Journal of Human Growth and Development
2014; 24(2): 181-187

VISUAL MOTOR INTEGRATION AND OVERALL DEVELOPMENT OF PRETERM AND AT TERM CHILDREN AT THE BEGINNING OF SCHOOLING

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Abstract

Objective: To investigate the influence of prematurity and low birth weight on development indicators, such as visual motor coordination, visual perceptive and fine motor skills of children in early schooling, as well as their relations with rates of global developmental delay. **Method:** It is a comparative study of case-control type. The research included 18 children with a history of preterm birth (Study Group), matched with 18 children without the same history (Comparison Group). These children were evaluated by the Denver Developmental Screening Test II and the test of Visual Motor Integration - VMI. **Results:** Statistical tests revealed significant differences between the Study Group and the Comparison Group regarding the visual motor (p = 0,000) and fine motor (p = 0,007) variables, while significant difference in performance between the Low Birth Weight and Appropriate Birth Weight groups was observed in the visual motor (p = 0,000), visual perceptive (p = 0,016) and fine motor (p = 0,036) variables, demonstrating that weight is more influential than prematurity in visual perception performance. Significant differences were observed in all parts of the VMI instrument (p = 0.001, p = 0.000, p = 0.000) when compared to the Denver Suspect and Denver Normal groups; it is possible to observed that poor performance on screening tests for development can be a predictive factor for poor performance on tests of visual motor integration. **Conclusions:** Preterm children showed worse performance in the assessment instruments confirming that preterm birth represents a risk to development. Skills of greater complexity required during schooling for reading and writing can be influenced by the visual motor, visual perceptive and fine motor difficulties.

Key words: preterm, visual motor integration, school health, occupational therapy.

INTRODUCTION

Child development occurs comprehensively, that is, all areas or fields of development work together in the evolutionary process. Somatic and/or environmental factors, which occur mainly in the prenatal, perinatal and postnatal periods, can cause long lasting deficits in the motor, sensorial and emotional development of children. The preterm birth, by itself, can be considered a risk factor, since premature children are susceptible to an array of neurodevelopment problems that influence their growth and development when compared to children with no history of prematurity[2].

The World Health Organization (WHO)[3] defines as preterm all infants born before 37 weeks of pregnancy. The newborn child at term is born between 38 and 42 weeks, and the post-term after 42 weeks of gestation. According to the Usher's classification, preterm newborn children are categorized as follows: moderate prematurity, ranging from 31 weeks to 36 weeks and 6 days of pregnancy; and extreme prematurity, ranging from 22 weeks to 30 weeks and 6 days of gestation[4].

Preterm birth is often associated with low birth weight. According to the WHO[3], newborn children are considered low birth weight (LBW) when their birth weight is equals to or lower than

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Funding Source: CAPES
Master's Thesis: Visual motor coordination and overall development of preterm and at term children: evaluation and detection of risks at the beginning of schooling. Federal University of Sao Carlos – UFSCar , 2012.
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Suggested citation: Pinheiro RC, Martinez CMS, Fontaine AMGV. Visual motor integration and overall development of preterm and at term children at the beginning of schooling*, Journal of Human Growth and Development*, 24(2): 181-187
Manuscript submitted Aug 01 2013, accepted for publication Dec 28 2013.

2,500 grams, subdivided into very low birth weight children (VLBW – birth weight lower than 1,500 g) and extremely low birth weight children (ELBW – birth weight lower than 1,000 g). Birth weight is a strong predictive factor of mortality and perinatal morbidity, where infants with weight lower than 2,500 g, according to the WHO[3], present greater mortality in the first weeks of life[5].

Several studies on the influences of preterm birth in school-age children include measures for visual perception, visual motor integration, fine motor skills, and motor development[6-11]. However, there is no systematic investigation of the prevalence and nature of the visual motor integration dysfunction and its relation with dysfunction in the fine motor coordination skills, visual perceptions, and perinatal variables in preterm children who seem normal during school age[12].

The integration between the visual and motor systems is called visual motor integration. This function is defined as the level where visual perception and the movement of limbs, in this case, the movement of hands and fingers, are well coordinated. This term is quite general and reflects, in fact, two distinct independent functions: visual perception and fine motor control. On the other hand, the fine motor function can be described, more specifically, as the development state of fingers and hand[12]. It is suggested that problems of global motor coordination and visual motor integration impair child performance in its occupational role, and it may cause academic difficulties in the copying of pictures, clipping and handwriting, and in the performance of daily living activities, such as eating, self-care and leisure.

Motor coordination difficulties, which are common in school-age children, have been remarked in the literature and considered an important health problem in children[13]. Such relevant motor deficits limit the participation of children in several school activities[14,15].

Most preterm newborns go to regular schools, but the majority of these children may present functional limitations that interfere in the performance of daily activities, behavior, and cognitive, motor and social skills, with impact on various developmental domains at preschool and school ages[16-17,10,18-19]. Considering that, in some domains, children tend to present worse performance during school age; it is recommended that the development of these children be monitored, at least until the beginning of elementary school, aiming at a preventive work in order to avoid the installation of possible deficits that might influence their academic performance[16].

In this light, the present research aimed to investigate the influence of preterm birth and low birth weight on development indicators such as visual motor, visual perceptive and fine motor coordination in children in their first school years, which may cause possible implications in their literacy process and other learning processes thereafter. This study also intends to observe the influence of gestational age and birth weight on these development indicators, as well as their relations with rates of global developmental delay.

METHODS

Because this research involves human beings, it was submitted to and approved by the Ethic Committee for Human Beings of the Federal University of Sao Carlos (CEP/UFSCar) under the opinion #291/2010.

It is a comparative study of case-control type. The research included 18 children with a history of preterm birth (*Study Group -SG*), aged between 5 and 7 years old, who attended the regular school system; matched by age, sex and attendance to the same class with 18 children without the same history (*Comparison Group -GC*).

The test of Visual Motor Integration - VMI[20] was used; this test was developed to assess effectively and objectively the integration of visual and motor skills, where the visual motor coordination, visual perception and fine coordination are evaluated, especially in children[21]. The test was validated for use in Brazil in 1992 by Pinelli-Junior and Pasquali[22].

The Denver Developmental Screening Test II was also used; it was elaborated with the intention to monitor objectively the neuro-psychomotor development of children from zero to six years old. It is an early screening and detection tool of child developmental conditions that evaluates four skill areas/categories: gross motor, adaptive fine motor, language, and personal-social[23].

A documental analysis was carried out by means of the data collected from the Statements of Liveborn (SLB) and stored in the TABNET application from the Health Secretary of the State of Sao Paulo and also the data provided by the responsible persons through the questionnaire proposed by the researcher for both groups. Finally, access to the medical records of the study subjects was requested to the Maternity Hospital of the city for confirmation and correction of the obtained data.

Statistical Analysis

In the present study, statistical analysis of data on continuous and categorical variables was carried out, as well as the dichotomization of some variables, aiming to create comparison groups with the continuous variables.

Table 1 shows the variables of the present study, their classification, and the groups created through the dichotomization of continuous variables.

Table 1: Variables of the Study

CATEGORICAL	***CONTINUOUS***	***DICHOTOMIZED***
	- GA	
- Profile of the study sample (SG/CG)	- Weight	- Group Weight (LBW/ ABW)
- *Denver* (Suspect and Normal)	- VMI vm	
	- VMI vp	
	-VMI fm	

SG: Study Group; CG: Comparison Group; GA: Gestational Age; Weight: weight at birth; VMI vm: result of the visual motor part of the VMI test; VMI vp: result of the visual perceptive part of the VMI test; VMI mf: result of the fine motor part of the VMI test; LBW: low birth weight; AW: appropriate birth weight.

Besides the comparison of groups according to gestational age – GA (preterm and without preterm history), groups using the weight variable were created, since this is also considered one of the most important factors for the maturity of several systems that, when not within the normal parameters, tend to result in increased neonatal morbidity [11, 24].

Due to the small number of subjects, children classified as extreme low birth weight (ELBW) and very low birth weight (VLBW) at birth were grouped and transformed in the low birth weight (LBW) group, which comprised all subjects weighing 2,500 g or less.

The Denver group was elaborated as from the application of the Denver-II test, with the following classification: *Suspect* (DS) - for children classified as suspect in the test; and *Normal* (DN) – for children classified as normal in the test[25].

Statistical analysis was carried out using the data recorded in the assessment protocols, copied and stored in file for database software: *Statistical Package for Social Science - 18.0* (SPSS).

The verification of the following conditions is necessary for the application of the parametric tests: (1) the dependent variable must have normal distribution; (2) the population variables must be homogeneous in the event of comparing two or more populations[26].

After the application of the *Kolmogorov-Smirnov* and *Levene* tests and the *kurtose* and *asymmetry* verifications, it was possible to observe that the requirements for the application of tests were met, enabling the application of the *t*-Student test in order to verify whether the means of the two populations are significantly different.

In this research, H_0 was rejected if p-value < 0.05. In the *t*-Student test, for the cases where the significance level (p-value) of the test was smaller than 0.05, the difference between the analyzed groups was considered and H_0[26,27] was rejected.

However, being statistically significant may not have a practical meaning if the amplitude of differences is very weak. In order to evaluate the practical meaning of differences, it is necessary to evaluate the effect size – ES (h). This is a correlational measure between the dependent variable and the independent variant or factor. It is possible to obtain a measure of the total variation proportion on the dependent variable that is explained by the factor[26] through the squaring of these statistics (h^2).

The interclass correlation coefficient (ICC) is a measure of the reliability of observers, which is defined as the ratio of the variance between units of analysis and the total variance[28,29]. The ICC, which was calculated through the fixed effects model, demonstrated strong concordance among the referees (ICC = 0.80), guaranteeing data reliability.

RESULTS

It is possible to observe in the *t*-Student test if the means of the two populations with small samples ($n < 30$) are significantly different[26]. In addition to the results of the *t*-Student test, the descriptive characteristics of each group studied are presented.

Initially, the comparison between the preterm children group (SG) and the at term children group (CG) is presented, and subsequently, the comparison between the groups that differ regarding some factors and risks observed in this study (weight and development screening through Denver II test) is presented.

First, the *t*-Student test between the SG and the CG was performed to verify whether there were significant differences between the age means of the two groups. The result, $p = 0.355$, proved that the two groups present similar ages.

Tables 2, 3 and 4 show, simultaneously, the descriptive characteristics of the groups elaborated regarding GA, weight and Denver II test development, and the *t*-Student test results through the *p*-value.

In Table 2, it is possible to verify that the inclusion criteria for the SG and CG groups have met the purposes of the research, considering that the differences in the GA and weight variables are significant ($p < 0.001$). The h^2 values of the GA and weight variables show that 84% of the variation in time of pregnancy and 86% of the

Table 2: Descriptive Characteristics and significance level of the differences between the SG and CG groups (n: SG = 18; CG = 18)

		Group	Mean	SD	Max	Min	P-value
GA		SG	30.33	2.19	34	27	**0.000**
		CG	38.83	1.5	37	42	
Weight		SG	1,445.72	334.01	2,130	970	**0.000**
		CG	3,231.11	399.31	3,740	2,465	
VMI	*Visual Motor*	SG	85.33	9.59	59	97	**0.000**
		CG	102.61	12.68	85	131	
	Visual Perceptive	SG	82.67	19.47	45	45	0.066
		CG	95.28	20.28	60	119	
	Fine Motor	SG	95.28	11.34	65	115	**0.007**
		CG	106.61	12.17	77	125	

SD: standard deviation; Max: maximum; Min: minimum; GA: gestational age; VMI: score at the VMI

Table 3: Descriptive Characteristics and significance level of the differences between the UW and AW groups (n: UW = 20; AW = 16)

		Group	Mean	SD	Max	Min	P-value
GA		UW	31.05	3.03	38	27	**0.000**
		AW	39.00	1.50	42	37	
VMI	*Visual Motor*	UW	86.75	10.52	109	59	**0.000**
		AW	103.00	12.98	131	85	
	Visual Perceptive	UW	81.70	19.12	119	45	**0.016**
		AW	98.06	19.21	143	73	
	Fine Motor	UW	96.95	11.94	115	65	**0.036**
		AW	105.94	12.74	125	77	

SD: standard deviation; Max: maximum; Min: minimum; GA: gestational age; VMI: score at the VMI

Table 4: Descriptive Characteristics and significance level of the differences between the DS and DN groups (n: DS = 7; DN = 29)

		Group	Mean	SD	Max	Min	P-value
GA		DS	31.00	3.51	38	27	**0.022**
		DN	35.45	4.57	42	27	
Weight		DS	1,581.14	726.68	3,110	970	**0.020**
		DN	2,521.21	947.63	3,740	985	
VMI	*Visual Motor*	DS	78.43	10.67	91	59	**0.001**
		DN	97.72	12.24	131	79	
	Visual Perceptive	DS	65.14	14.36	82	45	**0.000**
		DN	94.72	17.62	143	60	
	Fine Motor	DS	85.14	11.86	101	65	**0.000**
		DN	104.75	10.08	125	88	

SD: standard deviation; Max: maximum; Min: minimum; GA: gestational age; VMI: score at the VMI

variation in weight can be explained by prematurity.

Considering the results of the *t*-Student statistical test, it is possible to notice that there is significant difference between the two groups for the Visual Motor and Fine Motor variables of the visual motor instrument (VMI).

In the visual perceptive part of the VMI, it can be observed that the groups of children analyzed show similar behavior, once the *p-value* is greater than 0.05.

The calculation of h^2 shows that 38% of the visual motor variable variation can be explained by prematurity, that is, it belongs to one of the groups (SG or CG), as well as 17% of the fine motor variable variation.

Given that the weight factor is a predictor of perinatal mortality and morbidity, the analyses shown in Table 3 compare the subjects who were low birth weight, regardless of belonging to the SG or CG groups[5].

Table 3 shows that there is significant difference in development between the low birth weight - LBW and Appropriate Birth Weight - ABW groups regarding the Visual Motor, Visual Perceptive and Fine Motor variables, all belonging to the Visual Motor Instrument (VMI), and also, as predicted, in the GA variable.

When calculating the h^2, it is possible to observe that 72% of the GA variable is influenced by the weight, confirming once again that the subjects with lower weight are those of shorter gestational age, regardless of belonging to the SG or CG groups. In addition, it can be observed that 33%, 22% and 16% of the visual motor, fine motor and visual perceptive variables variations, respectively, are influenced by the birth weight, that is, belonging to LBW or ABW groups.

When the statistical results obtained through the SG and CG groups analyses are compared to the results obtained with the LBW and ABW groups, it is found that birth weight is more influential than prematurity for the visual perceptive development of the subjects, since the difference in means is significant between the LBW and ABW groups, but non-significant between the SG and CG groups for this variable.

Table 4 shows that there is statistical difference between the means of the groups for the GA and weight variables, and that the variation of these variables due to belonging to the group (h^2) is 14% and 15%, respectively. Based on these data, it is possible to conclude that the children belonging to the DS group present GA and weight at birth significantly lower than do the children belonging to the DN group, demonstrating that preterm and underweight children are more likely to present overall developmental delays.

Concerning performance in the instruments, it is possible to notice that there is significant difference in all dimensions of the VMI, with 30% of the visual motor variable variation, 37% of the fine motor variable variation, and 33% of the visual perceptive variable variation being explained by global development, that is, because they belong to the DS or DN groups. With this data, it is possible to hypothesize that the poorer performance in developmental screen tests enables to predict partially the performance level in the visual motor integration tests.

DISCUSSION

Through the application of the *t-Student* test on the different groups, it was possible to observe that preterm birth is indeed a risk factor to development. Birth weight is among the factors that most influence development, considering that the percentage of variation in performance on the instruments was more important in the comparison of the LBW and ABW groups, for the visual perceptive and fine motor dimensions, than in the SG and CG groups, although this was not the case for the visual motor coordination dimension.

Such results reinforce those obtained by previous studies that report that preterm children present greater difficulties regarding visual motor and visual perceptive coordination, as well as simple motor skills[6,7,10,30].

Just as the present research, Carvalho and Magalhaes (2004)[10] reported that there is a relation between motor accuracy and weight at birth, despite the fact that children present means within the expected ones for the age in the visual motor tests.

Yet, the studies by Luoma, Herrgard and Martkainen (1998)[7] and Goyen, Luy and Woods (1998)[6] reported that children born with lower weight presented the lowest scores in the visual motor and visual perceptive coordination tests.

Another important factor to be highlighted is the significant difference in means established between the groups classified through the Denver-II Test. The group classified as Suspect obtained score significantly lower compared to the group classified as Normal in all areas of the VMI test. These results corroborate the study by Palhares et al (2000)[1], showing that child development occurs comprehensively, where all fields act together in the evolutionary process, that is, the children that presented difficulties in the areas evaluated by the TTDD-II, also had troubles concerning visual motor performance.

The cross-sectional data collected did not allow to identify which area is influenced by which other area; nevertheless, it is worth highlighting the importance of the subject be evaluated and motivated in full, because when there are difficulties in certain areas there will possibly be difficulties in others as well.

The research by Fender et al (2005)[31] reported that preterm infants show significantly poorer performance in handwriting when compared to children born at term, also presenting difficulties in other sensory motor tasks, including motor coordination, manipulative tasks, visual motor integration, visual perceptive tasks and sensory awareness of the fingers. This fact evidences that poorer performances in visual motor and visual perceptive tasks, as demonstrated in this study, may influence handwriting performance in the later years of schooling.

Considering that reading and writing will be important factors in the occupational student role of these children, occupational therapists should be alert to this population and this type of problem, trying to minimize the risks as early as possible, avoiding problems in the later years of schooling.

Thus, children with preterm birth history, in most cases, present poorer performance in several development areas when compared to children born at term.

It is worth mentioning that, in spite of preterm birth being a risk factor for development alterations, some preterm infants show normal development, that is, despite the evident difficulties in development presented by preterm children, there are possibilities of successful coping with the adverse conditions of these children. Despite these exceptions, prematurity is still a risk for healthy development and, taking into consideration that the aspects analyzed in this research have direct implications in the academic performance of these children, monitoring should be carried out in order to minimize the adverse effects resulting from these difficulties.

In this study, it was possible to verify the necessity for monitoring the development of preterm children until their school years, since the impacts of visual motor, visual perceptive and motor skills alterations can be uncovered only by the time children begin regular schooling, with possible implications in other development areas, because, as aforementioned, development occurs comprehensively, where all the fields act together in the evolutionary process.

The activation of protection mechanisms should be provided in these children's lives, as well as the motivation of infant development skills based on the knowledge of their capabilities and limitations, through the supplying of orientation and motivational strategies in the school and family contexts.

The occupational therapist is the professional capable of analyzing infant development and the typical childhood activities through the motor skills and daily and academic lives of these children, playing an essential role in the activation of these protection mechanisms, becoming an actor with the development supervision, aiming to minimize potential risks by means of interventions in the school environment and orientation to educators and family.

The integral vision shared by the professionals in the sphere of health and education together with the parents and persons responsible for these children, effectively contributes to the early detection of risk factors and promotion of the quality of the interaction and environment where these children are inserted.

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