The Egyptian Journal of Hospital Medicine (October 2020) Vol. 81 (1), Page 1151-1155

The Relation between Visual Motor Integration and Cognitive Development in Full Term versus Preterm Infants

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ABSTRACT

Background: Preterm children present more often than children born at term with neurological problems that include severe neurological handicaps, such as cerebral palsy or severe mental retardation, or more subtle cognitive impairments.

Purpose of the study: To investigate the relation between visual motor integration and cognitive development in full term versus preterm infants.

Subjects: One hundred and twenty infants (full term & preterm infants) from both sexes, their ages ranged from 6 to 24 months. They were selected from Saray El-kobba Medical Center & Sawa Academy Nursery in Cairo (Ain shams area). **Methods:** Children were divided into 2 groups of equal number, **Group A:** Included sixty full term infants and **Group B:** Included sixty preterm infants (low risk preterm)**.** Within the 2 groups children were subdivided into 3 subgroups according to their chronological age for full term and corrected age for preterm. The participants of both groups were assessed by the following tools to assess their visual motor integration and cognition by The Peabody Developmental Motor Scales–Second Edition (PDMS-2) and the Portage Guide to early childhood education: (Arabic version) respectively.

Results: The results revealed that there was a strong positive correlation between PDMS-2 and Portage scale in full term sub groups (6-12months), (12-18 months) and (18-24 months) scores [(r= 0.48, p=0.03), (r=0.84, p=0.0001) and (r=0.75, p=0.0001) respectively]. There was strong positive correlation between PDMS-2 and Portage scale in preterm subgroups (6-12 months), (12-18 months) and (18-24 months) scores [(r=0.84, p=0.0001) – (r=0.63, p=0,003) –(r=0.88, p=0.0001) respectively].

Conclusion: Based on this study, it could be concluded that there is a relation between visual motor integration and cognitive development in full term versus preterm infants.

Keywords: Visual motor integration and Cognitive development, Full term infants, preterm infants.

INTRODUCTION

Normal development in childhood consists of sequential changes in function that occurs as an individual matures. This is different to the concept of growth. Growth consists of physical maturation of the individual, while the development of an individual focuses on stages or hierarchical changes, which incorporate the skills basis necessary as a prerequisite for higher-level skills. The most critical part of a child's development occurs between birth and three years of age **(1).** This stage is most critical due to the developmental sequence of the brain and the impact of neuroplasticity being at its greatest within these primitive years **(2).**

Late preterm infants (LPIs) are physiologically and metabolically immature at the time of birth, often lacking the self-regulatory ability to respond appropriately to the extra-uterine environment. Despite their appearance as small but "normal" babies, LPIs have higher rates of morbidity and mortality than their term counterparts do, not only during birth hospitalization, but also throughout the first year after birth and beyond **(3).**

The previous researches rarely focused on the relationship between cognitive flexibility and the visual motor integration (VMI) because of its complexity containing two subcomponents of executive function (working memory and inhibitory control) at the same time. However, children with better cognitive flexibility probably integrated visual and motor information automatically and could reduce the occupation of cognitive resources so as to deal with other more complex information **(4).**

The evidence from previous studies investigating the link between visual motor integration and cognitive development in full term and preterm infants is still not sufficient to draw firm conclusions. More research is needed investigating such specific links at this stage of early development, so this study was conducted to investigate the relation between visual motor integration and cognitive development in full term versus preterm infants.

Received:1 /7 /2020
Accepted:17 /8 /2020

MATERIALS AND METHODS

Participants:

One hundred and twenty full term & preterm infants from both sexes participated in this study. They were recruited during the period from November 2019 until February 2020 from Saray El-kobba Medical Center & Sawa Academy Nursery in Cairo (Ain shams area), where the data were collected and the assessment was conducted.

Ethical approval:

This study was approved by the Research Ethics Committee of Physical Therapy College, Cairo University.

Inclusion criteria:

The ages ranged from 6 months to 2 years. Corrected age for preterm less than 37 weeks and more than 32 weeks (± 7 days) and for full term infants 37- 40 weeks. They had no neurological disturbance and were medically stable.

Exclusion criteria:

Any problems during pregnancy or labor, major birth complication, apparent visual or auditory defects, past history of admission to neonatal intensive care unit more than 72 hours.

Instrumentation:

The Peabody Developmental Motor Scales – Second Edition (PDMS-2):

Is a test of gross- and fine-motor development for children from birth to 5 years old. The gross-motor component consists of four subtests: Stationary, Locomotion, Reflexes, and Object manipulation. Two subtests, Grasping and Visual Motor Integration, make up the fine motor portion. The test requires the child to perform specific motor items, which are scored with a 2, 1, or 0 for each item, depending on whether the child correctly, partially, or does not complete the item according to its description. Standard scores, percentiles, and age equivalents are available, as well as quotient scores in fine- and gross-motor areas. The entire PDMS-2 can be administered in 45 to 60 minutes. Separate fine- or gross-motor subtest administration takes 20 to 30 minutes [(5)].

The Portage Guide to early childhood education: (Arabic version):

The portage guide to early education (originally started as a demonstration project funded by U.S. department of education in 1969) and pioneered as a home based parent empowering developmental stimulation program. The kit covers five developmental areas: communication, language, literacy, social and emotional development. In addition to exploration approaches to learning, purposeful motor activity and social organization [(6)].

Cognitive Development (108 items):

The Cognition domain covers skills such as something to remember, see or hear. Similarities and differences between objects and establishing relationships between abstract matters and reality. Examples of this are 18 item and match similar items together [(7)].

Procedures:

1- Assessment of Peabody Developmental Motor Scale 2 (PDMS-2):

Visual motor integration subtest was used. This sub-test evaluates the child’s eye and hand co-ordination. Aside from controlling muscles, the test determines the level of the child’s visual perception. Some examples of the activities of this 72-item sub-test include building blocks and copying designs.

Preparation:

1. The infant sat on comfortable chair or on mother’s lap according to his or her age.
2. The infant sat in a pediatric chair while his trunk was at 90 degree, his hips at 90 degree and using a chest strap.
3. Assessment tools were presented in front of the child.
4. Therapist demonstrated the task for the infant then asked him to copy it (ask infant to put 3 cubes above each other).

Scoring:

2: Normal → making the task correctly
1: Impaired → can’t make the full task.
0: Absent → Unable to make the task

The Portage Guide to early childhood education: (Arabic version):

The participants were assessed using questions and tasks. The assessment sessions was brief, usually about 15 – 20 minutes, and were scheduled when the parent believed the infant was at their most receptive.

Statistical analysis

Non-parametric statistics were used as the data violated test of normality. Statistical analysis was composed of descriptive statics: mean and standard deviation for age and sex. Unpaired t test was conducted for comparison of age between groups. Chi squared test was conducted for comparison of sex distribution between groups. Mann–Whitney U test was conducted for comparison of row score of Peabody and row score of Portage between full term and preterm groups. Spearman Correlation Coefficient was conducted to determine the correlation between PDMS-2 and Portage scale in each subgroup. The level of significance for all statistical tests was set at $p \leq 0.05$. All statistical analysis was conducted through the statistical package for social studies (SPSS) version 25 for windows (IBM SPSS, Chicago, IL, USA).

RESULTS

Demographic data- Subject characteristics:

Table (1) showed the subject characteristics of full term and preterm groups. There was no significant difference between groups in age and sex distribution (p > 0.05).

Table (1): Comparison of age and sex distribution between the full term and preterm groups

			Full term	Preterm	p-value
Age, months, Mean,(SD)		6 to < 12 months	8.8 ± 1.43	8.65 ± 2	0.78
		12 to < 18 months	13.85 ± 2.1	14.1 ± 1.33	0.65
		18 months to < 24 months	18.95 ± 0.94	19.25 ± 1.06	0.35
Sex, n (%)	6 to < 12 months	Girls	15 (75%)	13 (65%)	0.49
		Boys	5 (25%)	7 (35%)	
	12 to < 18 months	Girls	12 (60%)	15 (75%)	0.31
		Boys	8 (40%)	5 (25%)	
	18 months to < 24 months	Girls	11 (55%)	10 (50%)	0.75
		Boys	9 (45%)	10 (50%)	

SD: Standard deviation p value: Probability value

PDMS-2 and Portage scale comparison between groups:

There was a significant difference in the PDMS-2 of 6 to < 12 months and 18 to < 24 months age groups in favor of full term infants as compared to that of preterm age groups (p = 0.001). However, there was no significant difference in PDMS-2 of 12 to < 18 months age group between full and preterm (p = 0.33). There was a significant difference in the Portage scale of 6 to < 12 months, 12 to < 18 months and 18 to < 24 months age groups in favor of full term infants as compared to that of preterm age groups (p < 0.05) (Table 2).

Table (2): Median values of PDMS-2 and Portage scale in full term and preterm groups

	Full term	Preterm		
	Median (IQR)	Median (IQR)	U- value	p-value
6 to < 12 months				
PDMS-2	44 (4)	19.5 (26.25)	65	0.001
Portage scale	6.5 (2.75)	3 (3.75)	46	0.001
12 to < 18 months	3.31	2.22		
PDMS-2	59 (14)	59 (4.25)	164.5	0.33
Portage scale	11 (3)	10 (2.75)	122.5	0.03
18 to < 24 months				
PDMS-2	83 (2.75)	76.5 (3.5)	43.5	0.001
Portage scale	14.5 (3)	10.5 (3)	83.5	0.001

IQR, interquartile range; U- value, Mann-Whitney test value; p-value, level of significance.

Correlation between PDMS-2 and Portage scale in full term and preterm groups:

The correlations between PDMS-2 and Portage scale in full term were moderate positive significant correlation in 6 to < 12 months age group (r = 0.48, p = 0.03), strong positive significant correlation in 12 to < 18 months age group (r = 0.84, p = 0.001) and strong positive significant correlation in 18 to < 24 months age group (r = 0.75, p = 0.001) (table 3).

The correlations between PDMS-2 and Portage scale in preterm were strong positive significant correlation in 6 to < 12 months age group (r = 0.84, p = 0.001), moderate positive significant correlation in 12 to < 18 months age group (r = 0.63, p = 0.003) and strong positive significant correlation in 18 to < 24 months age group (r = 0.88, p = 0.001) (table 3).

Table (3): Correlation between PDMS-2 and Portage scale in full term and preterm groups

		r value	p value
Full term	**6 to < 12 months**	0.48	0.03
	12 to < 18 months	0.84	0.001
	18 to < 24 months	0.75	0.001
Preterm	**6 to < 12 months**	0.84	0.001
	12 to < 18 months	0.63	0.003
	18to < 24 months	0.88	0.001

r value: Spearman correlation coefficient p value: Probability value

DISCUSSION

The aim of the present study was to investigate the relation between visual motor integration and cognitive development in full term versus preterm infants.

The choice of the infancy period to study the relation between VMI and cognitive development was based on the finding of **Ora *et al.*** [8] who stated that only a small number of studies reports evidence linking level of motor development with later cognitive development in children born preterm and/or with LBW. However, and more importantly, most of the previous studies did not control for early cognitive development.

The comparison of visual motor integration between full term and preterm infants revealed that there was significant difference from 6 to < 12 months and from 18<24 months (p= 0.0001).

This could be justified by the fact that the developing brain undergoes significant changes in functional organization. Not surprisingly, therefore, preterm birth exerts long-lasting effects on brain development, including the domain of visual function. Importantly, cerebral visual impairment can occur in the absence of any identifiable brain lesion. **Moreiraa *et al.*** [9]. Moreover previous studies report that preterm newborns have been shown to differ from the full term ones as regards such motor skills as postural control and kicking movements. **Van Der Heide *et al.*** [10] and **Fetters *et al.*** [11] reported that infants born preterm are at increased risk of developing motor impairments compared to infants born at term [12].

There was no significant difference from 12 to < 18 months age group (p= 0.33). This result come in line with **Pinheiro *et al.*** [13]**,** who stated that the impacts of visual motor, visual perceptive and motor skills alterations can be uncovered only by the time, with possible implications in other development areas, because, as aforementioned, development occurs comprehensively, where all the fields act together in the evolutionary process.

As mentioned before all infants were without neurological disturbance and medically stable. Moreover, the researcher concluded that the mothers of this subgroup were highly educated so theoretically speaking they must have received good care and social attention that might have affected their development.

The comparison of cognition between full term and preterm infant revealed that there was significant difference from 6 to < 12 months and from 18 < 24 months (p= 0.0001). This result comes in line with **Volpe *et al.*** [14] who documented that Preterm birth is associated with dysfunctional development of vital organs and increased risk of cognitive impairment later in life. Some problems that appear during the first weeks of life can be successfully treated, whilst others have a permanent influence on the development.

There was no significant difference from 12 to < 18 months age group (p= 0.33). As previously mentioned the parents of this sub group was highly educated. This comes in line with **Breeman *et al.*** [15] who stated that there is strong evidence that parental education acts as a predictor for cognitive development in preterm children. In addition, parental level of education, employment and income have additionally showed independent and additive effects on cognitive gain across preschool years [4, 16].

The correlation between visual motor integration and cognition in full term revealed that there was strong positive correlation between PDMS-2 and Portage scale in full term in all sub groups. These results are in line with **Zhang *et al.*** [17] who concluded that the VMI skills grew rapidly in the first two years. Firstly, the rapid physiological growth may probably lead to increase of brain areas related to the VMI such as occipital lobe, precentral motor area and posterior parietal cortex that were developing quickly. Secondly, the acquisition of some fundamental motor skills could contribute to the rapid development of VMI [18]. In addition, **Becker *et al.*** [19] added that children with better cognitive flexibility, probably integrated visual and motor information automatically could reduce the occupation of cognitive resources to deal with other more complex information. Finally, various studies addressed the link between motor development and later cognitive outcomes and the link between early postural control and quality of gross motor and later cognitive development [8].

These links are (at least partially) explained by the object exploration made possible by the acquisition of the skill of sitting. A different study with children born preterm reports that children born preterm had less well developed object exploration skills, compared to children born at term [20].

There is strong positive correlation between PDMS-2 and Portage scale in preterm in all sub groups. These results come in agreement with **Hadders-Algra**[21] who stated that theoretically in children born preterm and/or with LBW if motor skills are of poor quality, the benefits to cognition from sensorimotor interactions with the physical world are expected to be lower. Poor quality movements provide children with different information about their movements and about the environment and this information is less optimally supportive of their cognitive development**.**

The result of the current study and previous research suggest that there were a strong relation between visual motor integration and cognitive development in all age groups. Nevertheless, various domains of development are influenced by social interaction and family motivation. This result comes in agreement with **Gibson and McDougall [22]; Smith and Gasser [23] and Thelen and Smith [24]** who proved that children both receive information from their environment and act on their environment in a way that generates new information to be perceived.

This ongoing perception action cycles enable children to learn about the world around them and develop (among other things) their cognitive skills.

CONCLUSION

Based on this study and relevant literature it could be concluded that prematurity affect both visual motor integration and cognitive development and that there is strong relation between visual motor integration and cognitive development in both full term and preterm infants.

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