015. The samples were divided into two groups: SGA (n = 116, mean age = 2.98) and non-SGA (n = 866, mean age = 3.33) groups. The development scores were based on the CCDI, which consist of eight dimensions of development between the two groups. The linear regression analysis was adopted to examine the relationship of SGA with child development. **Results:** On average, the children in the SGA group scored less in all eight subitems of the CCDI than those in the non-SGA group. However, regression analysis revealed that there was no significant difference in both performance and delay frequency in the CCDI between the two groups. **Conclusion:** SGA children had similar developmental scores in CCDI as non-SGA children for preschool age in Taiwan.

Keywords: *Chinese Child Developmental Inventory, Preschool, Small for gestational age*

Introduction

According to the World Health Organization, low birth weight is defined as the weight of <2500 g at birth. Low birth weight might result from prematurity (preterm birth) or intrauterine growth restriction. In particular, small for gestational age (SGA) is defined as a birth weight of less than the 10th percentile of the birth weight norm at the same gestational age [1].

Several literatures have discussed the outcomes of prematurity, especially those groups with extremely low birth weight. Low birth weight is associated with fetal and neonatal mortality and morbidity, including pulmonary diseases, intracranial hemorrhage, necrotizing enterocolitis, and other fatal diseases [2,3].

Low birth weight results in poor development of body organ functions and poor growth and cognitive development [4]. Shariat *et al*. revealed that SGA children and those with low birth weight had attention deficits and impaired executive functions compared with those who have normal birth weight and who are appropriate for gestational age (AGA) [5]. Another study in Spain investigated the influence of prematurity and low birth weight on deficits of specific visual abilities [6]. They discovered that both prematurity and SGA caused negative outcomes in visual performance, independently. Thus, considering the different effects of low birth weight and SGA is vital.

Morsing *et al*. compared the intelligence quality (IQ) of preterm children with that of term AGA children and reported better results in the term AGA group [7]. Nevertheless, a significant discrepancy in the prematurity subgroups was observed when considering the AGA condition. Premature children who fit the proper AGA range of their age achieved higher IQ scores than those with prematurity and growth restriction, indicating the importance of AGA growth.

For low birth weight, Saigal mentioned that children with extremely low birth weight had poor performance in speech and scholarship compared with full-term children at age eight, based on an analysis carried out using a revised version of the Wechsler Intelligence Scale for Children [8]. Although some studies have reported that children with low birth weight tend

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to "catch-up" in terms of development [9,10], the negative influence of low birth weight and prematurity could last until young adulthood, resulting in a lower mean IQ and less academic achievements [11].

On the other hand, multiple studies have evaluated the effects of SGA on various developmental aspects using different questionnaires and assessment tools. Some studies with detailed models have established that SGA has significant effects on child development. Recently, according to a nationwide Japanese longitudinal survey, which included 44,124 children, children with SGA showed poor performance in neurobehavioral development [12]. Similarly, finding in the low birth weight study, which is defined by the IQ score, reported the negative influences of SGA on cognitive function could continue until adulthood [13].

Therefore, this study shows the comparison of the developmental outcomes between SGA and non-SGA of preschool children in Taiwan, using the Chinese Child Developmental Inventory (CCDI) to validate the effects of SGA on child development in multidisciplinary domains.

Materials and Methods

The participants who were enrolled in this study were children who visited a local clinic and kindergarten around Southern New Taipei City District and Taipei Tzu Chi Hospital. Two periods were used for the enrollment collection: first group, children aged 0–3 years enrolled from September 2013 to December 2015, and second group, children aged 3–6 years enrolled from June 2011 to April 2012 [14]. After obtaining the informed consent, data were collected using a questionnaire. Excluded in this study were children with congenital disease, chromosome anomaly, brain insult, and cerebral malformation. The children were classified as SGA and non-SGA groups based on the birth weight according to the nomogram in Taiwan [15]. If the birth weight was less than the 10th percentile of the neonatal birth weight by norm in Taiwan, they were included in the SGA group; on the other hand, the remaining were included in the non-SGA group. The data collection flowchart is provided in Figure 1.

Ethics declaration

Ethical approval for this study (Research Ethics Committee, REC No. IRB 06-X04-014) was provided by the Research Ethics Committee of Taipei Tzu Chi Hospital, Buddhist Tzu Chi Medical Foundation, on May 22, 2017. Informed written consent was waived because the study was a retrospective data analysis.

The questionnaire included two parts:

a. The basic information of the children include gender, birth weight, prematurity, family–social environment, parents' age, and parents' education degree
b. The CCDI, which was modified from the Minnesota Child Development Inventory developed in 1978, includes eight subitems as development analysis. The subitems were as follows:
   1. Gross motor (GM): evaluates the GM development, including muscle power, balance, and coordination, and is scored from 0 to 34

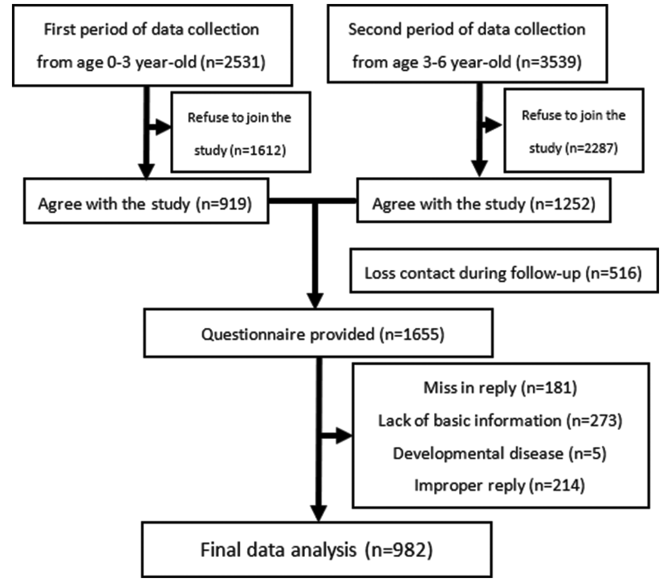

Figure 1: Data collection flowchart

   2. Fine motor (FM): evaluates the visual motor coordination and FM performing skills and is scored from 0 to 44
   3. Conceptual comprehension (CC): contains speech content development and abstract conception comprehension and is scored from 0 to 67
   4. Expressive language (EL): includes the ability of expression to others and is scored from 0 to 54
   5. Situation comprehension (SC): contains the ability to analyze environmental conditions and rules in games or situations and is scored from 0 to 44
   6. Personal–social (PS): includes the social interaction ability and is scored from 0 to 36
   7. Self-help (SH): evaluates the ability to achieve daily activities and is scored from 0 to 36
   8. General development (GD): scored from 0 to 138.

Taking into account the influence of age on children development, we calculate standardized scores for each item based on updated norm of CCDI developed in Ko *et al*. [16]. The calculation for standardized score of eight subitems is defined as (raw score minus mean score)/standard deviation (SD) for a child with specific age, while the age-specific mean and SD were obtained from [Table 1] in Ko *et al*. [16].

Statistical analysis

The descriptive statistics were mean and standard deviation (SD) for continuous variables, and numbers and percentages for categorical variables. For group comparisons, the independent sample *t*-test and Chi-square test were used whenever appropriate. Simple linear regression was performed to obtain an unadjusted estimate of the effect of SGA on standardized developmental score for each dimension of the CCDI. When considering the association between SGA and standardized developmental scores, other factors such as gender and parents' characteristics were used to clarify each compartment's true influence. After adjusting for gender, maternal age, maternal education, birth order, and breastfeeding (Yes or No), multiple linear regression analyses were performed to examine the

Table 1: Characteristics of the children in the small for gestational age and nonsmall for gestational age groups

	SGA (*n*=116)	Non-SGA (*n*=866)	*P*
Gender			
Female	51 (43.97)	427 (49.31)	0.280
Male	65 (56.03)	439 (50.69)	
Age (years)	2.98±1.72	3.33±1.72	0.04*
≤3	62 (53.45)	379 (43.76)	0.052
>3	54 (46.55)	487 (56.24)	
Gestational age (weeks)	38.32±2.38	38.67±1.93	0.075
Preterm birth			
Yes	19 (16.38)	79 (9.12)	0.016*
No	97 (83.62)	787 (90.88)	
Birth weight (g)	2415.2±404.1	3175.3±433.7	<0.001*
LBW			
Yes	59 (50.86)	34 (3.93)	<0.001*
No	57 (49.14)	832 (96.07)	
Birth order			
First	78 (67.24)	548 (63.28)	0.631
Second	32 (27.59)	277 (31.99)	
Third or below	6 (5.17)	41 (4.73)	
Breastfeeding			
No	20 (17.24)	130 (15.01)	0.723
Shorter than 3 months	22 (18.97)	186 (21.48)	
3 months or longer	74 (63.79)	550 (63.51)	
Maternal education			
Senior high or below	21 (18.10)	147 (16.98)	0.923
College	78 (67.24)	598 (69.05)	
Graduate school	17 (14.66)	121 (13.97)	
Maternal age	34.5±4.4	35.1±4.0	0.182

*P<0.05=Statistical significance. SGA: Small for gestational age, LBW: Low birth weight

association between SGA and child development (standardized scores). Subgroup analyses based on term/preterm, age at test (<3/≥3), gender, maternal education, birth order, and breastfeeding were further presented. P <0.05 was used to denote statistical significance, whereas P values between 0.05 and 0.1 were used to indicate borderline significance.

Results

Sample characteristics

In this study, a total of 982 children were enrolled; 116 (11.81%) were classified into the SGA group and 866 (88.19%) were classified into the non-SGA group. Both the groups had a higher percentage of males without statistical significance. On average, the SGA group was significantly younger than the non-SGA group (2.98 years vs. 3.33 years). The SGA group had less birth weight than the non-SGA group, with a difference of approximately 760 g on average, but without a difference in gestational age. Furthermore, no differences in parity, breastfeeding percentage, parents' nationality, parents' age, and parents' education degrees were observed between the two groups [Table 1].

Scores in the Chinese Child Developmental Inventory

The performances of the SGA and non-SGA groups in the eight subitems of the CCDI are presented in Table 2. On average, the SGA group had lower raw scores in all eight subitems than the non-SGA group. Statistically significant differences in raw scores were observed between the two groups: FM (SGA: 30.66 vs. non-SGA: 32.80; P = 0.040), CC (SGA: 36.39 vs. non-SGA: 41.04; P = 0.042), and SH (SGA: 20.94 vs. non-SGA: 23.48; P = 0.021). In addition, borderline significant differences in EL (SGA: 38.34 vs. non-SGA: 41.56; P = 0.052) and GD (SGA: 86.53 vs. non-SGA: 93.91; P = 0.055) scores were observed between the two groups. However, there were no significant differences of standardized scores between the two groups.

Regression of small for gestational age and each dimension of the Chinese Child Developmental Inventory

The results of simple and multiple linear regressions are presented in Table 3. After adjusting for other potential confounding factors (e.g. gender, maternal education, birth order, and breastfeeding), GM performance was not associated with SGA. Similar situation was noted when analyzing FM performance. When considering other potential confounding factors, the correlation of SGA with poor FM scores was not significant (β = −0.003; P = 0.974). The factors that affect higher FM performance include female gender and maternal education.

As for cognition development, the correlation between SGA and worse CC (P = 0.192) and EL (P = 0.269) performances was not statistically significant from simple linear regression. Similarly, when considering other factors, it was observed that SGA has no effect on these performances, but short breastfeeding time, male gender, and lower maternal education degree were significantly correlated with worse CC and EL scores. Surprisingly, SGA had lower EL performance and reached borderline significance (β = −0.077; P = 0.093).

When putting together other factors, SGA alone was not associated with PS and SH performances. Instead, children who were not the first child of the family (β =0.188; P = 0.01) and those who had longer breastfeeding time (β =0.249; P < 0.001) tended to have better scores in PS. In SH subitem, the female gender (β =0.428; P < 0.001) has effects on positive outcomes. In addition, in the SC subitem, SGA had no significant effect on the scores (β =0.094; P = 0.314) in multivariable analysis. The male gender (β = −0.329; P < 0.001) had disadvantages, as noted from the survey of other variable factors. Furthermore, male children (β = −0.299; P < 0.001) and higher birth order (β = −0.361; P = 0.024) had worse scores in GD. Factors resulted in higher GD scores were longer breastfeeding time (β = 0.256; P = 0.008).

Subgroup analysis

We further performed the subgroup analysis based on all the confounding factors including term/preterm, age at test, gender, maternal education, birth order, and breastfeeding. Significant differences in CCDI scores were only present from the gender subgroup analysis [Table 4]. The results showed that there is a negative impact of girl in SGA population over the domain of GM (β = −0.279; P = 0.045), CC (β = −0.438; P = 0.004), and SH (β = −0.393; P = 0.003), while boy has slightly positive effect in the domain of GM (β =0.326, P = 0.019). There was no significant finding over the resting subgroup analysis.

Table 2: Chinese Child Developmental Inventory scores in the small for gestational age and nonsmall for gestational age groups

Score	Subitems	SGA (*n*=116)	Non-SGA (*n*=866)	*P*
Raw score	GD	86.53±40.62	93.91±38.46	0.055+
	GM	25.41±9.03	26.79±8.37	0.098+
	FM	30.66±10.96	32.80±10.45	0.040*
	CC	36.39±23.88	41.04±22.97	0.042*
	EL	38.34±18.07	41.56±16.54	0.052+
	SH	20.94±11.16	23.48±11.05	0.021*
	PS	22.78±10.45	24.24±9.61	0.129
	SC	30.09±12.61	31.95±12.02	0.121
Standardized score	GD	0.220±1.09	0.277±1.06	0.584
	GM	0.037±0.96	−0.003±0.96	0.668
	FM	−0.015±0.95	0.007±0.96	0.812
	CC	−0.098±0.96	0.023±0.94	0.192
	EL	−0.055±0.89	0.041±0.89	0.269
	SH	−0.128±1.02	−0.0004±0.96	0.184
	PS	0.033±0.93	−0.001±0.95	0.710
	SC	0.067±0.96	−0.001±0.96	0.472

*P<0.05=Statistical significance, +P≤0.05-<0.1=Borderline significance. SGA: Small for gestational age, GD: General development, GM: Gross motor, FM: Fine motor, CC: Conceptual comprehension, EL: Expressive language, SH: Self-help, PS: Personal-social, SC: Situation comprehension

Table 3: Regression analysis of the association of small for gestational age and Chinese Child Developmental Inventory performance

Standardized score	SGA (reference: Non-SGA)	β	95% CI	*P*
GM	Unadjusted	0.040	−0.146-0.228	0.668
	Adjusted	0.062	−0.127-0.250	0.520
FM	Unadjusted	−0.022	−0.209-0.164	0.812
	Adjusted	−0.008	−0.193-0.177	0.932
CC	Unadjusted	−0.121	−0.305-0.061	0.192
	Adjusted	−0.114	−0.295-0.067	0.219
EL	Unadjusted	−0.097	−0.271-0.075	0.269
	Adjusted	−0.082	−0.253-0.089	0.345
SH	Unadjusted	−0.127	−0.316-0.060	0.184
	Adjusted	−0.113	−0.297-0.071	0.227
PS	Unadjusted	0.034	−0.149-0.219	0.710
	Adjusted	0.050	−0.133-0.234	0.591
SC	Unadjusted	0.068	−0.118-0.256	0.472
	Adjusted	0.091	−0.093-0.276	0.332
GD	Unadjusted	−0.057	−0.264-0.149	0.584
	Adjusted	−0.043	−0.247-0.161	0.679

*P<0.05=Statistical significance. Adjusted: For multiple linear regression, we adjusted for confounding factors including gender, maternal age, maternal education, birth order, and breastfeeding (yes or no). SGA: Small for gestational age, GD: General development, GM: Gross motor, FM: Fine motor, CC: Conceptual comprehension, EL: Expressive language, SH: Self-help, PS: Personal-social, SC: Situation comprehension, CI: Confidence interval

Discussion

This study compared the developmental outcomes between SGA and non-SGA children. When comparing the mean differences in raw developmental scores of the two groups, SGA children achieved significantly lower scores in FM, CC, and SH subitems of the CCDI. However, there were no significant differences in standardized scores between the two groups. In multiple regression analysis, it is worth noting that poor EL was borderline significant.

These findings were not compatible with some previous studies that SGA has adverse effects on developmental outcomes [4,5,7]. Arcangeli *et al*. reviewed 28 articles that included only full-term SGA children and reported that these children showed poor neurodevelopmental scores compared with full-term AGA children [17]. An explanation to the negative finding from our study, as opposed to this data, that children with specific congenital or developmental diseases were excluded at the beginning of our sample collection. This obviously led to the elimination of the negative outcomes from these children in the final analysis, thus causing insignificant results.

Moreover, a recent population-based longitudinal study in Japan used questionnaires to collect developmental information from full-term infants born in 2001 [12]. The questionnaires consisted of achievements including GM, language, and PS development performances. The infants were analyzed and classified into two groups: SGA and AGA groups. The investigators added the concept of "catch-up" for SGA children and was defined as the body height above −2.0 SDs at age two. They found that SGA children without "catch-up" growth were more likely to present poor performance. However, our study did not consider the "catch-up" condition.

In another study from Taiwan, some preterm children showed regression of developmental outcomes during follow-ups [18]. This "catch-up" phenomenon might be another important factor to clarify the effect of SGA on child development. Thus, long-term follow-up and timely assessment are necessary to evaluate the parameters in detail in future study.

Murthy *et al*. evaluated the association between SGA at birth and educational performance using the Florida Comprehensive Assessment Test (FCAT) in a large cohort study published in 2019 [19]. The FCAT scores were recorded from grade three to grade eight. The result showed a persistent but small negative association between educational performance and SGA in school-age children. This study, though using 23 SGA definitions (3rd–25th percentile) and collecting data from a wider gestational age range (23–41 weeks), reported that the adverse effect of SGA could persist until the middle-school age. Another study in Norway followed SGA children until young adulthood and reported that the IQ scores of SGA people remained low [13]. Considering these studies, the follow-up period in future studies should last until young adulthood is recommended.

In this study, although SGA showed no significant influence on child development, some correlations were detected for other variable factors that we examined. One of the findings was that the children whose breastfeeding duration was 3 months or longer had significantly better performance in nearly all subitems of the CCDI than those who were not breastfed. This finding confirmed to the previous studies

Table 4: Subgroup analysis: The effect of gender to performance of Chinese Child Developmental Inventory in the small for gestational age population

Standardized score	Gender					
	Girl			Boy		
	β	95% CI	*P*	β	95% CI	*P*
GM	−0.279	−0.551-−0.007	0.045*	0.326	0.055-0.598	0.019*
FM	−0.238	−0.504-0.028	0.080	0.176	−0.094-0.447	0.201
CC	−0.438	−0.733-−0.143	0.004*	0.166	−0.076-0.409	0.177
EL	−0.109	−0.391-0.173	0.446	−0.031	−0.282-0.219	0.806
SH	−0.393	−0.654-−0.132	0.003*	0.103	−0.161-0.368	0.444
PS	0.021	−0.261-0.302	0.885	0.090	−0.167-0.347	0.492
SC	−0.031	−0.302-0.240	0.824	0.190	−0.078-0.458	0.164
GD	−0.349	−0.705-0.007	0.055	0.173	−0.118-0.464	0.242

*$P<0.05$=Statistical significance. Adjusted: For multiple linear regression, we adjusted for maternal age, maternal education, birth order, and breastfeeding (yes or no). GD: General development, GM: Gross motor, FM: Fine motor, CC: Conceptual comprehension, EL: Expressive language, SH: Self-help, PS: Personal-social, SC: Situation comprehension, CI: Confidence interval

in other nations that breastfeeding had positive effects on cognitive development [20,21].

Furthermore, the higher the mother's education degree, the better the GD, CC, and EL performances. We assumed that mothers with higher education degrees had higher social status and better teaching skills, which resulted to positive effects on their children's learning process [22]. Consistent with our finding, Boardman *et al*. followed 5145 children aged 6–14 years found that race/ethnicity and maternal education had a large effect on child development than low birth weight [10]. It is consistent with our data that parents' education significantly affects nearly all developmental fields. In another study, paternal education still has effects on child development, although not shown in this study [18]. Furthermore, the investigators in Sweden discovered the positive effects of parental attitudes toward learning on the cognitive development of SGA children, but not parental social status [23]. A study from Norway compared the IQ test results of term SGA and AGA children at 5 years of age [24]. The SGA group had significantly lower scores than the AGA group. Nevertheless, after regression analysis, the parental factors showed the largest impact compared with birth weight.

In addition, the analysis discovered that children who are not the first child of the family showed better scores in PS development. The finding corresponded to that of a study that singleton might have fewer social behaviors presented during group activities [25].

Moreover, the results of subgroup analysis showed the negative impact of girl in SGA group over some aspects of the CCDI. Although few studies investigated gender differences, Hall *et al*. discovered that the attention problems in girls were more closely associated with SGA than boys [26]. Further research is needed for examining the potential gender differences regarding the development of SGA children.

Limitation

This study has several limitations. First, all data were obtained from the CCDI questionnaires, which may have caused recall bias and subjective content from the nonprofessional caregivers. There might have been some errors with the data provided, which include birth weight, gestational age, and other aspects from the parents' information. Moreover, other data for evaluating the children's development process, especially the family's lifestyle and education environment, were lacking. Thus, a more detailed evaluation method is needed.

Children diagnosed with congenital disease, chromosome anomaly, brain insult, or cerebral malformation were excluded at the beginning of the study, which may result to inconsistencies in the real cohort study of the general SGA population. Furthermore, psychoemotional development, such as attention-deficit problems, is not detected in CCDI.

Due to the limitation of the study design and data collection, the outcomes of long-term follow-up of SGA children could not be evaluated. Thus, a longitudinal study with a follow-up period from the preschool age to adulthood is necessary to discover the possible "catch-up" effect and gradual negative influence of SGA.

Conclusion

This study confirmed that SGA children had similar developmental scores as non-SGA children using CCDI for preschool age in Taiwan. Although one subitem revealed borderline significant results, a longitudinal study with a follow-up period from the preschool age to adulthood is necessary to further verify the findings.

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Conflicts of interest

Prof. Shu-Hui Wen, an editorial board member at *Tzu Chi Medical Journal*, had no role in the peer review process of or decision to publish this article. The other authors declared no conflicts of interest in writing this paper.

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