Research Paper

The Predictive Effect of Individual and Environmental Factors on Motor Performance of Low Birth Weight Infants

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Citation Shafaghatian N, Bordbar A, Maroufizadeh S, Mirzakhani N, Amini M. The Predictive Effect of Individual and Environmental Factors on Motor Performance of Low Birth Weight Infants. Iranian Rehabilitation Journal. 2022; 20(3):355-362. http://dx.doi.org/10.32598/irj.20.3.1501.1

http://dx.doi.org/10.32598/irj.20.3.1501.1

Article info:
Received: 11 Jun 2021
Accepted: 04 Sep 2021
Available Online: 01 Sep 2022

Keywords:
Motor performance, Low birth weight, Premature infant, Sensory profile, Home environment

ABSTRACT

Objectives: Premature infants in the neonatal intensive care unit (NICU) are exposed to environmental risks that may cause developmental problems i. The present study aimed to investigate the predictive effect of individual and environmental factors on the motor performance of low birth weight preterm infants.

Methods: This cross-sectional study was performed in the neonatal clinic of Shahid Akbarabadi Hospital in Tehran City, Iran. A group of 90 low birth weight infants were enrolled in the study by non-probabilistic method and according to the inclusion criteria. Test of infant motor performance (TIMP), sensory profile2 (infant section), affordance in the home environment for motor development (AHEMD), and a demographic questionnaire were used to evaluate motor performance, sensory status, home environment, and other factors (birth weight, corrected age, parent's education, etc.), respectively.

Results: TIMP elicited score was positively correlated with the infant's age (r=0.390, P<0.001) and infant's weight (r=0.260, P=0.011), and negatively correlated with duration of hospitalization in NICU (r=-0.210, P=0.047). A significant negative correlation was observed between TIMP elicited score and total infant sensory profile2 score (r=0.391, P<0.001) and a positive correlation was observed between TIMP elicited score and total affordance in the home environment for motor development score (r=0.207 P=0.049).

Discussion: The present study's results showed that elicited movement has a significant relationship with infant sensory status and home environment and demographic variables (infant's age, gender, infant's weight, type of delivery, NICU duration, father and mother's age, number of family children) and the sensory status has a more predictive effect on infant motor performance than the environmental questionnaire.

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Highlights

• A significant relationship is observed between sensory status and motor performance of preterm infants.

• Sensory status and physical environment can affect the infant's motor performance, which means that the richer the infant's physical environment in terms of sensory stimuli and toys, the better the infant's motor performance will be.

• Gender, weight, and age of the infant at birth and length of hospital stay in the neonatal intensive care unit affect the infant's motor performance.

Plain Language Summary

Individual and environmental factors affect the motor performance of premature infants, therefore occupational therapists can predict possible movement delays in premature infants by examining individual factors, such as age at birth, infant weight at birth, etc., as well as assessing the sensory processing status of the infant, to be able to maximize motor performance by early interventions and enrich the physical environment.

1. Introduction

Due to advances in obstetric care, the number of premature neonatal deaths has dropped dramatically, but a large number of premature infants, experience motor delays and neurological problems especially sensory processing disorders [1]. These infants need early intervention because the development of motor performance is crucial for the acquisition of skills and the ability to participate in school and leisure activities [1, 2] and also early intervention increases motor and cognitive development in infants at risk for cerebral palsy or mild neurological problems [3].

The action-perception model states that the infant's motor activity contributes to his/her participation in the environment, thereby achieving self-control and problem solving but infants with motor delay, have a limited ability to communicate with the environment and their ability to learn from the environment is limited and this is why poor postural control, motor coordination disorder and mild neurological disorders are common in premature infants [3].

The infant's motor development depends on individual factors (birth weight, age, biological maturity, multiplicity, birth weight, gender) and environmental characteristics (type of toys, space for mobility, presence of an active parent), studies have shown that infants with low weight and multiple births, who are in a poor environment with low toys and passive parents, are more prone to motor delays [4, 5].

The growth process of the sensory nervous system in premature infants continues in the neonatal intensive care unit (NICU) but due to the presence of environmental stressors and disturbing stimuli, the infant's sensory nervous system is likely to develop less quickly [6, 7]. Sensory processing disorder can affect the infant-parent interaction and for a long time may lead to mood swings, and attention deficit and affects the child's social interaction. Due to the importance of this issue, all premature infants should be evaluated and if necessary, early interventions should be performed on them [8].

Numerous studies have examined the relationship between individual and environmental factors and motor performance in preterm infants. In 2014, Chorna et al. showed that neonatal sensory problems can cause developmental and behavioral disorders in childhood [9]. Kavousipour et al. concluded that factors related to the home environment can predict fine and gross movements in infants aged 3-11 months, and fine and gross motor toys can predict early motor and cognitive skills at 12-18 months [10].

Considering the importance of individual and environmental factors on infant motor performance, this study aimed to investigate the predictive effect of these factors on the motor performance of preterm infants to determine which factor has the greatest impact, therefore that we can predict motor delays and initiate early treatment to prevent secondary problems.

2. Materials and Methods

A cross-sectional study was conducted to investigate the predictive effect of individual and environmental factors on the motor performance of low birth weight infants.

A total of 90 premature infants (corrected age: 3-5 months) participated in this study. The research participants were recruited from December 2020 to April 2020 from the Akbarabadi Hospital in Tehran City, Iran, by the non-convenience sampling method.

The inclusion criteria included premature infants with a corrected age of 3 to 5 months and having a birth weight of less than 2500 g, having a history of hospitalization in the NICU, not having any congenital anomalies, and abnormalities and having at least one parent being able to read and write in Persian. The exclusion criteria of the study included incomplete filling of the questionnaires by the parents, infant crying during assessment, and parents' desire to continue the assessment despite initial consent. The following instruments were employed to collect the required data in the present study:

Test of infant motor performance (TIMP)

The TIMP is a test used to identify infants with motor delay, identify premature infants at risk of motor impairment, is used from the age of 32 weeks after fertilization until 5 months of age and measures motor performance and the growth process of infants [11, 12]. TIMP has two subtests named "observed items" and "elicited items", TIMP can predict infants' fine and gross motor movement even until they enter school and the possibility of cerebral palsy [4]. This test has high reliability and validity (Intraclass correlation coefficient [ICC]: 0.74 to 0.100) [12].

Sensory profile 2

This questionnaire is completed by the parent or caregiver. This test determines the possible sensory preferences of the child and the information obtained can determine the effects of these sensory preferences on the child's participation in the home and various social environments and can predict the child's behavior and performance about sensory processing [13]. This test includes 25 questions and 6 subtests with the title of general, hearing, visual, tactile, oral, and motor processing. The validity and reliability of this scale for infants have been proven by a previous study in Iran (ICC: 0.72 to 0.95) [14].

Affordance in the home environment for motor development (AHEMD): This test assesses the home environment for infants aged 3-42 months, completed by parents. It examines the demographic conditions and socio-economic characteristics of the family, the relationship between the home and community environment, emotional conditions, and the child's cognitive development. It has 4 sub-categories including physical space, diversity, fine movement toys, and gross movement toys [15]. Validity and reliability of this scale have already been proven in Iran (ICC: 0.98-0.99) [15].

Information about the age, gender, weight, type of delivery, level of education of the parents, the age of parents, the number of children, and the number of days hospitalized in the NICU was collected using a demographic form.

After the approval of this research by the Ethics Committee of Iran University of Medical Sciences (Code: IR.IUMS.REC.1397.803), and obtaining permission from the hospital, the sampling process started. The evaluation process of the tests was explained to the parents of the infants who came to the hospital clinics, after the parents filled informed consent form for participating in this study, an expert occupational therapist (with 2 years of clinical experience in the field of infants) evaluated their infant and completed the questionnaires. Due to the situation of the COVID-19 pandemic, for parents who were not willing to have their infant evaluated by an occupational therapist, the questionnaire was filled out by the parents of infants online on the porsline platform at home. In all the steps of this procedure, parents were instructed and supervised online by that occupational therapist. For them to evaluate their infant themselves at home and send the results to the therapist, after sending the answer to the parents, and the infant video was sent to the researcher for further evaluation. A total of 87 participants were evaluated virtually and 3 participants were evaluated in person.

The statistical analysis of this study was performed using SPSS software v. 16.0 and a $P<0.05$ was considered statistically significant. Continuous variables were summarized using Mean±SD and categorical variables were summarized using count and percentage. In univariable analysis, the relationship of TIMP scores with individual and environmental factors was examined by using the independent t test for dichotomous variables and Pearson's correlation coefficient for continuous variables. Then, in multivariable analysis, hierarchical multiple linear regressions were applied to examine the relationship of TIMP scores with sensory and environmental scores, controlling for the infants' demographic characteristics. In this approach, two steps were performed, the demographic variables were entered in block 1, while the sensory and environmental scores were entered in block 2.

3. Results

Infant's characteristics

Table 1 presents the demographic characteristics of the infants. The age was between 3.0 and 6.0 months (3.74±0.90), and the weight was between 800 and 2490 g (1901.8±449.2). Of the infants, 51.1% were boys, and 68.8% were born by cesarean section (CS).

Univariable analyses

As present in Table 2, significant negative correlations were observed between TIMP elicited items subtest score and total sensory score (r=-0.391, P<0.001). A positive correlation was observed between TIMP elicited items subtest score and the total environment score (r=0.207, P=0.049). TIMP elicited score were significantly correlated with gross (r=0.290, P=0.006) and fine (r=0.214, P=0.043) but not with the physical environment.

As presented in Table 3, the subtest score of TIMP elicited items had a positive and significant correlation with infant's age (r=0.390, P 0.001) and infant's weight (r=0.260, P=0.011), and a negative significant correlation with duration of hospitalization in NICU (r=-0.210, P=0.047). Compared to boys, girls obtained lower scores in the subtest score of TIMP elicited items (P=0.034). The mean TIMP elicited items subtest score in the infant who was born by CS was lower than the infant who was born by natural vaginal delivery (NVD). Regarding TIMP observed score, infants of single-child families had a lower score compared to other infants (P=0.044).

Multivariable analyses

Regarding the TIMP elicited items subtest, in block 1, high infant's age was correlated with high TIMP elicited score (β=0.316, P=0.003), and girl was correlated with low TIMP elicited items subtest score (β=-0.203, P=0.046). When the demographic variables were included in the model, the model R^2 was equal to 0.266, indicating that 26.6% of the variance in the subtest score of TIMP elicited items was explained by the demographic variables. In block 2, sensory total score was negatively correlated with TIMP elicited items subtest score (β=-0.415, P<0.001). When the sensory and environment measures were added to the model, a considerable improvement existed in the model (ΔR^2=15.3%). More specifically, an additional 15.3% of the variance in the TIMP elicited score was explained by the sensory and environment scores (Table 4).

Table 1. Demographic characteristics of the infants (n=90)

Demographic Characteristics		Mean±SD/No. (%)
Infant's age (month)		3.74±0.90
Gender	Boy	46(51.1)
	Girl	44(48.9)
Infant's weight (g)		1901.8±449.2
Type of delivery	NVD	28(31.1)
	CS	62(68.9)
NICU duration (d)		16.03±18.58
Mother's age (y)		31.07±6.27
Father's age (y)		34.42±5.83
Number of family children	1	32(35.6)
	≥2	58(64.4)

NICU: neonatal intensive care unit; NVD: natural vaginal delivery; CS: cesarean section.

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Table 2. Correlation among major study variables in infants (N=90)

Variables		TIMP Observed Subtest		TIMP Elicited Subtest	
		r	P	r	P
Sensory	GP	-0.037	0.730	-0.387	<0.001
	AP	0.064	0.551	-0.040	0.710
	VP	-0.061	0.569	-0.243	0.021
	TP	-0.089	0.402	-0.337	0.001
	MP	0.078	0.468	-0.278	0.008
	OP	-0.175	0.099	-0.323	0.002
	Total	-0.050	0.639	-0.391	<0.001
Environment	A	0.005	0.961	-0.065	0.541
	B	-0.133	0.211	0.007	0.944
	Gross	0.056	0.600	0.290	0.006
	Diversity	-0.195	0.065	-0.038	0.725
	Fine	0.087	0.417	0.214	0.043
	Total score	0.010	0.925	0.207	0.049

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TP; typical pattern: GP; general processing: AP; auditory processing: VP; vestibular processing: TP; touch processing: MP; multi-sensory processing: OP; oral sensory processing

For TIMP observed items subtest, in block 1, high infant's age (β=-0.430, P=0.007) and long NICU duration (β=-0.422, P=0.006) were correlated with low TIMP observed items subtest score. The model R2 was equal to 0.180, indicating that 18.0% of the variance in the subtest score of TIMP observed items was explained by the demographic variables. In block 2, sensory total score (β=-0.047, P=0.674) and environment total score (β=0.056, P=0.614) were not correlated with the subtest score of TIMP observed items. The second step did not lead to significant improvement in the model (ΔR^2=0.5%, F(2,79)=0.22, P=0.800), indicating that sensory and environment total scores did not predict the subtest score of TIMP observed items.

4. Discussion

The present study's results showed a significant correlation between age, weight, gender, type of delivery, and duration of hospitalization in NICU with infant motor performance and also showed that the motor performance score of boy infants who is born naturally was higher. These results appeared to be consistent with the result of Lee et al.'s study [4], which reported that individual factors, such as cesarean delivery, infant seizures, and low birth weight can affect the motor function of the infants.

This research indicates that with an increasing number of hospitalization days in the NICU, the score of the observational part of TIMP will be lower, this result appeared to be consistent with the results of Cebral al.'s study [16], they reported that environmental stressors, such as loud noise, intense light, and painful experiences in the NICU reduce the secretion of the sedative hormone oxytocin, changes in the infant's physiological responses, such as changes in behavior, decreased social interaction, irritability and crying, changes in sleep patterns, decreased auditory responses and movement, all due to reduced brain inhibitory skills in processing, organizing, and selecting sensory input due to premature brain maturation [16]. The result obtained in the present study is probably due to the presence of high environmental stress in the NICU and the impossibility of various spontaneous motor play (due to the connection of medical equipment to the infant).

Table 3. Relationship of test of infant motor performance (TIMP) scores with demographic variables in infants

Demographic Characteristics		TIMP Observed Subtest		TIMP Elicited Subtest	
		Mean±SD/r	P	Mean±SD/r	P
Infant's age (m)		r=0.182	0.086	r=0.390	<0.001
Gender	Boy	11.74±2.00	0.478	73.11±20.39	0.034
	Girl	11.45±1.77		64.50±17.34	
Infant's weight (g)		r=-0.116	0.276	0.268	0.011
Type of delivery	NVD	11.11±1.89	0.096	74.75±18.58	0.053
	CS	11.82±1.86		66.26±19.24	
NICU duration (d)		r=-0.127	0.233	r=-0.210	0.047
Mother's age (y)		r=0.018	0.863	r=0.004	0.969
Father's age (y)		r=0.022	0.840	r=0.047	0.662
Number of family children	1	11.06±1.95	0.044	71.91±18.73	0.276
	≥ 2	11.90±1.80		67.24 ±19.64	

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NVD: natural vaginal delivery; CS: cesarean section; TIMP: the test of infant motor performance; NICU: neonatal intensive care unit; r: Pearson correlation coefficient

Table 4. Relationship of test of infant motor performance (TIMP) scores with demographic variables and sensory and environment scores in infants

Blocks	Demographic Variables	TIMP Observed Subtest				TIMP Elicited Subtest			
		b	SE	β	P	b	SE	β	P
1: Demographics	Infant's age (m)	0.378	0.224	0.181	0.095	6.751	2.167	0.316	0.003
	Gender (girl vs boy)	0.042	0.397	0.011	0.916	-7.805	3.844	-0.203	0.046
	Infant's weight (g)	-0.002	0.001	-0.430	0.007	0.007	0.006	0.151	0.303
	Type of delivery (CS vs NVD)	0.138	0.466	0.034	0.768	-6.874	4.512	-0.165	0.132
	NICU duration (d)	-0.043	0.015	-0.422	0.006	-0.041	0.147	-0.039	0.781
	Mother's age (y)	-0.012	0.052	-0.040	0.817	-0.316	0.500	-0.103	0.529
	Father's age (y)	0.011	0.057	0.035	0.841	0.448	0.552	0.135	0.420
	Number of family children (≥ 2 vs 1)	0.709	0.442	0.181	0.113	-3.290	4.286	-0.082	0.445
	Model characteristics	R^2=18.0%, F=2.22, P=0.034				R^2=26.6%, F=3.67, P=0.001			
2: Sensory and Environment	Sensory total score	-0.006	0.014	-0.047	0.674	-0.549	0.125	-0.415	<0.001
	Environment total score	0.015	0.030	0.056	0.614	0.282	0.257	0.103	0.274
	Model characteristics	R^2=18.5%, ΔR^2=0.5%, F Change=0.22, P=0.800				R^2=41.9%, ΔR^2=15.3%, F=10.38, P<0.001			

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NVD: natural vaginal delivery; CS: cesarean section; TIMP: test of infant motor performance; NICU: neonatal intensive care unit; b: Unstandardized regression coefficient; β: Standardized regression coefficient

Also, the existence of a significant relationship between being an only child and the low score of the observational subtest of TIMP may indicate that the presence of one or more other children at home provides opportunities for play and interaction and a rich environment for the infant to grow and develop which is consistent with Carson et al. that resulted in a significant relationship between parental physical activity and physical activity of children aged 0-5 years, and this relationship is stronger in two-parent homes versus single-parent homes [17].

Also, the results showed a significant relationship between infant sensory and home environment with infant motor performance (elicited items subtest) and statistical analysis showed that sensory factor affects infant motor performance more than environmental factor.

The results of this study showed a significant negative relationship between the total score of sensory profile (infant subtest), and the score of the TIMP (elicited items subtest) test. All sensory profile items except the auditory processing show a significant and negative correlation with infant motor performance this means that the more/fewer infants sensory processing can be predicted that the infant will have motor delays in the future and these results appeared to be consistent with Celik's study [18] which expressed a strong relationship between sensory status and motor function in preterm infants.

Other results of the present study showed that the poorer the home environment in terms of the type of toys, less relationship with family members, limited space to move and explore the environment. It can be predicted that the infant will have motor delays in the future and therapists can prevent motor delays by adapting to the home environment that was consistent with the results of Kavousipour et al. [10], which proved that home environmental factors can predict fine and gross movements in infants and also consistent with the Roberta and his colleagues [19], who conducted the SENSE project and showed that a suitable sensory environment promotes the growth and health of infants and brain development.

5. Conclusion

In this study, we concluded that environmental and individual factors can affect the motor performance of preterm infants, and sensory processing disorder can predict their movement delay. Therefore, therapists can prevent many motor and cognitive delays in these infants by considering these factors, and in this way, family costs are saved and the infant's rehabilitation process gives the best results in the shortest time.

The present study had some limitations. Due to the situation of COVID-19 pandemic, most parents avoided involving their infant in the study, and we had to use the porsline platform (send questionnaires virtually to parents) to collect enough data and use this platform without any validity and reliability also due to the small sample size, it may not provide practical information.

Ethical Considerations

Compliance with ethical guidelines

This research was approved by the Ethics Committee of the Iran University of Medical Sciences on November 5, 2020, (Code: IR.IUMS.REC.1397.803). Informed consent forms were obtained from all study participants and their parents before gathering information.

Funding

The current study was supported by the Iran University of Medical Sciences (Grant No.: 99-1-6-18296).

Authors' contributions

All authors equally contributed to preparing this article.

Conflict of interest

The authors declared no conflict of interest.

Acknowledgments

We thank for the contribution of the parents of premature infants. Also, the authors express their gratitude to these subjects as well as their colleagues at Akbarabadi hospital in Tehran.

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