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Risk factors of gross and fine motor development delays in children living in institution care

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ABSTRACT

Background: Growth delays, including gross and fine motor development, were commonly observed in children living in child residential facilities. However, there is limited data on the risk factors for delayed motor function in these children. This study aimed to evaluate the risk factors associated with delayed motor function in children in child residential facilities.

Methods: A cross-sectional study was conducted to assess children aged 1–60 months who had been living in child residential facilities for at least one month. We used the Developmental Surveillance and Promotion Manual (DSPM), in cooperation with evaluations from Developmental and Behavioral Pediatricians, to assess gross and fine motor development. Factors associated with months of delay in gross and fine motor development were calculated using generalized linear model.

Results: The prevalence of delayed motor development was 27.83 % for the gross motor domain and 50.87 % for the fine motor domain. Male sex was independently associated with months of gross motor delays (β = −0.741; 95 % confidence interval, −1.409 to −0.073). Significant factors associated with fine motor delay included older age at entry (β = 0.125; 95 % confidence interval, 0.056 to 0.194), smaller head circumference (β = −0.415; 95 % confidence interval, −0.758 to −0.072), and fewer children per house (β = −0.141; 95 % confidence interval, −0.219 to −0.062).

Conclusions: Delays in fine and gross motor skills were found in 50.87 % and 27.83 % of children under five years of age in child residential facilities, respectively. Sex was a predictor of delay in gross motor skills, while age at entry, number of children per house, and head circumference were associated with delays in fine motor skills.

1. Introduction

In 2015, an estimated 9.42 million children globally resided in child residential facilities (Desmond et al., 2020). As children who lived in the institution care do not have family support, they may have issues on both physical and mental aspects (Yin, 2024). In a Chinese qualitative study, 34 former residents of child residential facilities reported eight key risk factors, such as insufficient caregiving, substandard living conditions, low education levels, and physical impairment (Yin, 2024). Children in child residential facilities experienced growth delays equivalent to one lost month of development for every three to five months spent in the facility (Dozier et al., 2012). These issues may be caused by the severe effects of neglect in child residential facilities (Carr et al., 2020). As a result, the prevalence of delayed motor development was higher in child residential facilities than in regular households. The prevalence of delayed motor development in children under five years of age living in child residential facilities was 16.31 %, while this prevalence was much lower at 5.72 % in regular households (Alijanzadeh et al., 2024; Mitiku et al., 2023).

Generally, child residential facilities may have limited resources in terms of physical resources and caregivers (van IJzendoorn et al., 2011). The facilities usually have a family house served for 6–8 children with responsible caregivers. This facility environment is associated with delayed motor development. A previous study showed that the family-

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raised children had better locomotor (116.80 vs 76.76; $p < 0.05$) and fine motor (104.80 vs 68.80; $p < 0.05$) developmental quotients than institutional-raised children significantly (Giagazoglou et al., 2013). The consequences of delayed motor development may be associated with cognitive and language impairments. A lower motor score was associated with a 7 % increased risk of cognitive impairment and a 5 % increased risk of language impairment (Panceri et al., 2022). Delayed motor development may persist even after children leave residential facilities. A previous study showed that adopted children, an average of 6.26 years after leaving residential care, had lower motor function scores than a control group (9.44 vs. 14.12) (Roeber et al., 2012). Therefore, routine evaluation of motor development in children living in child residential facilities may lower the risk of future cognitive or language impairments.

Motor function, which includes gross and fine motor development, is important for daily activities. Gross motor function is crucial for physical activity, posture, balance, and coordination, while fine motor skills involve small muscles and are related to intricate activities such as dressing, writing, or drawing. Delayed motor development is one of the important domains found to be associated with the context of child residential facilities, particularly in terms of long-term effects (Baptista et al., 2019). After six months of living in child residential facilities, 31.3 % of children had a motor score below 80 on the Bayley Scales of Infant and Toddler Development, Third Edition (Bayley-III) (Baptista et al., 2019). However, there is limited data on risk factors for delayed motor function in children in child residential facilities, particularly in Thailand and other developing countries. This study aimed to evaluate the risk factors for delayed motor function in children residing in child residential facilities in Thailand.

2. Methods

We conducted a cross-sectional study at two child residential facilities in Nonthaburi, Thailand. These two facilities are located in Nonthaburi province, an urban area. Both child residential facilities are governmental units that follow the standards of the Ministry of Social Development and Human Security, Thailand, in regard to space for physical activity, play resources, and caregiver-child activities. The inclusion criteria were children aged 1–60 months who were placed in the Babies' Homes and had lived there for at least one month. Children who had a syndromic diagnosis and/or features, a chronic illness requiring treatment/intervention longer than six weeks, or who had recently recovered from an illness within the last two weeks were excluded. The study was conducted from March to May 2024. This study was reviewed and approved by the ethics in human research review committee of Panyananthaphikkhu Chonprathan Medical Center Srinakharinwirot University with the approval number: EC029/60, dated September 11th, 2023. An informed consent was given by legal authorities prior to study participation.

All children in both Babies' Homes were evaluated for baseline characteristics and motor delays, including gross and fine motor functions. Baseline characteristics included age, sex, duration of stay, number of children per house, number of children per caregiver, body weight, height, and head circumference. Nutritional status was assessed using Gomez's percent weight-for-age (%WA), Waterlow's height-for-age (%HA), and the WHO classification for percent weight-for-height (%WH). Normal nutritional status was identified if %WA was between 90 and 120, %HA was more than 95, and %WH was between 90 and 120 (Waterlow, 1973). Gross and fine motor evaluations were performed using the Thai Ministry of Public Health Developmental Surveillance and Promotion Manual (DSPM), with a comprehensive evaluation conducted by developmental and behavioral pediatricians (Morrison et al., 2018; Petersen et al., 1998; Thaineua et al., 2024). This DSPM had an internal validity coefficient of 0.84 and a reliability coefficient of 0.97 (Thaineua et al., 2024). Children were categorized as having delayed gross or fine motor development if they failed one or more items in the respective domain for their age group. The developmental delay, presented in months, was calculated as the difference between the child's chronological age at the examination and their developmental age (the highest milestone achieved in each domain). The delay was reported in months. Further details on the calculation of gross and fine motor delays can be found in the supplementary file.

Statistical analysis: Baseline characteristics of eligible children were analyzed using descriptive statistics and are reported as mean (SD) for numerical variables and as number (proportion) for categorical variables. Factors associated with delayed motor development (gross and fine motor), measured in months of delay, were analyzed using a generalized linear model. Studied variables were executed for univariate coefficients with 95 % confidence intervals (CI). Those variables with a significant p value by univariable generalized linear model or clinically significant variables were put into multivariable generalized linear model. Results of linear regression analysis were reported as unadjusted and adjusted coefficients with their 95 % confidence intervals. All analyses were computed by STATA software version 18.0 (College Station, Texas, USA).

3. Results

A total of 230 children met the study criteria. The baseline characteristics of these children are shown in Table 1. The average age at the developmental examination was 29.9 (SD 16.0) months, and the average age at entry into child residential facilities was 10.2 (SD 12.8) months, resulting in a mean duration of stay of 19.5 (SD 14.3) months. The sex distribution was nearly equal, with 116 males (50.43 %). Regarding the social context, the average number of children per house was 27.2 (SD 6.8), and the mean child-to-caregiver ratio was 4.2 (SD 0.5). Nutritional assessments revealed varying results based on the metric used. According to Gomez's weight-for-age classification, 37.83 % of children ($n = 87$) had normal nutritional status, with a mean %WA of 88.7 (SD 10.7). Using Waterlow's height-for-age classification, 44.35 % of children ($n = 102$) had a standard height for their age, with a mean %HA of 94.4 (SD 4.7). In contrast, a higher proportion (83.04 %, $n = 191$) were classified as having normal nutritional status by the WHO weight-for-height classification, with a mean %WH of 97.8 (SD 8.0). Most children (86.96 %, $n = 200$) had a normal head circumference (HC) within the 3rd–97th percentile range.

A total of 64 children (27.83 %) had delayed gross motor development, and 117 children (50.87 %) had delayed fine motor development.

Table 1
Baseline characteristic of children lived in child residential facilities evaluated for fine and gross motor development ($n = 230$).

Factors	Mean ± SD or number (%)
Age at developmental exam, (month)	29.9 ± 16.0
Age at entry, (month)	10.2 ± 12.8
Male, n (%)	116 (50.43)
Duration of stay (month)	19.5 ± 14.3
Number of children per house (person)	27.2 ± 6.8
Number of children per caregiver (person)	4.2 ± 0.5
Body weight (kg)	11.2 ± 2.5
Height (cm)	84.6 ± 11.5
Weight for age: WA (%) (Gomez)	88.7 ± 10.7
Height for age: HA (%) (Waterlow)	94.4 ± 4.7
Weight for height: WH (%) (WHO)	97.8 ± 8.0
Normal nutritional status by %weight for age: WA (Gomez), n (%)	87 (37.83)
Normal nutritional status by %height for age: HA (Waterlow), n (%)	102 (44.35)
Normal nutritional status by %weight for height: WH (WHO), n (%)	191 (83.04)
Normal head circumference percentile (3rd-97th), n (%)	200 (86.96)
Delayed gross motor development, n (%)	64 (27.83)
Delayed fine motor development, n (%)	117 (50.87)

The mean delay was longer for fine motor skills than for gross motor skills: 2.72 months (SD 4.33) versus 1.15 months (SD 2.60), respectively. Tables 2 and 3 present the results of the generalized linear model, which identified factors associated with the duration of motor delay (in months). For gross motor delay, being male was significantly associated with a shorter delay in both the unadjusted (coefficient: -0.742, 95 % CI: −1.411 to −0.073, $p = 0.030$) and adjusted models (coefficient: -0.741, 95 % CI: −1.409 to −0.073, p = 0.030). While percentage of weight-for-age (%WA) showed a significant negative association with gross motor delay in the unadjusted model (coefficient: -0.035, 95 % CI: −0.067 to −0.004, $p = 0.025$), this association became non-significant after adjustment (coefficient: -0.027, 95 % CI: −0.061 to 0.007, $p = 0.115$). Other factors, such as duration of stay, age at entry, number of children per house, and the child-to-caregiver ratio, were not significantly associated with gross motor delay in either the unadjusted or adjusted models (Table 2).

Three factors were significantly associated with fine motor delay: age at entry, the number of children per house, and head circumference. In the adjusted model, the coefficients for these factors were 0.125 (95 % CI: 0.056 to 0.194; $p < 0.001$) for age at entry, −0.141 (95 % CI: −0.219 to −0.062; p < 0.001) for the number of children per house, and − 0.415 (95 % CI: −0.758 to −0.072; $p = 0.018$) for head circumference, respectively. While percentage of weight-for-age (%WA) was significantly associated with fine motor delay in the unadjusted model (coefficient: -0.075, 95 % CI: −0.127 to −0.023, $p = 0.004$), this association became non-significant in the multivariable model (coefficient: -0.010, 95 % CI: −0.071 to 0.050, $p = 0.734$). Other variables, such as sex and the child-to-caregiver ratio, were not significantly associated with fine motor delay (Table 3).

4. Discussion

This study found that fine motor delays were more prominent than gross motor delays in this cohort (50.87 % vs. 27.83 %) and were associated with multiple risk factors. Consistent with previous reports, fine motor skills appear to be more sensitive to the living environment (Derikx et al., 2021; Lejarraga et al., 2002; Taverna et al., 2011). These skills may benefit most from programs that promote caregiver-child interaction, play-based activities, and environmental enrichment strategies. The high prevalence of delayed fine motor development may also be influenced by the age group of the participants and perinatal conditions such as prematurity, neonatal jaundice, or low birth weight, as fine motor skills continue to develop at older ages. For example, a previous study showed that preterm children had a significantly lower fine motor quotient than full-term children (100.0 vs. 106.0; $p = 0.021$) (Cuesta-Gómez et al., 2024).

Many studies have explored sex differences in gross motor development, yielding mixed findings across various contexts (D'Anna et al., 2025; Derikx et al., 2021; Ertem et al., 2018; Lejarraga et al., 2002; Martins et al., 2024; Zhang et al., 2024). In our study, boys displayed better gross motor outcomes, whereas no other variables were significantly associated with gross motor development in this population. This finding may reflect an interplay between biological and sociocultural factors within child residential facilities. For instance, boys sometimes reach certain motor milestones earlier than girls (Ertem et al., 2018) and might be encouraged more often to engage in the active, physical play that promotes these skills. Delayed gross motor development can also be associated with environmental factors. A previous study, consistent with our results, found that boys had a significantly higher gross motor development score than girls (53.46 vs. 51.32; $p = 0.030$) (Niemistö et al., 2019). This difference could be explained by time spent outdoors, as boys spent significantly more time outdoors (1–2 h/day) than girls (39.9 % vs. 35.0 %; $p = 0.001$) (Niemistö et al., 2019).

Table 2
Factors predictive of gross motor development delay (months) by generalized linear model in children lived in child residential facilities.

Factors	Unadjusted coefficient (95 % confidence interval); *p* value	Adjusted coefficient (95 % confidence interval); *p* value
Age at entry	0.021 (0.001, 0.043); 0.041	0.008 (−0.023, 0.040); 0.605
Male sex	-0.742 (−1.411, −0.073); 0.030	-0.741 (−1.409, −0.073); 0.030
Duration of stay	0.023 (−0.001, 0.047); 0.053	0.016 (−0.014, 0.047); 0.300
Number of Children per house	0.002 (−0.047, 0.051); 0.935	−0.001 (−0.050, 0.050); 0.999
Number of Children per caregiver	0.163 (−0.504, 0.832); 0.631	−0.240 (−1.011, 0.532); 0.542
%Weight for age	−0.035 (−0.067, −0.004); 0.025	−0.027 (−0.061, 0.007); 0.115

Table 3
Factors predictive of fine motor development delay (months) by generalized linear model in children lived in child residential facilities.

Factors	Unadjusted coefficient (95 % confidence interval); p value	Adjusted coefficient (95 % confidence interval); p value
Age at entry	0.066 (0.032, 0.100); < 0.001	0.125 (0.056, 0.194); < 0.001
Male sex	−0.543 (−1.663, 0.576); 0.342	0.047 (−1.061, 1.157); 0.933
Duration of stay	0.047 (0.008, 0.086); 0.016	−0.006 (−0.049, 0.048); 0.980
Number of Children per house	−0.121 (−0.202, −0.040); 0.003	−0.141 (−0.219, −0.062); < 0.001
Number of Children per caregiver	0.776 (−0.329, 1.881); 0.169	−0.272 (−1.495, 0.952); 0.664
Head circumference	0.074 (−0.143, 0.290); 0.504	−0.415 (−0.758, −0.072); 0.018
%Weight for age	−0.075 (−0.127, −0.023); 0.004	−0.010 (−0.071, 0.050); 0.734

In contrast, and consistent with previous reports, multiple factors influenced fine motor development (Derikx et al., 2021; Lejarraga et al., 2002; Taverna et al., 2011). A later age at entry was significantly correlated with longer delays, highlighting the cumulative risk from prolonged exposure to adverse pre-placement experiences. This finding points to the necessity of facilitating timely adoption into well-supported families. Additionally, it underscores the importance of a third strategy: arranging earlier placement into high-quality institutions for children identified as high-risk.

Contrary to some studies in typical family settings that found little to no association between family size and child development (Comuk-Balci et al., 2016; Lejarraga et al., 2002). Our study found that a higher number of children per house was associated with less fine motor delay. This might reflect the benefits of peer interaction and social learning opportunities in group settings (Józsa et al., 2023). However, this effect likely depends on variables not measured in our study, such as group dynamics and the quality of caregiver-child interactions. Therefore, while peer interaction can be beneficial, the potential risks—particularly the failure to provide individualized, comprehensive care—must be carefully balanced. The number of children per house should be optimized to ensure high-quality caregiving.

Head circumference, a proxy for brain growth, is commonly used to assess a child's developmental trajectory; however, findings on its association with motor development remain inconsistent (Dupont et al., 2018; NA et al., 2024). In our study, we found a significant negative correlation between head circumference and the duration of fine motor delay, indicating that a smaller head circumference was associated with a more severe delay. This result supports the hypothesis that early and chronic undernutrition adversely affects both brain growth (reflected by head circumference) and neurodevelopment. Furthermore, this finding reinforces the concept that neurodevelopment is closely linked to physical growth, particularly brain growth as measured by head circumference (Gale et al., 2006; Heinonen et al., 2008; Sanefuji et al., 2021). These data underscore the importance of routine head circumference monitoring as a critical component of developmental surveillance (Vandenplas et al., 2019). Finally, while weight-for-age (%WA) was significantly associated with fine motor delay in the unadjusted model, this relationship did not persist after adjusting for other factors. This suggests that the impact of a child's general nutritional status on fine motor skills may be mediated by other variables, reinforcing that developmental delays in institutionalized children are multifactorial (DeLacey et al., 2020; Leloux-Opmeer et al., 2016; Levin et al., 2014).

A key strength of this study is its comprehensive enrollment, as all children living in the targeted child residential facilities were included. Therefore, the reported prevalence rates of delayed gross and fine motor development accurately represent this specific population. Our findings underscore the need for routine developmental surveillance in child residential facilities. Moreover, children identified as being at risk for delayed gross or fine motor development warrant more frequent monitoring to prevent long-term adverse consequences. For instance, interventions such as providing motor-skill toys ($p < 0.01$) and creating dedicated spaces for physical activity ($p < 0.001$) have been shown to significantly improve motor function (Hua et al., 2016).

There are some limitations in this study. Firstly, the study was limited to children from two particular facilities; therefore, incorporating children from other institutes in different locations may yield different results. No data on environmental pollution or some nutritional assessments such as dietary intake, triceps skinfold thickness was recorded. Second, other potential risk factors for motor developmental delay were not included. Third, longitudinal study may be more beneficial.

5. Conclusions

Delays in fine and gross motor skills were found in 50.87 % and 27.83 % of children under five years of age in child residential facilities, respectively. Sex was a predictor of delay in gross motor skills, while age at entry, number of children per house, and head circumference were associated with delays in fine motor skills.

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CRediT authorship contribution statement

Benjaporn Srinithiwat: Writing – original draft, Resources, Methodology, Investigation, Data curation, Conceptualization. **Patcharapun Sarisuta:** Supervision, Investigation. **Tachakorn Angsanu:** Supervision, Investigation. **Phimphon Thuayta:** Supervision, Investigation. **Kittisak Sawanyawisuth:** Writing – review & editing, Formal analysis.

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Declaration of competing interest

The authors declare no competing interests.

Data availability

Data will be made available on request.

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