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Original Article

Screening preschool children for fine motor skills: environmental influence

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Abstract. [Purpose] The aim of this study was to investigate the influence of gender and family factors on performance in the fine motor domain of the Denver II developmental screening test. [Subjects and Methods] Data were obtained from 2038 healthy children, 999 boys (49%) and 1039 girls (51%) in four age groups: 0–24 months (57%), 25–40 months (21.1%), 41–56 months (10.4%), and 57–82 months (11.5%). [Results] Female gender, higher maternal age, especially in children older than 24 months, and higher maternal education were associated with earlier accomplishment of fine motor items. Higher socioeconomic status was correlated with fine motor skills more noticeably at young ages. [Conclusion] The results of this study support the role of environmental factors in the interpretation of fine motor test results and point to target groups for intervention, such as infants in the low socioeconomic group and preschool children of less educated mothers. Studies in different populations may reveal particular patterns that affect child development.

Key words: Development, Socioeconomic, Maternal educational status

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INTRODUCTION

Neurologic development during infancy and childhood depends on physical health and genetic disposition, and progresses under the influence of the social context and environment[1)]. To perform activities in daily life, motor process and social interaction skills are required. Motor development is based on actions that a person enacts when interacting with and moving task objects and themselves around a task environment[2, 3)]. Among environmental factors, home and family play a primary role during early childhood years. Parental education, socioeconomic status, family size, and interaction with siblings are main elements of a child's close environment[4)]. Fine motor development affects other areas of development, and in particular, school performance in later childhood. Despite their importance, age-appropriate fine motor abilities are seldom questionedor evaluated in pediatric clinics: often, physicians ask parents or caregivers about the child's language and gross motor abilities, and observe social and gross motor functions during physical examination. Developmental screening tests, despite their high reliability and interest agreement, are used only by 60% of U.S. physicians, a rate likely to be lower in many other countries[5, 6)]. To interpret any observations or test results, health professionals should be familiar with normal development and influencing factors, and recognize the nature and extent of external influences so that delays due to medical and treatable conditions are not erroneously attributed to adverse environmental factors. Therefore, the aim of this study was to investigate the effect of socioeconomic and maternal factors on the fine motor development of healthy children.

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SUBJECTS AND METHODS

Data were obtained from 2,038 healthy children aged 0–82 months, 999 boys (49%) and 1,039 girls (51%) in four age groups: 0–24 months (57%), 25–40 months (21.1%), 41–56 months (10.4%), and 57–82 months (11.5%). Children with a history of preterm delivery, birth weight <2,500 g, hospitalization, congenital malformation or current illness were excluded.

Demographic data collected by using a standard questionnaire included the following:

- Mother's age: stratified as 20≤, 21–25, 26–30, 31–39, and 40≥ years;
- Mother's education: no education, up to 8 years' schooling, 8–12 years schooling, and ≥12 years;
- Number of children at home;
- Area of residence within the district of Ankara, indicating three different socioeconomic groups (SEG) as identified by the Turkish Institute of Statistics: high, middle, and low SEG[7].

The developmental items commonly used in outpatient evaluation were retrieved from the Denver II developmental screening test. The Denver II version standardized for Turkey was applied by trained child development specialists or a pediatric neurologist. The test contains total 134 items in four developmental domains: personal-social, fine motor, language, and gross motor. The result is scored as "normal" when there is no delay in any items. The fine motor section of Denver II contains 33 items[8]. Inter tester and intra tester reliability were assessed by testers watching video recordings of 20 children at 4 weeks' interval and scoring separately, and were >90% throughout the data collection. Only children with normal test results were included in this study, and the mean age at which they passed each fine motor item was calculated.

This study was conducted by Ihsan Doğramaci Childrens' Hospital and the Department of Pediatric Neurology of Hacettepe University, Ankara, Turkey. Ethical approval was obtained from the ethics committee of Hacettepe University Faculty of Medicine. The data were collected after informed parental consent was received.

The effect of demographic and maternal factors on fine motor items was assessed for each age group. The results of tests were expressed as the number of observations (n), mean (X) ± standard deviation (SD). Homogeneity (Levene's) and normality (Shapiro Wilk) tests were used to choose statistical methods. Groups with normal distribution and homogeneous variances were assessed by using Pearson's correlation coefficient. As parametric test assumptions were not available for some variables, these were assessed by using Spearman rho correlation coefficient. All statistical analyses were performed with the SPSS software (SPSS ver. 17.0; SPSS Inc., Chicago IL, USA), and $p<0.05$ was considered statistically significant.

RESULTS

The demographic characteristics of children are shown in Table 1, and those of mothers in Table 2. The number of boys and girls were similar. Most children were from middle SEG and most mothers' educational level was high school (8–12 years). Forty-eight percent of households contained only one child.

The factors affecting fine motor items were gender, mother's age and education, SEG, and number of siblings. Girls acted at earlier ages in grasping a rattle (Table 3), copying a circle (Table 4), copying a square (Table 5), and drawing a man of six parts (Tables 5 and 6).

The mother's age was influential on several items in all age groups, most markedly in older children (>57 months) (Tables 3–6). As the mother's age increased, the fine motor skills of the children were acquired earlier. The mother's educational level was associated with earlier acquisition of fine motor items, mostly in children older than 24 months (Tables 3–6). SEG was positively correlated with fine motor skills before 56 months, most markedly in the first 6 months of life (Tables 3–6). The number of children at home was not effective; however, it showed a negative correlation with one fine motor skill between 41 and 56 months: copying a square (Table 5).

DISCUSSION

Fine motor functions carry great biological importance for humans, as reflected by the large cortical representation of the hands in the cerebral cortex. Fine motor skills correlate with cognitive test results, partly because of their part in psychometric testing and partly because they allow the child to experiment and learn about the environment[9, 10]. On the other hand, they are less well recognized by parents who usually are more aware of gross motor milestones and more often concerned with delays in gross motor skills[11]. Factors likely to affect fine motor skills must be known to plan interventions in children at a risk for delayed development. The present study analyzed fine motor development with respect to environmental factors in the population, namely, mother's age and education, socioeconomic status, and number of children in the household.

The overall effect of gender was modest, with girls starting earlier in certain fine motor skills of various ages. Similarly, Nordberg et al.[12] found that girls had higher scores in eye-hand coordination on Griffiths development scales at 4 years of age. Flatters et al.[13] reported that girls were more likely to have superior manual control in aiming and tracing tasks at school age. Other studies also showed girls out performing boys on manual dexterity, especially in pencil- and paper-based skills[14–16]. It is plausible that fine motor maturationis completed at a later age in boys.

The quality of the family environment has been associated with the intellectual and motor development of the family members[16]. SEG affects the home environment, opportunities for educational and play activities, and therefore gross and fine motor performance[8]. Certain studies observed the influence of social class on a child's development after 1 year[17] and at 3 and 5 years of age[18], while others demonstrated the effect of cultural factors, home environment, and SEG on fine motor development in 9-month-old children and during the first 18 months of life[10, 19]. Our results also show that the effect of SEG begins from early infancy. Children of low SEG tend to show delays on several motor development assessment batteries, although certain reports point to earlier achievement of gross motor milestones than in children from higher SEG[20–22]. Perceptual-motor problems of children with lower environmental resources may be related to poor nutrition, poor health care, or lack of stimulation and opportunities for experience.

The effect of maternal education may involve higher intellectual level, positive psychology, or higher income resulting in increased opportunities for the child. Jackson et al.[23] observed fewer behavioral problems and improved preschool motor development in children of single-parent families with higher maternal education. Higher social class and maternal education was found to be related to psychomotor performance in children >1 year of age[17, 23] and low maternal education, after the age of 2 or 3 years[24, 25]. Our findings are consistent with these studies: the positive effect of the mother's education was observed mostly in children >24 months of age. The mother's age had a modest effect from late infancy through childhood, which is less marked than the mother's education.

Table 1. Demographic characteristics of children

		n		%
Age (months)	0–24	1,136		57.0
	25–40	420		21.1
	41–56	208		10.4
	57–82	229		11.5
Gender	Girl	1,039		51.0
	Boy	999		49.0
Number of children at home	1	999		48.8
	2	713		34.8
	3	205		10.0
	4≥	55		6.4
		Min	Max	X±SD
Age (months)		0.3	82	24.9±20.5
Height (cm)		50	135	84.1±20.5
Weight (kg)		1.6	30.8	11.9±5.5
Head circumference (cm)		34	58	46.4±4.3

Table 2. Demographic characteristics of mothers

		n		%
Age (years)	<20	107		5.3
	21–25	496		24.6
	26–30	683		33.8
	31–39	646		32.0
	40≥	86		4.3
Education	No education	37		1.8
	1–8 years	722		36.0
	8–12 years	764		38.1
	>12 years	483		24.1
Socioeconomic group	Low	519		25.9
	Middle	806		40.2
	High	651		32.5
		Min	Max	X±SD
Age (years)		16	53	28.8±5.5

Table 3. Factors affecting fine motor skills at 0–24 months of age

		Follows past midline	Grasps a rattle	Follows 180°	Reaches for objects	Looks for ayarn	Transfers blocks from hand to hand	Takes two blocks	Bangs two blocks together	Places cube in a cup	Scribbles sponta-neously	Dumps raisin from bottle—demonstrated	Dumps raisin from bottle—spontaneous
Gender	r	**0.090***	0.002	0.004	0.001	0.029	0.020	0.122	0.040	0.002	0.050	0.039	0.036
Mother's age	r	0.049	0.066	0.080	0.029	0.069	0.023	**−0.225***	**0.134***	**0.090***	**0.151***	**0.092***	0.071
Mother's education	r	0.037	0.087	0.048	0.049	0.081	0.018	0.024	0.082	0.015	0.068	0.003	**0.094***
Socio-economic group	r	**0.217***	**0.187***	**0.153***	**0.181***	**0.093***	**0.117***	0.155	0.070	**0.139***	0.025	**0.153***	**0.176***
Number of children at home	r	0.001	0.027	0.008	0.007	0.058	0.031	0.058	0.044	0.017	0.002	0.037	0.017

Significant p values are in bold. *p<0.05

Older siblings may serve as models for fine motor tasks and provide encouragement to their younger siblings. However, siblings may also fail to elicit a positive interaction. Our study did not show a considerable influence of the number of children at home: if at all, the correlation with fine motor skills was negative. This may be explained by the division of parental attention as suggested by “dilution of parental resources” or fewer opportunities for the young child’s fine motor experience[26]. Alvik[27] also demonstrated the presence of an older sibling to be associated with reduced scores in the Ages and Stages Questionnaire, a parent-completed screening instrument for children <5.5 years old.

Our study is based on items used in clinics for developmental screening because our aim was to offer recommendations for pediatric outpatient and well-baby clinics caring for children on a day-to-day basis. Research on developmental patterns and their neurobiological basis require more detailed tests. Fine motor problems are an important part of developmental coordination disorder (DCD), a term defining a neuromotor disability where motor difficulties (lower speed, lower accuracy) interfere with daily life or school activities. Motor control and muscle strength impairments are the primary reasons for motor behavior disorders[28]. DCD affects about 5% of school-age children[29]. Whether the diagnosis of DCD can be predicted by screening for early fine motor skills, and whether the severity of DCD may be reduced by means of intervention on influencing factors constitute interesting areas to explore[30].In addition, attention-deficit hyperactivity disorder (ADHD) is a common neurodevelopmental disorder that affects 3–7% of preschool and school-aged children. It has been suggested that the deficits of ADHD children in memory performance, and the inability to allocate sufficient attention to postural control may contribute to the trend of further deteriorating fine motor skills with postural balance[31, 32]. Lee et al.[33]suggested that complex interactions between multiple risk factors such as physical fitness levels of children are responsible for ADHD.

In conclusion, sex and environmental and maternal factors appear influential in the development of fine motor skills in

Table 4. Factors affecting fine motor skills at 25–40 monthsold

		Copies a circle	Draws a man of three parts
Child’s gender	r	**0.209***	0.027
Mother’s age	r	**0.156***	**0.123***
Mother’s education	r	**0.179***	**0.123***
Socioeconomic status	r	**0.137***	0.070
Number of children at home	r	0.056	**0.120***

Significant p values are in bold. *p<0.05

Table 5. Factors affecting fine motor skills at 41–56 months old

		Copies a circle	Copies a cross	Copies a square	Copies a square—demonstrated	Draws a man of six parts
Child’s gender	r	0.131	0.121	**0.140***	0.122	**0.240***
Mother’s age	r	0.043	0.073	0.068	0.020	0.081
Mother’s education	r	0.063	**0.184***	**0.172***	0.133	0.105
Socioeconomic status	r	**0.206***	**0.226***	0.134	**0.147***	**0.206***
Number of children at home	r	0.136	0.051	**−0.152***	0.084	0.102

Significant p values are in bold. *p<0.05

Table 6. Factors affecting fine motor skills at 57–82 months old

		Copies circle	Copies cross	Copies square	Copies demonstrated square	Draws man and parts
Child’s gender	r	0.022	0.010	0.072	0.019	**0.231***
Mother’s age	r	**0.235***	**0.217***	**0.233***	**0.165***	0.117
Mother’s education	r	**0.200***	**0.334***	**0.350***	**0.309***	0.309
Socioeconomic Status	r	0.057	0.126	0.085	0.038	**0.232***
Number of children at home	r	0.125	0.034	0.008	0.012	0.054

Significant p values are in bold. *p<0.05

early life. These first years are a period of intense biological maturation likely to shape the architecture of the central nervous system. Negative environmental factors increase the developmental risk brought by adverse medical conditions such as prematurity[34]. On the other hand, those children at risk may benefit from reinforcement of positive factors: interventions may overcome the effect of adverse perinatal events[35, 36]. The findings of our study may help the planning of interventions, such as providing additional preschool education for children from disadvantaged economic and maternal education groups, and can also contribute to the planning of research projects with matching intervention and control groups.

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