Brief Report: Taiwanese Infants' Mental and Motor Development—6–24 Months

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Objectives To establish the normative data of the Bayley Scales of Infant Development—Second Edition (BSID-II) on Taiwanese infants from age 6 to 24 months and to explore the factors that relate to their mental and motor development. **Methods** Five hundred and seven Taiwanese full-term infants were prospectively examined with the BSID-II at 6, 12, 18, and 24 months of age. **Results** Taiwanese infants' Bayley mental and motor raw scores were lower than the United States norms from age 6 to 24 months, however, the discrepancy gradually declined with increasing age. Gender, intrauterine growth status, birth order, region of residence, maternal education, and paternal occupation were shown to have longitudinal associations with their mental and/or motor scores. **Conclusions** Differences existed in the mental and motor development among Taiwanese and American infants. Our preliminary norms of the BSID-II may be more appropriate than the United States norms for Taiwanese children.

Key words BSID-II; culture; infants; mental; motor; predictors.

Contemporary approaches to management of infants who are at risk of developmental disability has emphasized early intervention (Blasco, 2001; Committee on Children With Disabilities, 2001; Zimmer & Panko, 2006). Identification of infants who are in need of early intervention and subsequent determination of intervention efficacy require the use of valid developmental diagnostic assessment (Bagnato & Neisworth, 1999; Blasco, 2001). The Bayley Scales of Infant Development—Second Edition (BSID-II) is one of such assessments that examine infants' mental and motor development from 1 to 42 months of age (Bayley, 1993). The solid theoretical background and acceptable psychometric properties have made it a widely used instrument in clinics. However, interpretation of the Bayley scores is based on the data of a United States (U.S.) reference sample that may not be appropriate for children outside the U.S.

Differences might exist in the cross-cultural application of the BSID-II for assessment of normally developing infants. For example, English infants ($N = 300$) aged 1 to 15 months manifested higher Bayley mental and motor raw scores than the Bayley U.S. sample (Francis-Williams & Yule, 1967), whereas Mexican ($N = 288$) and Brazilian infants ($N = 30$) aged 1 to 12 months exhibited poorer performance on the Bayley motor scale (Santos, Gabbard, & Goncalves Vanda, 2001; Solomons, 1980). The discrepancy has been attributed to variation in heredity, socio-economic status (SES), and child-rearing practices among societies. Because previous studies employed a medium sample size, a small age range, or motor scale only, a larger scale of cross-cultural equivalence is necessary to offer better evidence of the BSID-II for practical application. Although high internal consistency (Cronbach $\alpha > .95$) (Huang, Chuang, Jong, & Shieh,

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2000) and concurrent validity with the Alberta Infant Motor Scale ($r = .78–.90$) (Jeng, Yau, Chen, & Hsiao, 2000) and the Chinese Child Developmental Inventory ($r > .75$) (Chen, Jeng, Tsou, & Taipei Long-Term Developmental Follow-Up Group for Preterm Infants, 2004) have been found for the BSID-II on Taiwanese children with high developmental risk or developmental delay, no information was available for its use on normally developing children in Taiwan. Therefore, the first purpose of this study was to prospectively administer the Bayley scales on a large sample of Taiwanese infants from age 6 to 24 months and to compare their mental and motor scores with the U.S. norms.

Understanding the factors that contribute to infant development provides the foundation for designing effective early intervention programs. Potential influencing factors considered for infant development include perinatal and demographic variables. For perinatal variables, intrauterine growth status and postnatal growth have been shown to correlate with both mental and motor outcomes throughout childhood (Harvey, Prince, Bunton, Parkinson, & Campbell, 1982; Ounsted, Moar, & Scott, 1986; Sommerfelt et al., 2002; Tenovuo et al., 1988; WHO Multicentre Growth Reference Group, 2006). For demographic variables, family's SES has been extensively reported to associate with infants' mental and motor development (Duncan, Brooks-Gunn, & Klebanov, 1994; Hoff & Tian, 2005; Najman, Bor, Morrison, Andersen, & Williams, 1992; To, Cadarette, & Liu, 2001). Female gender and first birth order appear to favor infants' mental development, especially the language ability, from 0 to 6 years of age (Bryant, Davies, & Newcombe, 1979; Durmazlar, Ozturk, Ural, Karaagaoglu, & Anlar, 1998). Ethnicity may influence infants' motor development in infancy (Bayley, 1965). Because these results were mostly obtained from studies with a cross-sectional design on the Western children, their generalizability requires cross-cultural validation. The second purpose of this study was, hence, to explore the factors that related to Taiwanese infants' mental and/or motor development on the Bayley scales during the age period of 6–24 months.

Methods

Participants

Participants were full-term infants drawn from a multicentered research study that longitudinally examined the development of preterm and full-term infants from 6 to 24 months of age during the period of 1995–1999. Nine medical centers and two regional hospitals in the northern, central, and southern regions on the west side of Taiwan had participated in this study. The inclusion criteria of participants were: gestational age within 37–42 weeks, birth weight > 2500 g, singleton, no maternal complications, no prenatal and perinatal complications, and considered normal in regular newborn examinations.

Procedure

Infants were enrolled at ages younger than 6 months by posting announcements at the pediatric department or by mailing recruitment letter to the families that had newly delivered babies. The study was approved by the Ethics Committee of the Premature Baby Foundation and the study hospitals. Informed consent was obtained from parents before participation in this study.

Perinatal and demographic data were abstracted from infants' medical charts or via parental interview. Perinatal variables included gestational age, birth weight, intrauterine growth status, birth set, and mode of delivery. Intrauterine growth status was classified into small for gestational age (SGA, birth weight below the 10th percentile), appropriate for gestational age (AGA, birth weight within the 10th and 90th percentile), and large for gestational age (LGA, birth weight above the 90th percentile) according to the intrauterine growth curve of Taiwanese infants (Hsieh et al., 2006). Mode of delivery was classified into natural spontaneous delivery and Cesarean section. Demographic variables included child's gender, birth order, region of residence, parental age at delivery, parental education (stratified into > 12 years, 9–12 years and <9 years), and parental occupation (stratified into professional, technician, and unskilled labor or unemployed).

Measures

The BSID-II is composed of the Mental Scale (178 items), the Motor Scale (111 items), and the Behavioral Rating Scale (30 items) (Bayley, 1993). Only the mental and motor scores were used for analysis in this study. The total scores were calculated for each scale by adding the number of items scored ''credit.'' Ten psychologists served as the Bayley examiners who undertook a training course before conducting assessment. The course consisted of lecture and practice sessions as instructed by an experienced psychologist. The lecture sessions focused on review of child development theories and the administration and scoring of the scales. The practice sessions required each examiner to assess five infants at each age. All examiners' test results were in agreement with the instructor's assessments on at least 90% of the items prior to study. In completion of the training course, the examiners noted

difficulty in administering one mental item ''Uses Past Tense'' (No. 148) because Taiwanese language does not have past-tense verbs in grammatical structures. To accommodate for this, a modified protocol that examines infants' ability of using reference to past events in communication was considered equivalent in the study.

Data Analysis

The Bayley raw scores of our sample were compared with the U.S. norms using Student's *t*-tests. Cohen's *d* measure of effect size was also calculated for the difference of scores between samples at each age (effect size of < 0.5 considered as small, 0.5–0.8 as median, and ≥ 0.8 as large) (Cohen, 1988). The relations of the perinatal and demographic factors with the Bayley scores at each time point were examined using the Generalized Estimating Equations method (Zeger & Liang, 1986). The method takes into account time points and within-subject correlations of the outcome measures, and provides a regression coefficient (β) and standard error (*SE*) for each variable. The variables were initially examined for their independent relations with the outcome when adjusted for age. Factors that were significantly correlated with the outcome ($p < .05$) were simultaneously entered into the model to determine whether they predicted developmental outcome.

Results

Study Sample

This study included a total of 507 full-term infants that their mean gestational age was 39 weeks ($SD = 1.1$ weeks) and the mean birth weight was 3279 g ($SD = 379$ g). Of the total sample, 91% had intrauterine growth status stratified as AGA, 6% had LGA, and 3% had SGA. The majority of the infants (73%) were born via natural spontaneous delivery. The proportion of boys and girls was equivalent and about two-thirds were first-born. Approximately, half of the families resided in the northern and central regions, and half resided in the southern region. The majority of the parents (98%) received >9 years of education and only a small proportion (2%) had <9 years of education. Furthermore, four-fifths of the fathers worked as professionals or technicians and one-fifth worked as unskilled labor or unemployed. In contrast, half of the mothers worked as professionals or technicians and half worked as unskilled labors or unemployed.

The attrition rate for 6, 12, 18, and 24 months was 8, 13, 33, and 36%, respectively. Half of the sample were compliant to receive four times of the Bayley assessments and half have been lost to follow-up at least one time. Comparison of the basic data of the infants who ever missed assessment in follow-up with those who were compliant revealed comparable characteristics except for younger paternal age and less parental education in the former (all p's $< .05$).

The Bayley Scores of the Taiwanese and American Sample

Taiwanese infants showed significantly lower mental and motor raw scores than the U.S. sample (all p's $< .05$). The mean Bayley mental raw scores of the Taiwanese sample and the U.S. norms at 6, 12, 18, and 24 months were 57.8 versus 62.8, 83.3 versus 87.7, 109.1 versus 112.4, and 131.3 versus 133.0, respectively. The mean motor raw scores of the samples at four ages were 35.5 versus 39.9, 61.5 versus 64.8, 72.8 versus 75.2, and 83.4 versus 84.4, respectively. The differences of the mean mental scores between samples ranged from 1.7 to 5.0 points and for the motor scores 1.0 to 4.4 points. There was a gradual decline in the differences with age: large effect sizes at 6 (.88 and 1.06 for the mental and motor scores, respectively) and 12 months (.82 and .97), moderate effect sizes at 18 months (.48 and .74) and small effect sizes at 24 months (.23 and .27).

Table I presents the mental and motor raw scores that corresponded to several clinically significant index scores for the Taiwanese sample. The mean and standard deviation data of our sample were used to compute index scores based on an assumption of a normal distribution. An index score of 100 corresponded to the mean raw scores and each index score interval of 15 was equivalent to 1*SD*.

Predictors for the Bayley Mental and Motor Scores

LGA, first birth order, and female gender each had a positive longitudinal relation with the mental scores, whereas residence in the southern region, parental education of ≤12 years, and paternal occupation as technician or unskilled labor each had a negative longitudinal relation with the mental scores (all p's $< .05$). LGA and first birth order each had a positive longitudinal relation with the motor scores, whereas paternal occupation as technician had a negative longitudinal relation with the motor scores (all p's $< .05$).

The preceding significant variables were subsequently entered into multivariate model to examine their relations with the Bayley scores (Table II). The factors remained to have significant associations with the mental scores were intrauterine growth status, child's gender, region of residence, maternal education, and paternal occupation

Table I. The Bayley Mental and Motor Raw Scores for Each Corresponding Index Score of Taiwanese Infants

		Index scores															
Subscales and age	*N*	55	60	65	70	75	80	85	90	95	100	105	110	115	120	125	130
Mental (for males)																	
6 months	234	47.4	48.5	49.7	50.9	52.0	53.2	54.4	55.5	56.7	57.9	59.1	60.3	61.4	62.6	63.8	64.9
12 months	227	73.1	74.2	75.3	76.4	77.5	78.6	79.7	80.8	81.9	83.0	84.1	85.2	86.3	87.4	88.5	89.6
18 months	171	90.8	92.7	94.6	96.5	98.4	100.3	102.2	104.1	106.0	107.9	109.8	111.7	113.6	115.5	117.4	119.3
24 months	156	111.5	113.6	115.7	117.8	119.9	122.0	124.1	126.2	128.3	130.4	132.5	134.6	136.7	138.8	140.9	143.0
Mental (for females)																	
6 months	226	44.9	46.4	47.8	49.2	50.7	52.1	53.5	55.0	56.4	57.8	59.2	60.6	62.1	63.5	64.9	66.4
12 months	214	71.4	71.3	72.7	74.1	76.8	78.2	79.6	80.9	82.3	83.7	85.1	86.5	87.8	89.2	90.6	91.9
18 months	167	91.1	93.3	95.4	97.5	99.7	101.8	103.9	106.1	108.2	110.3	112.4	114.5	116.7	118.8	120.9	123.1
24 months	169	109.1	111.6	114.2	116.8	119.3	121.9	124.5	127.0	129.6	132.2	134.8	137.4	139.9	142.5	145.1	147.6
Motor (for all)																	
6 months	460	25.3	26.5	27.6	28.7	29.9	31.0	32.1	33.3	34.4	35.5	36.6	37.7	38.9	40.0	41.1	42.3
12 months	441	53.1	54.1	55.0	55.9	56.9	57.8	58.7	59.7	60.6	61.5	62.4	63.3	64.3	65.2	66.1	67.1
18 months	338	64.7	65.6	66.5	67.4	68.3	69.2	70.1	71.0	71.9	72.8	73.7	74.6	75.5	76.4	77.3	78.2
24 months	325	73.2	74.4	75.5	76.6	77.8	78.9	80.0	81.2	82.3	83.4	84.5	85.6	86.8	87.9	89.0	90.2

Table II. Multivariate Generalized Estimating Equations for the Relations of Predictors With the Bayley Mental and Motor Raw Scores

Factor	Mental raw scores		Motor raw scores	
	Estimate (β)	*p*	Estimate (β)	*p*
Assessment age				
12 months (vs. 6 months)	25.6	<.01	25.9	<.01
18 months (vs. 12 months)	25.5	<.01	11.2	<.01
24 months (vs. 18 months)	22.5	<.01	10.6	<.01
Perinatal				
Intrauterine growth status (vs. AGA)				
LGA	1.6	<.01	0.9	.02
SGA	−1.3	.15	−0.3	.67
Demographic				
Girl (vs. boy)	1.1	<.01		
First birth order (vs. second or higher)	0.6	.12	0.5	.02
Geographical region (vs. northern)				
Central	−0.8	.10		
Southern	−1.0	.01		
Maternal education ≤12 years (vs. > 12 years)	−0.8	.03		
Paternal occupation (vs. professional)				
Technician	−0.8	.05	−0.6	.03
Unskilled labor/unemployed	−1.6	<.01	−0.3	.36

LGA, large for gestational age; AGA, appropriate for gestational age; SGA, small for gestational age.

(all p's < .05). The factors remained to have significant longitudinal relations with the motor scores included intrauterine growth status, birth order, and paternal occupation (all p's < .05).

Discussion

The results of this study illustrated that Taiwanese infants' Bayley mental and motor scores from 6 to 24 months of age were lower than the U.S. norms. Furthermore, several perinatal and demographic factors were longitudinally associated with Taiwanese infants' mental and motor scores. The results indicate that differences existed in the cross-cultural application of the BSID-II on Taiwanese full-term infants aged 6–24 months.

The lower Bayley mental and motor raw scores of Taiwanese infants at 6–24 months of age in comparison to the U.S. norms may be explained by three factors. First, the discrepancy of developmental scores may relate to differences in methodology among studies. Bayley (1993) employed a cross-sectional design to study the development of infants from local kindergartens or churches to establish the U.S. norms, whereas we used a longitudinal follow-up design to examine the development of infants born or regularly visiting medical centers in Taiwan. Second, the Bayley scales were originally designed for U.S. infants that certain items and materials may not be appropriate for cross-cultural application. For example, two mental items examine infant's ability

of manipulating small-sized objects, i.e., pellet and beads. However, Taiwanese parents consider these objects ''dangerous'' and tend not to allow their infants to play with. In addition, one mental item that examines infant's ability of using past-tense verbs in communication was modified in its protocol to meet the cultural specificity for Taiwanese infants. This modification did not seem to contribute to the discrepancy between samples, however, because the item is placed at the end of age set 23–25 months that only few 2-year-old children (<2.5%) obtained credit. Future standardization of this test item is necessary to eliminate variation in administration. Finally, varied priority in rearing practices among cultures may also lead to different developmental performance. Taiwanese parents emphasize eating and sleeping over play in the early months believing that the former activities are critical for growth. In addition, they tend to place their infants on their back or side when sleeping or awake. The Bayley II was normed before the recommendation of American Academy of Pediatrics in 1992 that infants sleep supine to combat Sudden Infant Death Syndrome. Extensive evidence supports that supine sleepers acquire motor milestones at a later age than prone sleepers, but show catch-up in the second year of life (Jantz, Blosser, & Fruechting, 1997; Davis, Moon, Sachs, & Ottolini, 1998; Monson, Deitz, & Kartin, 2003; Majnemer & Barr, 2005). We speculate that supine sleep position and limited play activity in early months may contribute to poorer performance of Taiwanese infants on the Bayley scales.

The differences of Bayley mental and motor scores between the Taiwanese sample and the U.S. norms gradually declined from 6 to 24 months of age. This phenomenon may be accounted for by a higher drop out rate of infants from lower SES at older ages. In addition, some sort of practice effects associated with our longitudinal assessment may benefit the developmental scores at later ages. Finally, there may be actual narrowing of the developmental discrepancy between Taiwanese and U.S. infants.

Several perinatal and demographic factors were associated with Taiwanese infants' mental and motor development. Intrauterine growth status as LGA and a higher paternal occupation level had positive relations with the mental and motor scores. Infant's gender as girl, residing in the northern area, and mothers with a higher education had positive associations with the mental scores alone, whereas first birth order was singularly correlated with higher motor scores. The effects of individual predictors are delineated as follows.

Intrauterine growth status and paternal occupation were predictive of infants' mental and motor development. Infants with LGA achieved higher mental and motor scores than those with AGA, while infants with SGA showed similar scores than those with AGA. The observed favorable effect of LGA on developmental outcome was consistent with the data of Ounsted et al. (1986). However, our results failed to show a negative relation of SGA with infants' mental and motor development as documented by several previous studies (Harvey et al., 1982; Strauss, 2000; Tenovuo et al., 1988; Sommerfelt et al., 2002; WHO Multicentre Growth Reference Group, 2006). This might be attributed to the inclusion of fewer infants with SGA ($N = 13$) than estimated ($N = 507 \times 10\% = 51$) in the study that limited the statistical power to detect difference. In addition, our data replicated the findings of several studies (Najman et al., 1992; Duncan et al., 1994; To et al., 2001; Hoff & Tian, 2005) that a higher paternal occupation level was positively associated with infants' mental and motor development. The results imply that paternal occupation and income was the family's main revenue source in Taiwan that related to child development.

Gender, region of residence, and maternal education were associated with infant mental development alone. Girls attained higher mental scores than boys at ages 6–24 months in this study. The finding was consistent with the results of previous studies (Bryant et al., 1979; Durmazlar et al., 1998). The data implicates that examination of Taiwanese infants' mental development at early ages may need to consider the gender effect. Our finding concerning the positive association between maternal education and infant mental outcome has paralleled the results of numerous studies (Parcel & Menaghan, 1990; Durmazlar et al., 1998; Bradley & Corwyn, 2002). Finally, infants in the northern region had higher mental scores than those in the southern region. The former were mainly recruited from medical centers in a large city, while the latter were mostly recruited from local hospitals and rural clinics. In Taiwan, mothers of urban areas appear to be more authoritative and permissive in parenting, while mothers of rural areas are more authoritarian (Li, 2003). Furthermore, urban areas tend to have more social and educational resources than rural areas (Li, 2003). Whether parenting style and resources explain the effects of residence region on infant's mental development warrants further investigation.

First birth order was found to have a singular, positive relation with infant's motor development.

Birth order has previously been found to affect infant's language development (Bryant et al., 1979). The favorable effect observed for first birth order on motor development in this study may relate to maternal rearing attitude. One study reported that Taiwanese mothers use more encouragement and emphasize independence toward their first-born children (Yang, 2003). Future study is required to examine if parenting style contributes to the relationship between birth order and child development.

We conclude that Taiwanese infants' Bayley mental and motor raw scores from 6 to 24 months of age were lower than the U.S. norms. Although our infants were restricted to full-term infants in Western Taiwan, the use of a large sample size and a follow-up design may qualify our data to serve as the preliminary norms for Taiwanese children. Furthermore, several perinatal and demographic variables were longitudinally associated with infants' mental and motor development during the age period of 6–24 month. The identified predictors may be used as the foundation when planning social and welfare policy for infant development in Taiwan.

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