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Preterm birth risk factors and their impact on sensory and motor development in preschoolers

Okul öncesi çocuklarda erken doğum risk faktörleri ve bunların duyusal ve motor gelişim üzerine etkisi

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ABSTRACT

Introduction: This study examines how risk factors linked to preterm birth affect sensory and motor development in preschool children.
Method: The study included 48 preterm children: 24 with a history of only preterm birth (PB) and 24 with additional risk factors (RPB). (intraventricular hemorrhage, periventricular leukomalacia, respiratory distress syndrome, bronchopulmonary dysplasia, premature retinopathy, and necrotizing enterocolitis). Additional risk factors included respiratory distress syndrome, intraventricular hemorrhage, periventricular leukomalacia, necrotizing enterocolitis, retinopathy of prematurity, and bronchopulmonary dysplasia, which are common in preterm infants. The Peabody Motor Development Scale-2 was used to assess motor development, and the Sensory Profile Questionnaire was used to assess sensory processing and development.
Results: There was a significant difference between the Peabody Motor Development Scale-2 gross motor, fine motor, and total motor development scores in favor of the PB group ($p<0.05$). According to the Sensory Profile results, it was observed that the RPB group had lower sensory processing scores than that of the PB group ($p<0.05$).
Conclusion: It was concluded that risk factors, as well as preterm birth, may have a negative impact on motor development and sensory processing skills. Considering that development in the preschool period can affect physical, social and academic achievements at school age, it may be useful to evaluate children with risk factors in addition to a history of preterm birth in terms of sensory processing skills and motor development.

Keywords: Motor development; preschool age; preterm birth; sensory integration skills

ÖZET

Giriş: Bu çalışmada, erken doğumla ilişkili risk faktörlerinin okul öncesi çocuklarda duyusal ve motor gelişimi nasıl etkilediği incelenmektedir.
Yöntem: Çalışmaya 48 preterm çocuk dahil edildi: 24'ünde sadece preterm doğum öyküsü (PB) vardı ve 24'ünde ek risk faktörleri (İntraventriküler kanama, periventriküler lökomalazi, respiratuar distres sendromu bronkopulmoner displazi, prematüre retinopatisi, nekrotizan enterokolit) (RPB) vardı. Prematüre bebeklerde sık görülen respiratuar distress sendromu, intraventriküler kanama, periventriküler lökomalazi, nekrotizan enterokolit, prematüre retinopatisi ve bronkopulmoner displazi gibi risk faktörleri ek risk faktörleri olarak kaydedildi. Motor gelişimini değerlendirmek için Peabody Motor Gelişim Ölçeği-2, duyusal işlemleme becerilerini değerlendirmek için Duyu Profili Anketi kullanıldı.
Bulgular: Peabody Motor Gelişim Ölçeği-2 kaba motor, ince motor ve toplam motor gelişim puanları arasında sadece preterm doğum grubu lehine anlamlı fark vardı ($p<0,05$). Duyu Profili Anketi sonuçlarına göre ise ek risk faktörlerine sahip preterm doğum öyküsü olan grubun, sadece preterm doğum grubuna göre daha düşük duyusal işlemleme puanlarına sahip olduğu görüldü ($p<0,05$).
Sonuç: Preterm doğumun yanı sıra risk faktörlerinin de motor gelişim ve duyusal işlemleme becerilerine olumsuz etki edebileceği sonucuna varıldı. Okul öncesi dönemdeki gelişimin okul çağındaki fiziksel, sosyal ve akademik başarıları etkileyebileceği göz önüne alındığında, duyusal işlemleme becerileri ve motor gelişim açısından preterm doğum öyküsüne ek risk faktörleri olan çocuklara değerlendirmelerin yapılması faydalı olabilir.

Anahtar Kelimeler: Motor gelişimi; okul öncesi dönem; preterm doğum; duyusal işlemleme beceriler

Introduction

Today, most babies born preterm survive thanks to improved treatment options. However, while improvements in neonatal intensive care units (NICUs) have reduced mortality in preterm and very low birth weight infants, the increase in pulmonary, neurological and developmental morbidity has greatly increased

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the material and moral burden on families, society and health services (Cheong, Burnett & Treyvaud, 2020). In addition, respiratory distress syndrome (RDS), retinopathy of prematurity (ROP), and necrotizing enterocolitis (NEC) are seen in preterm infants in the short term, and neurodevelopmental disorders such as mild neurological dysfunction, motor incoordination, and cerebral palsy (CP) are at high risk in the long term (Paul, Nahar, Bhagawati & Kunwar, 2022; Pisani, Prezioso & Spagnoli, 2020; Broström, Vollmer, Bolk, Eklöf & Ådén, 2018). The motor, sensory, cognitive, and speech/language development of preterm infants is influenced by many environmental factors. From the earliest stages of life, sensory information plays an important role in all areas of development, and infants use sensory information to develop movement and postural control from the first month of life. However, the NICU is an environment with excessive and prolonged exposure to auditory, visual, and tactile stimulation during the critical period of brain development, which may lead to difficulties in sensory modulation (Soleimani et al., 2020). Babies born prematurely have more neurodevelopmental problems than their full-term peers. In addition, these babies have a higher incidence of learning disabilities, motor development, and sensory processing problems (Ferrari et al., 2012). A study examining white matter development in preterm infants up to 13 years of age found axonal reductions in many fiber tracts and slower axonal growth over time, particularly in the corpus callosum and corticospinal tract, in very preterm infants compared to their term peers. Earlier gestational age at birth, lower birth weight, and neonatal brain abnormalities have been identified as important perinatal factors associated with later axonal changes in the preterm population (Kelly et al., 2020). Studies have also found that preterm children have lower cognitive levels than their peers, and this delay can persist until 5-6 years of age (Oliveira, Magalhaes & Salmela, 2011; Montagna et al., 2020). A study conducted by Jeanie Cheong et al. examining 2-year outcomes in children born at moderate and late preterm, reported that they had poorer cognitive, language, and motor development at age 2 compared to their term peers (Cheong et al., 2017). It is likely that these differences from term peers, even at mid- and late-term preterm, are magnified by small gestational age and the presence of additional risk factors. These ages include the preschool period, which is an important time in life. In the preschool years, preterm infants in particular may experience problems with muscle tone, fine motor skills, and coordination (De Jong et al., 2012). These problems, which are common in the preschool years, are strongly associated with learning and behavioral problems. Therefore, assessing sensory processing and motor performance in the preschool period is important for their future development and school success (Alkan & Mutlu, 2019).

This study was conducted to examine the effects of additional risk factors associated with preterm birth on sensory and motor development. Because the preschool years are a critical period of development, laying the foundation for an active lifestyle and academic success, children in this age group were included in the study. Thus, this study also examined the continuity of the negative effects of preterm birth and additional risk factors on motor and sensory development at later ages.

Method

Study Design

This is an observational case-control study. The study was conducted at Gazi University, Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation, Pediatric Rehabilitation Unit between October 2020 and August 2021.

Participants

While the normal period for gestational age is between 37 and 40 weeks, deliveries before 37 weeks are called preterm births. While corrected age is used up to 2 years of age in preterm birth, chronological age is used after 2 years of age. Children aged 2-5 years with a history of preterm birth were included in the study.

That the age range of 2-5 years was included in the study has critical importance because it is a period in which motor performances such as running and jumping are developed, and an active lifestyle is formed in this age group.

In the analysis performed using the reference study (Cabral, da Silva, Tudella & Martinez, 2015) using the G*Power 7 program (version 3.1.9.2 Universität Düsseldorf, Düsseldorf, Germany), the number of participants needed to be included to provide 80% power with 95% confidence was determined as 48 children in total, 24 children per group. Before the study, a total of 73 children's families were interviewed. Twenty-three children who did not meet the inclusion criteria, could not come to the appointment due to the pandemic, or whose family did not want to participate in the study were excluded. Two children who could not comply with the assessment stages were also excluded. The inclusion criteria were: (1) children with a history of preterm birth; (2) without a neurological diagnosis; (3) children with sufficient mental level are included in the study (4) willingness of participant and family to participate in this study. Exclusion criteria were: (1) children with diagnosed neurological, neuromuscular, or genetic diseases; (2) whose parents did not volunteer to participate in the study; (3) children with vision and hearing problems were excluded from the study.

Twenty-four children with a history of only preterm birth (PB) and twenty-four children with risk factors in addition to preterm birth (RPB) were recruited in the study. Risk factors were intraventricular hemorrhage, periventricular leukomalacia, respiratory distress syndrome, bronchopulmonary dysplasia, retinopathy of prematurity, and necrotizing enterocolitis, which are common in preterm infants (Locke & Kanekar, 2022; Cannavò, 2021).

Measurements

The demographic characteristics and birth information of the children enrolled in the study were obtained by interviewing the family and reviewing discharge summaries.

All assessments were conducted in a clinical setting, face-to-face and with family participation, by two physical therapists experienced in pediatric rehabilitation. The evaluation of each child was completed in approximately 40 minutes.

Peabody Motor Development Scale-2

The Peabody Motor Development Scale (PMDS) (Folio & Fewell, 1984) was revised by Folio and Fewell in 2000 and PMDS-2 was defined (Folio & Fewell, 2000). It is the preferred tool for assessing young children's motor development from birth to 72 months, with separate tests and rating scales for gross and fine motor skills. Gross and fine motor development assessments can be performed on the same day or at different times. Corrected age should be used up to 2 years of age in preterm children. Gross motor skills consist of 151 items in four subtests. These subtests are reflex, stationary, locomotion, and object manipulation. Fine motor skills consist of 98 items. Its subtests consist of grasping and visual-motor integration (Yang et al., 2019). Each item is scored as 0, 1, or 2. Two means that the child completed the task completely, 1 means that the child completed the task partially, and 0 means that the child could not complete/start the task. The scoring system allows to determine the level of development, compare the child with peers, and show the level of motor skills (Gill et al., 2019). The completion time of the test is 30to 45 minutes.

Sensory Profile

The Dunn Sensory Profile (SP), a questionnaire designed by Winnie Dunn and completed by parents, was used to assess sensory processing. It is a reliable and valid caregiver/parent questionnaire that evaluates sensory processing skills in daily life of children aged 3-10. The questionnaire consists of 125 items, and the parent evaluates the event defined in each item according to the child's situation. For each of the 125 items, the parent is asked to respond on a five-point Likert scale of 1 = always, 2 = often, 3 = sometimes, 4 = rarely, and 5 = never. Higher scores perform better (Dunn, 1999; Dunn, 2006). The Turkish version of Dunn SP was studied by Kayihan et al. (Kayihan et al., 2015).

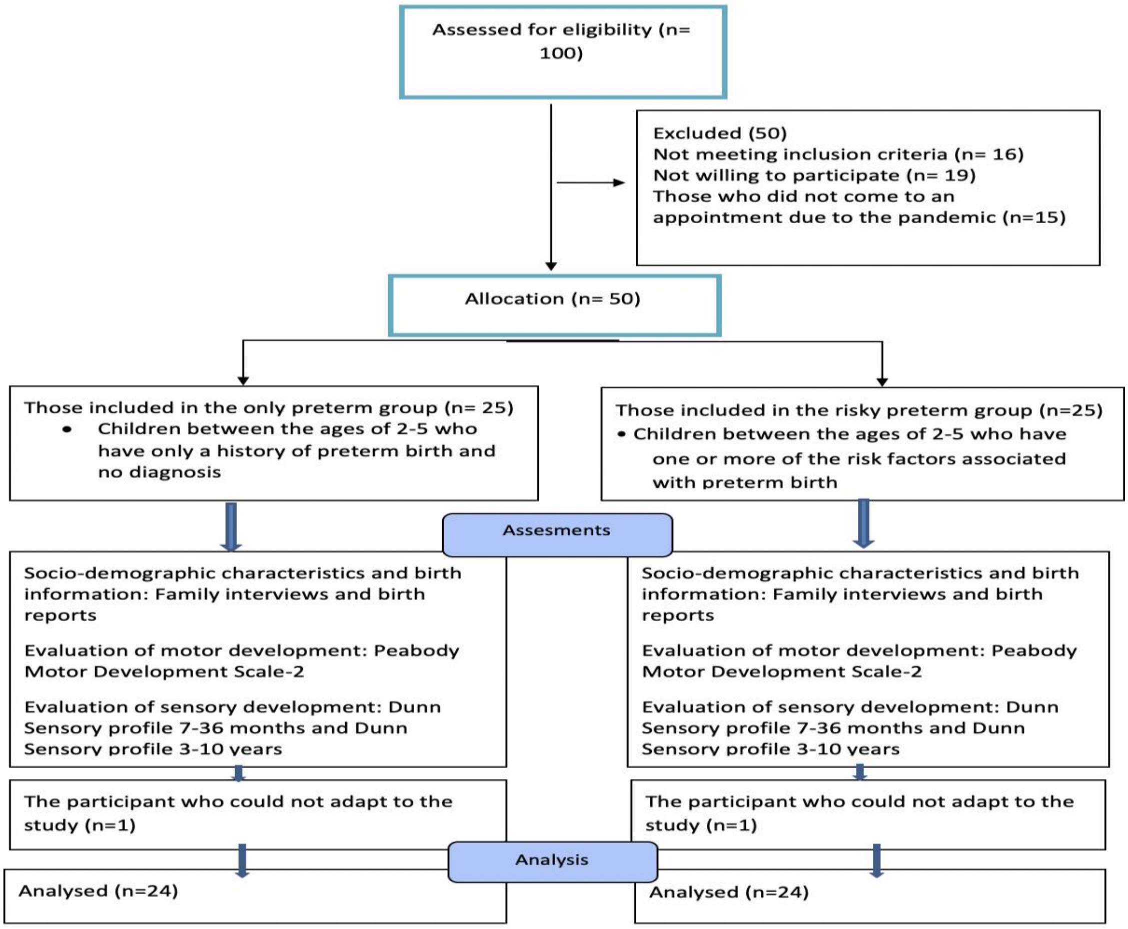

Figure 1. Flow chart

Dunn's Infant Toddler Sensory Profile

The Dunn's Infant/Toddler Sensory Profile (Dunn, 2002) is a questionnaire that is completed by an infant's or toddler's primary caregiver in order to gather information about the child's sensory processing abilities. It is a parent- or caregiver-report questionnaire that assesses children's responses to sensory inputs up to age 3. Some forms evaluate two different age groups: 0-6 months and 7-36 months. In this study, the form for 7-36 months was used. It has items in six different sections: general, visual, auditory, vestibular, tactile, and oral. Parents evaluate their child's response to sensory stimuli on a 5-point Likert scale. Higher scores perform better (Dunn, 2014).

Since the age range of the children participating in the study was between 2 and 5 years, the sensory profile scales suitable for 7-36 months and 3-10 age groups were used. The data of the scales used were analyzed by creating separate databases.

Statistical Analysis

"Statistical Package for Social Science for Windows version 22.0-SPSS 22.0" statistical program was used to record and analyze the data. The Shapiro Wilk test was used to determine the conformity of the numerical variables to the normal distribution. Percentage values and frequencies of categorical variables and standard deviations and means of numerical variables were used in statistical analysis. For numerical variables, the independent samples t-test was used to compare sociodemographic characteristics, Peabody Motor

Development Scale-2 scores, and Sensory profile 3-10 age scores between groups, while the Mann-Whitney U test was used to compare Sensory profile 7-36 months data. The chi-square test was used to compare two independent groups in terms of categorical variables. As statistical significance level, p<0.05 was accepted.

Ethical Statement

Approval was granted by the Ethics Committee of Gazi University (Ethics Approval Date: 23.11.2020; E-77082166-604.01.02-27508). A signed parent-informed consent form was obtained from the families of all infants participating in the study. A Helsinki Declaration was followed during the conduct of the study. Trial registration number has been assigned to this study by ClinicalTrials.gov (NCT05087511).

Results

The comparison of the two groups, children with a history of only preterm birth and preterm children with additional risk factors participating in the study, in terms of socio-demographic characteristics and birth information is shown in Table 1.

Table 1. Sociodemographic characteristics and birth information

	PB n=24		**RPB n= 24**		**p***
	Mean	**Standard deviation (SD)**	**Mean**	**Standard deviation (SD)**	
Chronological age (months)	41.1	11.6	40.08	13.44	0.766[a]
Gestational age (weeks)	33.75	1.96	30.00	2.24	**0.000[a]**
Birth weight (gr)	2226.25	532.20	1594.16	563.14	**0.000[a]**
Length of stay in the incubator (days)	11.25	713.88	48.54	28.06	**0.000[a]**
Maternal age (years)	30.58	3.77	31.00	4.62	0.734[a]
Gender (M/F)	15/9		12/12		0.383[b]
Mode of delivery (vaginal/caesarean section)	2/22		5/19		0.220[b]
Pregnancy Type (unassisted conception/IVF)	20/4		15/9		0.104[b]
Consanguineous Marriage (yes/no)	0/24		0/24		1.000[b]
Smoking (yes/no)	1/23		0/24		0.312[b]
Alcohol use (yes/no)	1/23		0/24		0.312[b]

Additional risk factors	**RPG (n= 24) n / % n**
Convulsion	4 /16.7
HIE	0
ICH	8/33.3
PVL	5/20.8
RDS	17/70.8
Surfactant Treatment	17/70.8
BPD	10/41.7
ROP	5/20.8
PDA	4/16.7
Stroke	1/ 4.2

a: Independent groups t-test, b: Chi-square test, *p<0.05 IVF: in vitro fertilization N: sample size M: male F: Female CI: Confidence interval PB: children with a history of only preterm birth, RPB: children with risk factors in addition to preterm birth RDS: Respiratory Distress Syndrome, BPD: Bronchopulmonary Dysplasia, ROP: Retinopathy of Prematurity, HİE: Hypoxic-ischemic encephalopathy, PDA: Patent ductus arteriosus, PVL: periventricular Leukomalacia ICH: İntracerebral hemorrhage

A statistically significant difference was found between the gross motor, fine motor, and total motor development scores in favor of the PB group (p<0.05). In the comparison of subcategory scores, there was no difference in locomotion, comprehension, and visual-motor integration scores, and a statistically significant difference was found in favor of the PB group in fixed movements and object manipulation scores (p<0.05).

In addition, the scores were reclassified according to the norm values as above average and below average. Group comparison results are shown in Table 2**.**

Table 2. Peabody motor development scale-2 comparison results

	PB (n=24) (mean)	**RPB (n=24) (mean)**	p [a]
GROSS MOTOR	100.10	83.08	**0.000**
Stationary	48.04	43.29	**0.017**
Locomotion	139.12	125.08	0.091
Object manipulation	30.62	24.25	**0.027**
FINE MOTOR	96.12	86.16	**0.001**
Grasping	46.08	44.75	0.213
Visual-motor	114.20	105.29	0.095
TOTAL	97.04	83.12	**0.000**
	PB (N=24) N (above average)-N (below average)	**RPB (N=24) N (above average)-N (below average)**	p [b]
GROSS MOTOR	23-1	9-15	**0.000**
Stationary	23-1	13-11	**0.001**
Locomotion	24-0	8-16	**0.000**
Object manipulation	24-0	7-17	**0.000**
FINE MOTOR	20-4	9-15	**0.001**
Grasping	23-1	15-9	**0.004**
Visual-motor	23-1	7-17	**0.000**
TOTAL	22-2	8-16	**0.000**

a: Independent groups t-test, b: chi-square test, $p<0.05$ CI: Confidence interval PB: children with a history of only preterm birth, RPB: children with risk factors in addition to preterm birth, N: sample size

As a result of the comparison performed between the groups of children aged between 2and 3 years, the scores obtained in all areas were found to be statistically higher in the PB group than in the RPB group ($p<0.05$). In addition, PB group scores were statistically higher in quadrant scores than those of the RPB group ($p<0.05$). Group comparison results are shown in Table 3.

Table 3. Comparison results of children aged between 2 and 3 years in terms of sensory profile and quadrant scores

	PB Group n= 7 Mean -SD	**RPB Group n= 10** Mean-SD	**p***
General processing	13.28-1.25	10.20-1.54	**0.001**
Auditory processing	39.57-4.57	30.40-5.16	**0.002**
Visual processing	29.85-3.28	22.20-3.55	**0.000**
Touch processing	64.85-8.59	47.60-6.31	**0.000**
Vestibular processing	25.57-2.82	18.20-3.73	**0.000**
Oral sensory processing	29.85-3.07	23.60-1.77	**0.001**
Poor Registration	47.71-3.30	37.20-3.29	**0.000**
Sensation Seeking	57.85-10.39	39.80-8.05	**0.003**
Sensory Sensitivity	48.71-4.23	36.10-3.57	**0.000**
Sensory Avoiding	53.57-2.43	39.20-5.05	**0.000**

* Mann-Whitney U test, $p<0.05$ PB: children with a history of only preterm birth, RPB: children with risk factors in addition to preterm birth, CI: Confidence interval

As a result of the comparison made in children aged between 3 and 5 years, the sensory scores obtained in 8 of 14 different areas were found to be statistically higher in the PB group than in the RPB group (p<0.05). In addition, there was a statistically significant difference in favor of the PB group in poor registration, sensory sensitivity, and sensory avoidance quadrant scores, and no statistical difference was found in the sensory seeking quadrant score (p<0.05). Group comparison results are shown in Table 4.

Table 4. Comparison of the results of 3-5 years of age Sensory Profile and quadrant scores

	PB Group n=17	**RPB Group n= 14**	**p***
	Mean (SD)	Mean (SD)	
Auditory processing	35.24(4.84)	28.71(6.33)	**0.003**
Visual processing	36.70(4.39)	31.64(7.92)	**0.032**
Vestibular processing	46.88(5.45)	38.00(9.80)	**0.003**
Touch processing	77.58(10.08)	62.85(15.19)	**0.003**
Multi-sensory processing	28.76(3.26)	24.78(6.48)	**0.035**
Oral sensory processing	42.82(7.91)	41.85(8.87)	0.751
Sensory processing related to endurance and tone	42.64(4.78)	31.42(8.34)	**0.000**
Modulation related to movement and body position	38.17(7.12)	35.00(7.96)	0.251
Modulation of movement affecting activity level	26.35(4.84)	26.00(6.06)	0.858
Modulation of sensory input affecting emotional responses	16.64(2.47)	13.78(4.33)	**0.028**
Modulation of visual input affecting emotional responses and activity level	16.29(3.58)	14.57(4.18)	0.227
Emotional-social responses	70.82(8.84)	62.21(13.82)	0.057
Behavioral outcomes of sensory processing	6.41(8.98)	10.50(7.55)	0.187
Items indicating thresholds for response	13.64(1.45)	9.14(4.14)	**0.001**
Poor Registration	64.35(16.02)	52.35(12.25)	**0.029**
Sensation Seeking	98.11(13.93)	88.28(18.24)	0.100
Sensory Sensitivity	84.58(8.08)	73.57(12.27)	**0.006**
Sensory Avoiding	124.05(13.17)	109.92(18.67)	**0.020**

*Independent groups t-test, p<0.05 CI: Confidence interval PB: children with a history of only preterm birth, RPB: children with risk factors in addition to preterm birth

Discussion

This study examined the effects of risk factors associated with a history of preterm birth on motor and sensory development in children aged 2 to 5 years. The motor and sensory development scores of children with additional risk factors associated with a history of preterm birth were found to be significantly lower than those of children with only a history of preterm birth.

Preterm infants are physiologically unstable and require support in the NICU to maintain their vital functions. Interventions such as oxygen therapy, weight monitoring, and drug treatment are considered important for the recovery of infants' vital functions. Since small gestational age, low birth weight and additional risk factors affect the development of the baby, it is associated with the length of stay in the incubator (Kerstjens et al., 2012). These reasons can be cited as the reason for the longer stay in the incubator in the risk group. The length of time spent in the incubator, which has a significant impact on infant development, can be seen as a reason for the lower test scores in the RPB group than in the PG group. The NICU is an environment of prolonged and excessive exposure to auditory, visual, and tactile stimulation during the critical period of brain development, which may lead to difficulties in sensory modulation (Bröring et al., 2017). Loud sounds and bright lights have short-term adverse effects on weight gain and cardiorespiratory parameters, and these factors have been reported to affect developmental outcomes (Van Wassenaer-Leemhuis et al., 2016). In this study, the preterm RPB group scored significantly lower than the

PB group in three quadrants of the Dunn's Sensory Profile (poor registration, sensory sensitivity, sensory avoidance). In addition, scores were statistically higher in areas of the Dunn's Sensory Profile including sensory processing, sensory modulation, and behavioral and emotional responses in the PB group. Differences in sensory development may be the result of situations such as negative environmental factors, medical interventions, and separation from parents to which the at-risk group was exposed after birth. We believe it is important to pay more attention to children at risk in the early and preschool years. In addition, it is important to consult with relevant professionals about problems that arise at home, at school, and in different environments. Communication between the family, doctors, teachers and physiotherapists can help to identify developmental delays.In addition, although there was no difference between the groups, it was thought that expectant mothers should be informed about the risks that may occur in terms of maternal risk factors such as smoking history, alcohol consumption and maternal age.

Preterm infants have a higher incidence of conditions such as sensory processing problems, learning disabilities, and respiratory illnesses compared with term infants (Ferrari et al. 2012). In between-group comparisons, there were statistically significant differences in gestational age, birth weight, and latency, but no differences in age at assessment, maternal age at birth, sex, consanguineous marriage, mode of delivery, or mode of pregnancy. The lower gestational age and birth weight of the RPB group may have resulted in additional complications, which was an expected finding (Schonhaut, Armijo & Perez, 2015). In addition, there are studies that examine the negative consequences of preterm birth, which may vary and differ with the effect of gestational age and birth weight (Ask, Winter, Bocca-Tjeertes, Bos & Reijneveld, 2018).

Improved motor skills are considered important for the physical, social and psychological development of children. It can also be the basis for an active lifestyle, as there is a positive correlation between fine motor skills and high levels of physical activity. Early childhood is a critical and rapid period of full and healthy motor and cognitive development in human life, and increased physical activity can secure the motor and cognitive benefits throughout childhood and adolescence (Fisher et al., 2011). Therefore, the toddler and preschool years are an important period for the development of motor skills.

Early childhood has also been described as the age of acquisition of motor skills that provide the foundation for complex motor activities, such as daily living, recreation, and sports, later in life (Hestbaek et al., 2017). A study examining the relationship between gestational age and attention-deficit/hyperactivity symptoms in preschool children found that preterm birth was associated with high levels of attention-deficit/hyperactivity symptoms. The developmental risk of these children is high not only because they are more susceptible to illness, but also because they are exposed to the stress of separation from their mothers, mechanical ventilation, and prolonged interventions (Ask et al., 2018). Similarly, the fact that the preterm group with risk factors was exposed to more stress due to a longer stay in the incubator may have influenced the developmental parameters assessed in the current study. Studies evaluating motor development and sensory processing in preterm and term infants have reported that preterm infants are at greater risk in terms of sensory processing and motor development (Celik, Elbasan, Gucuyener, Kayıhan, Huri, 2018). Since it is known that preterm infants are at developmental risk, it is believed that including children with a history of preterm birth with additional risk factors instead of their term peers in the current study will add new information to the literature. In addition, early studies of preterm infants are presented in the literature (Rogers & Hintz, 2016; Garfinkle et al., 2020). In this study, preschool age, which is a critical period of life, was taken into account.

Patra et al. found that infants with a history of intraventricular hemorrhage (IVH) were at greater risk for mental development and neuromotor abnormalities at corrected 20 months of age (Patra, Wilson-Costello, Taylor, Mercuri-Minich & Hack, 2006). In the current study, it was observed that the gestational age and birth weight of infants with a history of IVH in the RPB group were significantly lower than those in the PB group, and the length of stay in the incubator after delivery was numerically higher. Retardation in motor and sensory development was noted compared with the PB group, and it was thought that more care should be taken in their follow-up.

Impaired lung function has been described in the literature in individuals with a history of bronchopulmonary dysplasia (BPD) and has been associated with more respiratory symptoms and abnormal chest imaging findings. However, impaired lung function during childhood and adolescence has been described in individuals with a history of BPD in addition to preterm birth (Doyle et al., 2006). Lung function is of great importance in activities that require exertion, such as running, jumping, throwing, and climbing stair (Pazini, Pietta-Dias & Roncada, 2020). Since these activities are in the domain of the gross motor development assessment of the Peabody Motor Development Scale, it was thought that these scores of the children with BPD included in the at-risk group were one of the factors that caused the group average to be low. In addition, factors that cause negative sensory stimuli, such as the intubation of infants, have been found to cause stress in infants (Bröring et al., 2017). Brain development in preterm infants has been reported to be adversely affected by sensory overstimulation during NICU care procedures, such as medical device sounds, opening vascular access, and intubation (Lasky & Williams 2009; Van Wassenaer-Leemhuis et al., 2016). Most of the children in our study with a history of BPD received oxygen supplementation by intubation. Therefore, negative developmental symptoms in the Dunn's Sensory Profile scores of the preterm at-risk group may be due to the exposure to excessive and negative emotional expressions in the early stages of life. It was thought that minimizing these environmental factors that are present in the early stages of life may be beneficial in the developmental stages at later ages. In addition, promoting physical activity and an active lifestyle in children during the school period may be beneficial for their development.

Moderate to severe white matter abnormalities detected in magnetic resonance imaging studies have been reported to cause several adverse neurodevelopmental outcomes, including cognitive delay and CP at the age of 2 years (Novak, Ozen & Burd, 2018). In addition, increased severity of cerebral white matter abnormality was associated with lower intelligence quotient scores and poor motor performance outcomes at the age of 7 years (Anderson et al. 2017). With age, the effect of genetic factors on the white matter microstructure decreases, and the effect of environmental factors increases. Environmental factors influence the development of white matter microstructure throughout life. In general, positive environmental exposures, such as breastfeeding and nutritional support, may result in faster and larger white matter development, whereas negative environmental exposures, such as prenatal exposures or early deprivation, may result in slower or impaired white matter development. In the current study, it was hypothesized that the exposure of children with a history of periventricular leukomalacia (PVL) to adverse environmental factors in the intensive care unit affected their white matter development. The length of stay in the intensive care unit, which is one of the environmental factors affecting the development of white matter, was longer in the RPB group and the developmental outcomes were lower in this group than in the PD group. At the same time, differences in outcomes may be likely due to the differences in the support offered in family/home environments for the children's development (Lebel & Deoni, 2018). Considering the impact of environmental factors on development, it is important to reduce adverse conditions. In addition, there may be differences in hospital care procedures, hospital budget amounts, and interventions due to the differences in information among employees.

An individual's social participation depends on his or her socio-emotional status, language skills, physical abilities, and environmental factors. The preschool years, when the foundation of activity and participation skills are formed, are a critical period for supporting children's development and intervening in problems that may arise in the future (Lubans, Cliff, Barnett & Okely, 2010; Goodway, Ozmun & Gallahue, 2019). By including children with a history of preterm birth in this critical period in our study, it has been shown that risk factors that affect motor and sensory development can adversely affect development. It is thought that it is important to follow preterm infants in their early and long-term development. It will be important to pay more attention to the development of preterm babies who have additional risk factors in order to prevent future problems. In addition, the negative effects of environmental conditions in the NICU on the development of the children were observed in this study. It was thought that reducing adverse environmental conditions, creating appropriate environments, and providing family education would be beneficial in supporting children's development

Strengths and Limitations

In this study, motor and sensory development of children with additional risk factors for preterm birth were investigated. While the comparison of term and preterm born infants is generally made in the literature, only preterm and risky preterm groups were compared in this study, which is considered a strong aspect of the study. In addition, it was emphasized in this study conducted in the pre-school period that the effects of preterm birth on development can also be seen in the following years. We tried to include children diagnosed with different risk factors and seen as frequently as possible in this study, but due to the COVID-19 pandemic, most eligible children could not attend the evaluation session. Since risk factors associated with preterm birth are closely related to gestational age and birth weight, it is difficult to examine the mere effect of these factors. This situation can be shown as a limitation of our study.

Conclusion

It was determined that preterm children at risk had lower motor performance and sensory processing skills compared to preterm children with no additional risk. It is recommended to evaluate preterm children at risk in terms of motor and sensory performance since it is thought that developmental problems detected in preschool children may affect school success. Furthermore, joint strategy planning by the Ministry of National Education and the Ministry of Health about the development of children may be important in terms of psychosocial development.

Credit authorship contribution statement

Rabia Zorlular: Conceptualization, Methodology, Data curation, Investigation, Visualization, Writing – original draft, Writing – review & editing. **Pelin Atalan Efkere** Conceptualization, Methodology, Investigation, Formal analysis, Writing – _review & editing. **Kıvılcım Gucuyener:** Conceptualization, Resources, Supervision, Writing – _review & editing. **Bulent Elbasan:** Conceptualization, Methodology, Supervision, Resources, Writing – review & editing.

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