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Role of Visual Motor Integration in Academic Performance of Preschool Children

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Abstract

Poor visual-motor integration (VMI) in children is associated with problems in learning and academic achievement and could be an early predictor to guide intervention and improve their academic performance. The purpose of this study was to examine the relation between VMI, and academic performance amongst preschool children, and to study the association with various demographic factors and screen time exposure. The study participants were recruited using a multi-stage stratified sampling technique. VMI was assessed using Beery VMI guidelines, a visual perception test, and a motor coordination test. Participant age, academic performance, maturity at birth, neonatal intensive care unit (NICU) stay, and screen time were studied with the VMI standard score. Data were collected for 850 preschool children (52.4% males and 47.6% females). As per VMI standard scores, 90.4% of children had average, 8.9% had above average and 0.7% had below-average scores respectively. Among the demographic factors, mean age, maturity at birth, NICU stay, and screen time showed a significant difference with VMI scores while no such significance was seen for socioeconomic status, maternal education, and gender. A significant difference between mean VMI, visual perception, and motor coordination scores and the various categories of academic performance in the study group was obtained. Findings from this study show that pre-term birth, NICU stay, and screen time may affect VMI which can lead to poor academic performance. Screening for VMI could serve as an indicator to direct early interventional measures in preschool children, aiding better academic inclusion.

Keywords: *Preschool, Screen-Time, Visual Perception VMI.*

Introduction

Visual-motor integration (VMI) is the ability to coordinate visual perception and motor skills in children through eye-hand coordination, providing the foundation for efficient and smooth patterns [1]. A normal child's visual-motor development begins at 3 months of age, beginning with tracking an object while lying supine, and progresses as the nervous system develops to process visual and proprioceptive information, translating it into skilful and refined movements, including fine motor skills [2]. VMI is important in helping children accomplish their academic activities during kindergarten and primary school. Firstly, Visual perception (VP) skills, an important part of VMI, is an intricate system that helps interpret, analyse, and identify visual information. VP skills include visual discrimination, visual memory, visual-spatial relation, visual-spatial orientation, visual form

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constancy, visual closure, and visual figure-ground perception [3].

Apart from VP, another main part of the VMI process in children is motor coordination (MC). Identifying motor coordination in preschool children helps to identify early motor delay. Fine motor skills are essential for good academic success which comprise movements that need coordination between eyes and hand, eyes and feet, or eyes, hand and feet [4]. Deficits in VMI have been associated with several education-related problems including reading difficulties, mathematical difficulties, perceptual problems, and a decrease in overall academic achievement [5,6].

The variability in VMI development during early childhood was inconsistent in children with developmental delay, learning difficulties, and neurological issues [7]. Previous studies showed that early identification of children with poor VMI can be offered early remedial intervention and timely referral to therapists to improve their academic inclusion [8]. The Beery Developmental Test of VMI is a commonly used standardized test that evaluates visual-motor integration [9]. Thus, in this study, we aimed to identify the association between VMI scores and academic performance in preschool children along with demographic factors that may impact VMI.

Materials and Methods

This study was a descriptive, cross-sectional study, conducted over one year from January 2018 to January 2019.

Inclusion and Exclusion Criteria

Pre-school children aged 3–6 years, attending kindergarten or primary school in Chennai urban setting, India were recruited for this cross-sectional study. They were familiar with the use of the English and/or Tamil languages.

Children with pre-existing neuro-disabilities, Autism Spectrum Disorder (ASD), Attention Deficit Hyperactivity Disorder (ADHD), Intellectual Disability (ID), uncorrected visual or hearing impairment, and those whose parents did not provide consent to participate were excluded from this study.

Ethical Considerations

The study was approved by the institutional human ethics committee. Informed written consent was obtained from all the parents of study participants who were willing to enrol their children in the study. The risks and benefits involved in the study and the voluntary nature of participation were explained to the parents of study participants before obtaining consent. The confidentiality of the study participants was maintained.

Sampling and Stratification

Based on a multi-staging stratified sampling technique, study participants were recruited from two private and two government schools that are situated in one of the 15 zones of the greater corporation of Chennai which was chosen by the lottery method. Approval from the authorities of the concerned schools was obtained to conduct this study. The sample size was calculated considering the prevalence of poor academic performance as 10 -20%, as per previously published studies [10]. The other parameters considered for sample size are 80% sensitivity and 7% precision from previous studies [11]. The sample size obtained was 835, which was rounded off to the nearest possible number, 850.

Statistical Analysis

VMI Beery Buktenica Developmental Test of Visual Motor Integration, 6th edition [12]. The raw scores were converted into a standard score based on the child's age. Descriptive analysis was carried out by mean and standard deviation. A comparison of mean scores was performed using an independent T-test and ANOVA. Categorical variables were analyzed using the Chi-square test and correlation was assessed by calculating the Pearson correlation coefficient. P-value <0.05 was considered

statistically significant. IBM SPSS version 22 was used for statistical analysis.

Scoring Procedure

Visual-motor integration was assessed in the following order: Beery VMI, VP, and MC. To assess VMI, a 21-item short form available for ages 2 through 6 is usually administered in less than 10 minutes. In the visual perception test for young children, the three items involving identifying body parts, picture outlines, and parts of a picture were included. In the standardized MC test, the first three items require young children to climb on a chair, hold a pencil correctly, and hold the paper while marking it. The standard VMI score concerning performance is categorized as Very High (>129), High (120-129), Above Average (110-119), Average (90-109), Below Average (80-89), Low (70-79), and Very Low (<70). Scores were used to calculate VMI, VP, and motor coordination. Raw scores are converted to standard scores based on age and are divided into performance categories as per the Beery manual.

Results

A total of 850 children aged between 3-6 yr participated in the study with male participants of 445 (52.4%) and female participants of 405 (47.6%). The following demographic details: participant's birth maturity (term or preterm), presence or absence of neonatal intensive care unit (NICU) stay, screen time, academic performances, educational and employment status of the primary caregiver, and socioeconomic status as per the modified Kuppuswamy scale [13] were collected using a structured proforma. 108 (12.7%) participants were premature and 118 (13.9%) reported NICU stay. Parent-reported screen time of >2 hours was reported in 269 (31.6%) participants. With regards to caregiver demographics, 54.8% of mothers completed an undergraduate degree or above, and 41.7% of mothers were working professionals. 60.3% of the families belonged to the upper and upper-middle classes. The academic performances of the participants were stratified as grades A - E (excellent, good, average, poor, or very poor) based on grades obtained during the regular assessments at school.

The VMI standard score for children born preterm was (mean ± SD: 97.85 ± 5.49), when compared to children born term (mean ± SD: 103 ± 4.18). For children who had NICU stay, their mean VMI was (mean ± SD: 98.38±5.71) as against those who had no NICU stay (mean ± SD: 103.27 ± 4.17). Children with parent-reported screen time of more than 2 hrs (mean ± SD: 100.98 ± 5.58) showed a significant difference in VMI ($p < 0.05$) when compared to parent-reported screen time of less than 2 hr per day (mean ± SD: 103.33±4.06). The categorical representation of VMI standard scores concerning gender ($p = 0.101$), literacy status of the mother ($p = 0.449$), occupation of the mother ($p = 0.511$), and socioeconomic status ($p = 0.258$) did not show significance for VMI (Table 2). There was no significant difference in mean VMI scores concerning socioeconomic status, literacy, and occupation of mothers in this study (Table 1).

Table 1. Comparison of Mean VMI Scores with Demographic Variables of Pre-School Children

Parameter		**N**	**Mean VMI ± SD**	**p-Value**
Maturity	Term	742	103.28±4.18	0.000
	Preterm	108	97.85±5.49	
NICU Stay	Yes	118	98.38±5.71	0.000
	No	732	103.27±4.17	
Screen Time	Less Than 2 hr	581	103.33±4.06	0.000

	More Than 2 hr	269	100.98±5.58	
Gender	Male	445	102.84±4.54	0.101
	Female	405	102.31±4.91	
Socioeconomic Status	**Upper**	227	102.52±4.92	0.258
	Upper Middle	286	103.03±4.57	
	Lower Middle	163	102.03±4.95	
	Upper Lower	123	102.33±4.84	
	Lower	51	102.82±3.30	
Literacy Status of Mother	Primary School	63	102.01±4.53	0.449
	Secondary School	87	101.89±4.74	
	Higher Secondary	234	102.52±4.79	
	Degree	230	102.97±4.53	
	Postgraduate	36	101.97±4.08	
	Technical	101	103.00±5.21	
	Professional	99	102.63±4.80	
Occupation of mother	Homemaker	313	102.29±4.89	0.511
	Unskilled	38	103.57±4.09	
	Skilled	144	102.79±4.71	
	Office Going	252	102.67±4.53	
	Professional	103	102.66±4.90	

A significant difference in academic performance was observed between VMI, VP, and MC. The academic performance of 17.6% of children belonged to the "excellent" category, 44.2% of them belonged to the "good", 26.2% fell under the "average" category, and 11.9% fell under the "poor" category. Participants falling under the "excellent" and "good" academic performance categories showed better VMI, VP, and MC scores when compared to participants in the "average" and "poor" academic performance categories (Table 2).

Table 2. VMI Standard Score, Visual Perception Score, Motor Coordination Score Versus Academic Performances

Parameter		**N**	**Mean ± SD**	**p-Value**
Scores	**Academic Performance**			

VMI Score	Excellent	150	108.43 ± 3.24	<0.05
	Good	376	103.23 ± 2.58	
	Average	223	101.44 ± 2.09	
	Poor	68	95.02 ± 2.64	
	Very Poor	33	92.09 ± 3.29	
VP score	Excellent	150	106.89 ± 4.76	<0.05
	Good	376	102.76 ± 3.85	
	Average	223	101.10 ± 3.03	
	Poor	68	92.86 ± 4.12	
	Very Poor	33	89.81 ± 4.14	
Motor Coordination Score	Excellent	150	107.18 ± 3.89	<0.05
	Good	376	103.36 ± 3.17	
	Average	223	101.73 ± 2.67	
	Poor	68	94.14 ± 4.58	
	Very Poor	33	91.63 ± 3.83	

Discussion

Our study aimed to measure VMI as an indicator of academic performance in preschool children aged 3-6 years. Fine motor skills and eye-hand coordination skills contribute to visual motor function in pre-schoolers. Ages 3-6 are early childhood years, where VMI helps predict a child's future handwriting skills [14] and academic performance like reading and writing [15]. Studies indicate that children with better VMI skills at an early age are more likely to have good reading, writing, learning, better social behaviour, attention, and academic achievement [16,17]. Mean VMI scores about gender did not differ, male (mean ± SD: 102.84±4.54) and female (mean ± SD: 102.31±4.91). A notable significant difference was observed with maturity (preterm), NICU stay, and children who had screen time of more than 2 hrs.

Similar to our study, Goyen et al [18] also found statistically significant differences in VMI scores ($p<0.001$) between children with a history of NICU stays when compared to children with no history of NICU stays. Studies showed children born preterm with low birth weight had deficits in VMI (copying figures, fine motor tasks, and visual perception) compared to age-equivalent-born children [19,20]. We observed a statistically significant difference in parent-reported screen time exposure versus VMI score categories. Out of 269 children whose parents reported screen time of more than 2 hrs/day, the majority 244 had average VMI scores. Out of 6 children with below average VMI scores, 5 (83.3%) had screen time exposure of more than 2 hrs/day as against 1 in the less than 2 hrs group. Research shows that television watching may impact children's motor development, learning, and cognitive development [21, 22]. This demonstrates that prolonged screen time affects the VMI and can also lead to delayed cognitive and social development. In the present study, there was a significant difference noted concerning mean VMI, VP and MC standard scores about various grades of academic performance (p-value = 0.000) with progressively decreasing mean scores from excellent to very poor academic performance categories.

Early identification of difficulties associated with VMI can aid in early intervention and better the academic performance and inclusion of preschool children [23]. No significant difference was observed between the socioeconomic status, literacy status, and

occupation of mothers and the participant's VMI scores. In contrast to our study, there were significant associations found between VMI in children about maternal education [24], gender [25], and socioeconomic status [25,26]. This underscores the need for more studies to better our understating of such associations.

Conclusion

Our study showed that a decreasing trend of academic performance was associated with declining VMI scores. Children aged 3-6 years who were born prematurely, reported NICU stay and had daily exposure to screen time exceeding 2 hrs demonstrated average VMI scores. Also, findings from this study show that pre-term birth, NICU stay, and screen time are indicative of risk factors for low VMI which can lead to poor academic performance in the future. Gender, socioeconomic status, maternal literacy, and occupation did not exhibit a significant relation with VMI in our study but need to be investigated in larger cohorts. VMI, which encompasses fine motor coordination, as well as visual perception skills is crucial for normal cognitive development in children and significantly influences perceptual learning and overall academic performance.

Conflict of Interest

The authors declare no conflict of interest.

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