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SENSORY PROCESSING IN PRETERM CHILDREN AT 5 YEARS OF AGE AND ITS ASSOCIATION WITH SCHOOL READINESS

ORIGINAL ARTICLE

ABSTRACT

Purpose: This study aimed to determine the sensory profile of preterm children an to investigate the relationship between sensory processing and school readiness at five years of age.

Methods: Seventy-six children aged 60–72 months (36 preterm children born <37 weeks of gestation and 40 age-matched term children) were enrolled in the study. Sensory processing was assessed using the Sensory Profile of Dunn, and school readiness was evaluated using the Marmara Primary School Readiness Scale.

Results: Sensory processing scores of the preterm group were significantly lower than the term group (p<0.05) at five years of age. Sensory symptoms in preterm preschoolers were associated with school readiness (p<0.05). Total Sensory Profile score was a significant predictor for school readiness in preterms (p<0.05).

Conclusion: Preterm children exhibited more sensory processing disorder than their term typical peers. Sensory processing disorders in preterm children may affect their school readiness at five years of age.

Key Words: Child Development; Premature Birth; Term Birth.

OKUL ÖNCESİ DÖNEMDE PRETERM ÇOCUKLARDA DUYUSAL İŞLEMLEME VE OKULA HAZIR OLUŞLA İLİŞKİSİ

ARAŞTIRMA MAKALESİ

ÖZ

Amaç: Bu çalışmanın amacı, okul öncesi dönemde preterm çocukların duyusal profilini belirlemek ve duyusal işleme ile okula hazır oluş arasındaki ilişkiyi araştırmaktı.

Yöntem: Çalışmaya 60-72 ay arası 76 çocuk (gestasyonel yaşı 37 haftadan küçük 36 preterm ve 40 term çocuk) dahil edildi. Duyusal işlemleme Dunn Duyu Profili ile değerlendirildi. Okula hazırlık durumu Marmara İlköğretim Okulu Hazır Oluş Ölçeği ile değerlendirildi.

Sonuçlar: Okul öncesi dönemdeki preterm grubun duyusal işlemleme skorları term gruptan anlamlı olarak daha düşüktü (p<0,05). Preterm çocuklarda duyusal semptomlar okul hazırlığı ile ilişkiliydi (p<0,05). Total Duyu Profili skoru, pretermlerde okula hazır oluşun anlamlı bir belirleyicisiydi (p<0,05).

Tartışma: Preterm çocuklar, akranlarından daha fazla duyusal semptom sergilediler. Beş yaşındaki preterm çocuklarda duyusal işlemleme bozuklukları, okula hazır olma durumlarını etkileyebilir.

Anahtar Kelimeler: Çocuk Gelişimi; Prematüre Doğum; Term Doğum.

INTRODUCTION

Preterm children may often have specific learning disabilities, attention deficit hyperactivity disorders, language and speech disorders, low Intelligence Quotient (IQ) levels, visuomotor disorders, language and speech problems, or low performance at school (1). Impaired neurological and biological systems may lead to sensory processing disorder (SPD) in preterm infants. SPD is described as an individual's inability to effectively register, process, organize, or respond to sensory stimuli (2). Neonatal Intensive Care Units (NICUs) cannot meet the sensory and developmental needs, unlike in uterus, which is the best environment for infants. Although the uterus is a dark, warm, and supportive environment with rhythmic sounds and vestibular input, NICUs largely deprive infants at risk from their natural sensory environment and cause excessive stimulation (3). In addition, there is a lower parasympathetic activity in preterm children due to the lower vagal tone response (4). All these problems may cause sensory problems in preterm infants. Moreover, it has been shown that SPD continues until the preschool and school-age, which is a critical period for learning (5,6).

Dunn's model for sensory processing could provide a possible explanation for the relationship between sensory processing abilities and behavioral output. Dunn's model summarizes the relationship between a person's central neurological thresholds and behavioral response (7,8). Among individuals with hyposensitivity, fundamental habit mechanisms support high limits. However among individuals with low thresholds, neurons are more easily triggered and thus react more frequently to stimuli from the environment, resulting in hypersensitivity (8). Children with sensory avoiding behavior have low neurological thresholds. Therefore they could not prevent stimuli that disturb them. They do not want to participate in the activities that cause excessive or new sensory stimuli (8). Children with sensory seeking behaviors have high neurological thresholds and often produce voices and display unsafe practices to meet their sensory needs (8). These behaviors may affect their social interactions with their peers and their participation in academic life. When they are unable to meet their sensory needs, the children may become explosive and aggressive in their daily life. For those children who have extreme sensory seeking, behaviors may disrupt attention so profoundly that learning is compromised or activities of daily living become challenging (2). Children who exhibit rapid and intense reactions to sensory stimuli often display emotional responses include irritability, moodiness, inconsolability, or poor socialization (2). A sensitive child may have problems focusing, and an external stimulus could easily disturb the child while trying to focus on the task. It may affect a child's ability to participate in academic, social, and play activities in the classroom. Children with low registration behaviors may not explore the environment, engage in socialization, or participate in school activities such as play and academic projects. In addition, these children are often apathetic and distracted in both at home and school settings (2).

School readiness is defined as children's academic and cognitive skills, language and literacy abilities, and social-emotional functioning when they enter school (9). In particular, school readiness could be better understood as property or product of the ecologies in which children are embedded to support their development and educational progress: a range of interactions and processes, environments (home, school, and child care), and institutions (communities, neighborhoods, and governments) (10). The school readiness is the result of direct and indirect interaction of children with these resources; it involves the acquisition of academic, language, and socio-emotional competencies that are invaluable to educators through social relationships between peers, familly, and teachers (10).

The teachers expect preschool children to focus on tasks, sit quietly, follow instructions, self-regulate their emotions, and collaborate with teachers and peers (11). Preschoolers with SPD may have difficulty in attending these school activities and adapting to classroom behavior (12). For this reason, it is essential to examine the relationship between sensory processing and school readiness.

The first aim of the current study was to evaluate sensory processing in pretem children at five years of age and compare with their typical peers. The

second aim of the present study was to investigate the association between sensory processing and school readiness.

METHODS

Participants

Ethical approval for this cross-sectional study was obtained from the Gazi University Ethics Committee (Approval Date: 10.10.2017 and Approval Number: E.149186). Written informed consent was obtained from the parents. The study was carried out between January 2017 and July 2017 at Gazi University, Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation. Participants were invited by calling the families of the 100 children (50 preterms and 50 terms) between 60 and 72 months of age who were born at Gazi University Hospital in Ankara, Turkey. The study was completed with 36 preterms and 40 term-born children who met the inclusion criteria (Figure 1). While children with gestational ages less than 37 weeks and without any complications were included in the preterm group, children with a gestational age greater than 37 weeks and without any significant health problems were included in the term group. Children with any neurological diagnosis (such as cerebral palsy), genetic disease (such as Down Syndrome), visual and hearing impairment were excluded from the study. The clinical information of children obtained from their hospital files.

Procedure

Dunn Sensory Profile (SP) which is a caregiver-completed questionnaire designed by Winnie Dunn, was used to assess sensory processing (13). Marmara Primary School Readiness Scale was applied to determine the level of readiness for primary education in the field of development and basic academic skills(14). The scale consists of two forms that are the Practice Form and the Development Form. Physiotherapist applied the Practice Form. The Development Form was applied by the teachers/parents. Permission for the use of both scales was obtained from their developers. Maternal education (<12 years, 12 years, and >12 years) was used as an indicator of socioeconomic status.

Outcome Measures and Variables

Demographics and health information: Sociodemographic and clinical characteristics were obtained from the parents. Age, gender, gestational age, birth weight, presence of consanguineous marriage, multiple gestation status, and type of delivery, and pregnancy were questioned.

Dunn Sensory Profile: It is a reliable and valid caregiver/parent questionnaire that assesses children's, aged 3-10 years, behavioral responses to sensory stimuli occurring in daily life. Turkish version study of the Dunn SP was conducted by Kayihan et al. (13). The SP has 125 items that describe the most common behaviors of children with sensory problems. Items are scored on a Likert scale ranging from 1 (always) to 5 (never). Lower scores on the total score and subscales indicate more sensory symptoms. The Dunn SP provides scores in "sections" and "quadrants." The sections are sensory processing, sensory modulation, and social-emotional responses. In addition, it gives scores for four quadrants: low registration, sensory seeking, sensory sensitivity, and sensory avoiding (15).

Marmara Primary School Readiness Scale: The scale was developed and standardized to measure the school readiness of the preschool children aged 60-78 months. The scale explicitly developed for Turkish children. The scale consists of two forms that are the Practice and the Development Forms. The Practice Form consists of five parts as mathematics, science, sound, drawing, and the labyrinth. The Practice Form includes 74 questions, and a researcher one to one applied each of them. The Development Form consists of four sub-scales that are mind and language development, socioemotional development, physical development, and self-care skills, as well as 175 items, and each item was filled by the teachers/parents (14). The item-total, item remaining, and discriminant analysis of the scale yielded significant results at the level of $p < 0.001$. The scale showed high internal consistency. Cronbach α value of the Practice form and Development Form was found to be 0.930-0.982, respectively. The maximum total score was 459. Higher scores indicate better school readiness (15). The test has cutoff values for both the total

Table 1: Demographic Characteristics of the Participants.

Characteristics	Preterm (n=36)	Term (n=40)	p
Sex (female/male)	14/22	20/20	0.343[c]
Age (months)	66.64±4.72	68.72±4.80	0.063[a]
Gestational Age (weeks)	32.60±4.10	39.62±1.00	**<0.001*[a]**
Birth Weight (g)	1830 (1060-2268)	3450 (3150-3600)	**<0.001*[b]**
Cesarean Delivery, n (%)	29 (80.5)	20 (50)	**0.001*[c]**
Maternal Education Status <12 years 12 years >12 years	13 14 9	4 21 15	**0.024*[c]**

*p<0.05. [a]Student t Test; [b]Mann Whitney U Test; [c]Chi-square Test.

score and the subdomains. School readiness status are classified as follows: children who have 75% or more of the scores "ready for school"; children who have 50% and 75% of the scores "need to be supported"; children who have scores below 50% of the scores "not ready for school" (14).

Statistical Analysis

Statistical analyses were performed using SPSS (IBM SPSS Statistics 22.0, IBM Ehningen, Germany). Frequency (percent) and mean±standard deviations (median [minimum-maximum]) for metric variables were given as descriptive statistics. Shapiro-Wilk test and histograms were used to assess distributions for the normality of data. If the data is normally distributed, parametric analyses were performed. Student t-test and Mann-Whitney U test were used, as appropriate. Chi-square test was performed to analyze categorical variables to compare groups. Factors affecting sensory processing scores were investigated using multiple linear regressions. The variables that were evident from a clinical perspective that they might be associated with the dependent variables or variables that were significant in a univariate test with a p-value of less than 0.1 were included in regression

models. Outliers and multicollinearity assumptions were checked and handled in the multiple linear regression models. Correlation coefficients were calculated using Pearson and Spearman correlation coefficients, as appropriate. A p-value of <0.05 was considered statistically significant. G*Power (Version 3.1, Dusseldorf, Germany) power analysis program was used to determine the sample size. The parameters were set as α=0.05, 1-β=0.95, and the number of cases to be included in the study were found to be 36 for the two groups.

RESULTS

There was no difference in terms of age and gender between the groups (p>0.05). The birth weight and gestational age were significantly lower in the preterm children (p<0.05) (Table 1). Term children had no history of stay in NICU. They did not receive any mechanical ventilation support.

The sensory processing scores of the preterm group were significantly lower than the term group (p<0.05) (Table 2). In the preterm group, all quadrants of the Dunn SP were significantly correlated with the total scores of the Developmental and Practice Forms (p<0.05) (Table 3).

Table 2: Dunn Sensory Profile Scores and Sensory Group Classification.

Dunn Sensory Profile	Preterm (n=36)	Term (n=40)	p	Mean Difference 95% CI	Effect Size
Low Registration	61.00±11.50	69.77±5.79	**<0.001***	0.50–1.45	0.97
Sensation Seeking	99.71±16.58	107.83±12.84	**0.040***	0.09–1.01	0.55
Sensory Sensitivity	80.16±10.15	87.77±8.39	**0.004***	0.35-1.29	0.82
Sensation Avoiding	112.48±16.49	122.97±12.10	**0.007***	0.26-1.19	0.73
Total SP Score	499.03±70.98	530.79±47.93	**0.037***	0.14-0.91	0.53

*p<0.05. Mann Whitney U test. CI: Confidence Intervals. SP: Sensory Profile

Table 3: Relationship between Marmara Primary School Readiness Scores and Dunn Sensory Profile Scores within the Preterm Group.

Dunn Sensory Profile	Marmara Primary School Readiness Scale			
	Development Form Total Scores		Practice Form Total Scores	
	r	p	r	p
Low Registration	0.569	**0.001***	0.507	**0.004***
Sensation Seeking	0.435	**0.015***	0.364	**0.044***
Sensory Sensitivity	0.567	**0.001***	0.540	**0.002***
Sensation Avoiding	0.359	**0.047***	0.434	**0.015***
Total SP Score	0.589	**0.001***	0.604	**0.001***

*p<0.05. Spearman Correlation Coefficients.

Linear regression analysis was performed in the full sample to investigate the factors that predict sensory processing symptoms. The outcome variable for the model was Marmara Primary School Readiness Development Form and Practice Form scores, and the predictor variables included gestational age, maternal education, gender and total SP score. The model was significant at p<0.001 and explained 32.2% of the variance for the Development Form score. The model was significant at p<0.001, and explained 41.3% of the variance for the Practice Form score. The total SP score was the only significant predictor of school readiness (p<0.05) (Table 4).

DISCUSSION

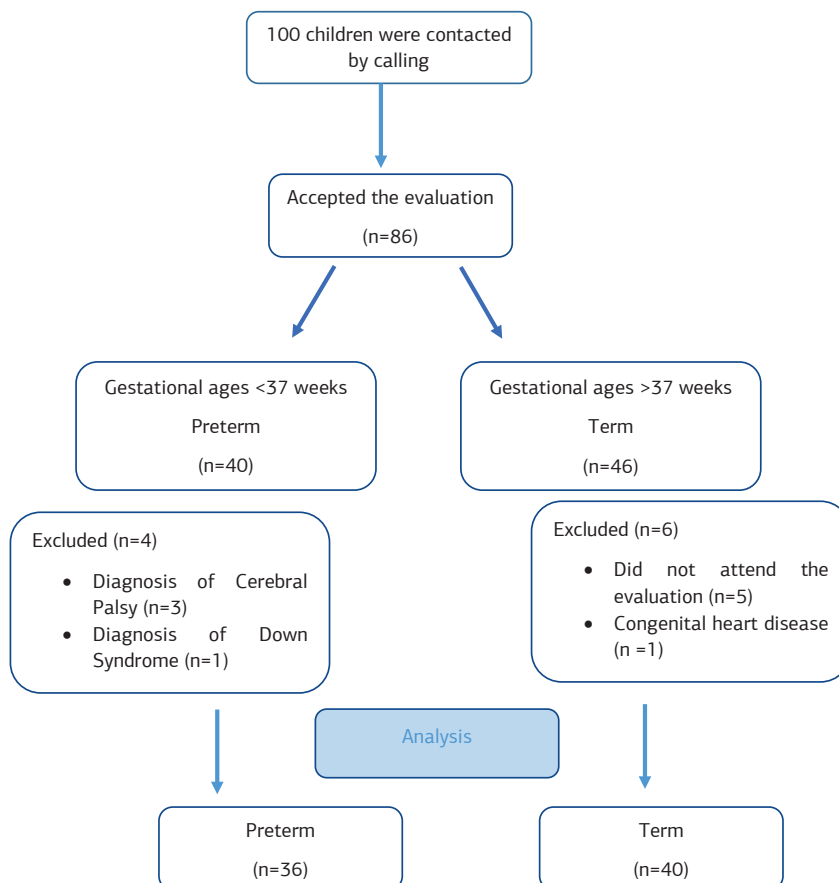The preterm children were found to be behind their term typical peers concerning sensory processing

Figure 1: Flow Chart of Participants.

Table 4: Linear Regression Model within the Full Sample Predicting to School Readiness.

Outcome	Adjusted R²	β	F	p
Development Form				
Total SP Score	0.322	0.38	7.655	**0.002***
R²=0.320, p<0.001, constant=62.068				
Practice Form				
Total SP Score	0.413	0.52	6.955	**<0.001***
R²=0.410, p<0.001, constant=-25.820				

*p<0.05. B: unstandardized coefficient, SE B: standard error of B, β: standardized coefficient. SP: Sensory Profile.

at five years of age. There was a positive correlation between SPD and school readiness in preterm children. Sensory processing might affect school readiness in the preterm preschoolers.

Sensory symptoms are associated with preterm birth. Studies conducted to date are primarily focused on preterm infants and toddlers (16,17). Eeles et al. stated that preterm children have lower scores on the Lower Registration, Sensation Seeking, Sensory Sensitivity, and Sensation Avoiding quadrants compared to their term peers (16). Adams et al. found that the percentage of preterm preschoolers classified as having elevated numbers of sensory symptoms as 37% (18). In another study with 107 preterm children, 39% of the children had atypical scores in at least one quadrant or section, and the auditory, tactile, and vestibular processing sections are most affected in preterm children (17). In addition, many studies have shown that SPD associated with preterm labor persist at later ages (5,18) These results support our findings that term children had better sensory processing skills than preterm children at five years of age. Therefore, sensory processing skills should not be ignored during the follow-up of preterm children. Specific tests, clinical observations, and questionnaires could be used for early diagnosis of the SPD. In addition, informing parents/caregivers and teachers about SPD might facilitate early diagnosis and intervention.

The SPD negatively affects children's social, emotional, and academic function (19,20). These children have difficulties in learning new information and performing tasks that would lead to problems in classroom activities (20). Physical and social stimulations in school settings seriously disturb children with SPD (21). Ayres stated that children with insufficient sensory processing skills could not acquire the skills necessary to succeed in school (22). Miller et al. have found that children experiencing sensory difficulties the early education period have more considerable challenges in achieving subsequent school achievement (2). A study showed that children with SPD had five dominant maladaptive behaviors, including extreme talkativeness, overly fidgety, lack of focus, inability to stay on task, and inability to remain seated/standing (23). Adams et al. found that sensory symptoms were associated with executive function impairment in preterm preschoolers (18). Therefore, it might be beneficial to screen preterm children before school age in terms of sensory processing (2). Thus, opportunities for effective intervention programs for educational settings may treet to be established.

School readiness is a multidimensional and dynamic process, and includes health and physical development, emotional well-being, social competence, approaches to learning, communication skills, and cognitive skills (24). It is essential to assess children both academic skills and developmental domains. In this study, it was an advantage of using the Marmara Primary School Readiness Scale, which measures multiple domains of school readiness, a scale developed for the Turkish population.

The limitation of our study is that preterm children are not classified as extremely, very, moderate, or late preterm according to their gestational age. The other limitation is sensory processing is only evaluated by a questionnaire filled by the parent/caregiver and has not been assessed using direct observational scale or electrodermal testing. Another limitation is that the maternal education status was different between the groups. In future studies, it is recommended to use objective and observational assessment methods so that more detailed information about specific

sensory conditions could be provided using direct observation.

In conclusion, the current study showed that SPD in preterm children was more common than term children. Sensory processing might affect school readiness in preterm children. The preschool period is the most complex and vital period of a child's development. If a child is ready for school, it is more likely to be successful. School readiness affects performance throughout academic life and academic success at work in adulthood. Therefore, early learning experiences, in turn, affect academic achievement. It is necessary to evaluate SPD that interferes with learning that could affect academic success and development of preterm children during the preschool period.

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