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Research Article

Do moderate-to-late preterm twins and singletons differ in the early motor repertoire and later developmental functioning?

Orta-geç Preterm İkiz ve Tekil Bebeklerin Erken Motor Repertuar ve İleri Yaş Gelişimsel Fonksiyonellik Sonuçları Farklılık Gösterir Mi?

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ABSTRACT

Purpose: The aim of this study was to investigate the differences in early motor repertoire and later developmental functioning between moderate-to-late preterm twins and singletons. **Material and Methods:** The study included 40 moderate-to-late preterm twin infants (50% female), and 40 moderate-to-late preterm singleton infants (50% female). All infants were assessed from 9 up to 20 post-term weeks of corrected age using the General Movement Assessment (GMA), and between 24 and 42 months of age using the Bayley Scales of Infant and Toddler Development, Third Edition (Bayley-III). **Results:** There were no differences between the Motor Optimality Score (MOS) and all its subcategories, including fidgety movements, obtained as a result of detailed GMA ($p>0.05$), when the early motor repertoire results were examined. At later ages, there were also no significant differences in cognitive, language, and motor domain composite scores between twin and singleton infants, according to Bayley-III ($p>0.05$). **Conclusion:** Our results suggest moderate-to-late preterm twin infants had a similar developmental process to moderate-to-late preterm singleton infants from early periods up to 3.5 years of age. However, all preterm infants, including moderate-to-late infants, should be assessed in the clinic in terms of the risks of developmental problems from the early period of life.

Keywords: Infant Development; Movements; Multiple Birth; Preterm birth; Twins.

ÖZ

Amaç: Bu çalışmanın amacı, orta-geç preterm ikizler ve tekil bebekler arasındaki erken motor repertuardaki ve ileri yaştaki gelişimsel fonksiyonellikte farklılıkları araştırmaktı. **Gereç ve Yöntem:** Çalışmaya 40 orta-geç erken doğmuş ikiz bebek (%50 kız) ve 40 orta-geç erken doğmuş tekil bebek (%50 kız) dahil edildi. Tüm bebekler, General Movement Değerlendirmesi (GMD) kullanılarak düzeltilmiş yaşları post-term 9 – 20 hafta arasında ve ileri dönemde Bayley Bebek ve Küçük Çocuklar için Gelişim Ölçeği, Üçüncü Baskı (Bayley-III) kullanılarak 24 – 42 aylar arasında değerlendirildi. **Sonuçlar:** Erken motor repertuar sonuçları incelendiğinde detaylı GMD sonucunda elde edilen Motor Optimallik Skoru (MOS) ve fidgety hareketlerin de dahil olduğu tüm alt kategorileri arasında fark yoktu ($p>0,05$). İleriki yaşta Bayley-III'e göre ikiz ve tekiz bebekler arasında bilişsel, dil ve motor alan bileşik puanlarında da anlamlı fark yoktu ($p>0,05$). **Tartışma:** Sonuçlarımız, orta-geç erken doğmuş ikiz bebeklerin, yaşamlarının erken dönemlerinden 3,5 yaşına kadar orta-geç erken doğmuş tekiz bebeklerle benzer bir gelişim sürecine sahip olduğunu göstermektedir. Ancak orta-geç preterm bebekler de dahil olmak üzere tüm erken doğmuş bebeklerin, klinikte yaşamın erken döneminden itibaren gelişimsel sorun riskleri açısından değerlendirilmesi gerekmektedir.

Anahtar Kelimeler: Bebek Gelişimi; Hareket; Multipl Doğum; Erken Doğum; İkizler.

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Multiple births have an increased risk of complications, including pre-eclampsia, gestational diabetes, and intrauterine growth retardation (Goldenberg, Culhane, Iams et al., 2008; SMFM Research Committee, Grantz, Kawakita, et al., 2019). Studies also reported that multiple births are associated with an increased risk of preterm birth and low birth weight (Heino, Gissler, Hindori-Mohangoo et al., 2016; Tough, Greene, Svenson et al., 2000; Blondel, Macfarlane, Gissler et al., 2006). With the increase of these risk factors, multiple births might expose more children to risk for long-term impairment, including visual impairment, hearing impairment, and developmental problems at later age, such as cerebral palsy (CP) (Sellier, Goldsmith, McIntyre et al., 2021; Sutcliffe and Derom, 2006; Škrablin, Kuvačić, Šimunić et al., 2007). Wadhawan et al. (2009) revealed that twin infants with extremely low birth weight had higher incidence rates for death and neurodevelopmental impairments compared to singleton infants at 18 to 22 months of corrected age.

Preterm birth, which is more common in multiple births, as mentioned above (Tough et al., 2000; Blondel et al., 2006), is defined as infants born <37 weeks of gestation (World Health Organization, 1977) and is classified as extremely preterm (born <28 weeks), very preterm (born 28 to <32 weeks), moderately preterm (born 32 to <34 weeks) and late preterm (born 34 to <37 weeks) (Blencowe, Lee, Cousens et al., 2013). Studies have reported that the risk of developmental delay or problems increases as gestational weeks decrease in children born preterm (Kerstjens, De Winter, Bocca-Tjeertes et al., 2012; Williams, Lee, and Anderson, 2010). Månsson and Stjernqvist (2014) revealed that children born extremely preterm, 17.29% of whom were of multiple births, had lower cognitive, language, and motor development results compared with children born at term at 2.5 years of age. Woythaler, et al. (2011) also found that children born late preterm, 14.7% of whom were of multiple births, compared with children born at term had lower results in mental developmental and psychomotor developmental domains at 24 months of age. Additionally, it was reported that children born preterm who were not diagnosed with CP had a high risk of motor impairment (Williams, et al., 2010). On the other hand, studies comparing twins and singletons as preterm infants are examined, Ylijoki et al. (2020) reported that there were no significant differences in neurodevelopmental outcomes at 5 years of age, so twin preterm infants had no major additional neurodevelopmental risks. Similar to this study, Nan et al. (2013) found that although twins without any diagnosis had signs of developmental delay in the first year, twin infants caught up to singletons after the age of 12 months. As a result of all these findings, there was no study comparing moderate-to-late preterm twin and singleton infants in terms of early motor repertoire in the first months of life and developmental functioning outcome at later ages.

This study aimed to answer the following questions: Do moderate-to-late preterm twins and singletons differ in early motor repertoire between 9 and 20 post-term weeks of corrected age, and in later developmental functioning between 24 and 42 months of age?

METHODS

Participants and Procedure

This retrospective observational study included 40 moderate-to-late preterm twin infants (20 twin pairs) and 40 moderate-to-late preterm singleton infants who were referred to the Developmental and Early Physiotherapy Unit, Faculty of Physical Therapy and Rehabilitation, Hacettepe University, Ankara, Türkiye between 2015 and 2022. The inclusion criteria for all infants were (1) having been videotaped for the General Movements Assessment (GMA) at 9-20 weeks post-term corrected age, (2) having assessment results of the Bayley Scales of Infant and Toddler Development, Third Edition (Bayley-III) between 24 and 42 months of age, and (3) not having a diagnosis of any neurological, genetic, or metabolic disorders. This study was approved by the Non-interventional Clinical Research Ethics Board, Hacettepe University (GO 22/1239).

Instruments

Assessing Early Motor Repertoire Using the General Movements Assessment (GMA): The early motor repertoire of all moderate-to-late preterm infants was assessed using detailed GMA between 9 and 20 post-term weeks. General Movements (GMs) are based on visual Gestalt perception and occur in age-specific patterns (Prechtl, Einspieler, Cioni et al., 1997). What we know as fidgety movements between 3- and 5-months post-term age, are defined as small movements and variable acceleration of the neck, trunk, and limbs in all directions (Einspieler, Prechtl, Bos et al., 2004; Einspieler, Bos, Krieber-Tomantschge et al., 2019). It was reported that fidgety movements had high specificity and sensitivity ranging between 89%-96% and 95%-98%, respectively (Prechtl et al., 1997; Bosanquet,

Copeland, Ware et al., 2013; Kwong, Fitzgerald, Doyle et al., 2018). In addition to this global GMA between 9 and 20 post-term weeks, detailed GMA could assess not only fidgety movements but also concurrent movement and postural patterns (Einspieler et al., 2004; Einspieler et al., 2019), and Motor Optimality Scores (MOS) could be determined. The maximum MOS is determined as 28, indicating the best performance, while the minimum is 5 (Einspieler et al., 2004; Einspieler et al., 2019). Recently, it was also reported that MOS related to neurodevelopmental outcomes at 2 years in infants born extremely preterm or extremely-low-birthweight (Kwong, Doyle, Olsen, et al., 2022); to cognition, attention, working memory, executive function, and motor function at 8 years in infants born very preterm (Salavati, Bos, Doyle et al., 2021); and neurodevelopmental outcomes at 12 years in children born extremely preterm (Örtqvist, Einspieler and Ådén, 2022).

Using the score sheet of the Motor Optimality Score for 3- to 5-Month-Old-Infants–Revised (Einspieler et al., 2019), MOS were determined. The revised score sheet of MOS comprises the following five subcategories: (i) temporal organization and quality of fidgety movements, (ii) observed movement patterns, (iii) age-adequate movement repertoire, (iv) observed postural patterns, and (v) movement character (Einspieler et al., 2004; Einspieler et al., 2019).

Three five-minute video recordings were made for the GMA in the supine position during active wakefulness according to the GMA standards (Einspieler et al., 2004). The video recordings were evaluated by two certified scorers (AM and BNYL) and in the case of disagreement between the scorers (only 2 recordings: 2,5%), the video recordings were re-evaluated together until consensus was reached.

Evaluation of Developmental Functioning Outcomes: All moderate-to-late preterm infants were examined for developmental functioning using the Bayley-III between 24 and 42 months of age by a certified assessor. The Bayley-III assessment is used for evaluating the developmental function in the early period of life. It comprises these three domains: Cognitive, Language (Receptive and Expressive), and Motor (Fine and Gross) (Bayley, 2006). The raw score of each of the three domains is converted into a scaled score (a mean of 10 and a standard deviation, SD, of 3), and then composite scores (a mean of 100 and an SD of 15) are calculated for cognitive, language, and motor scales (Bayley, 2006).

Bayley-III was conducted at the pediatric clinic by certificated physiotherapists in well-lit rooms where the children feel comfortable and free from distractions. It lasted between 45 and 120 minutes depending on the child's age and cooperation.

Statistical Analysis

The SPSS package for Macintosh, version 25.0 (SPSS Inc, Chicago, IL, USA), was performed for statistical analysis. The variables were investigated using visual (histograms, probability plots) and analytical methods (Kolmogorov-Simirnov test) to determine whether or not they were normally distributed. Categorical variables were presented as n (%), and continuous variables were expressed as mean ± SD if they were normally distributed and as median (minimum- maximum) if they were not normally distributed. The Pearson chi-squared was used to compare the categorical variables (e.g., sex) between the groups. In the comparisons of continuous variables between groups, a one-way ANOVA test was used if the data were normally distributed (e.g., birth weight), and the Mann-Whitney U test was used if they were not normally distributed (e.g., MOS). P-values of less than 0.05 were considered statistically significant.

RESULTS

We present all moderate-to-late preterm infants' characteristics in Table 1.

Early Motor Repertoire Using the General Movements Assessment (GMA)

The MOS and its subcategories' results of all moderate-to-late preterm infants are presented in Table 2. When we compared the early motor repertoire results, there were no differences in MOS and its subcategories between twin and singleton infants ($p>0.05$).

Normal movement patterns were observed in more than one-third of twin infants, including kicking (22/40; 55%), smiles (18/40; 45%), hand-to-mouth contact (17/40; 42.5%), hand-to-hand contact (15/40; 37.5), foot-to-foot contact (24/40; 60%), legs lift (15/40; 37.5%), visual exploration (36/40; 90%). In a few twin infants, we observed abnormal movement patterns including foot-to-foot contact (3/40; 7.5%), tongue movements (3/40; 7.5%), wiggling-oscillating (2/40; 5%), kicking (2/40; 5%), hand-to-mouth contact (1/40; 2.5%). In the singleton infants, wiggling-oscillating (18/40; 45%), kicking (19/40; 47.5%), foot-to-foot contact (22/40; 55%), legs lift

(15/40; 37.5%), and visual exploration (35/40; 87.5%) were observed in more than a third of them. The abnormal movement patterns which included wiggling-oscillating (1/40; 2.5%), kicking (2/40; 5%), mouth movements (1/40; 2.5%), side-to-side movements of the head (1/40; 2.5%), foot-to-foot contact (2/40; 5%), legs lift (1/40; 2.5%), and visual exploration (2/40; 5%) were observed in few singleton infants.

Infants with predominantly normal postural patterns in both the twin and singleton groups were able to hold their head in midline (26/40; 65%, 31/40; 77.5%, respectively), show a symmetrical body posture (20/40; 50%, 18/40; 45%, respectively), and variable finger postures (33/40; 82.5%, 30/40; 75%), and only one singleton infant (2.5%) had a persistent asymmetric tonic neck response.

13 of the twin infants (32.5%) exhibited smooth and fluent movement character, while the figure for the singleton infants was 11 (27.5%).

Developmental Functioning Outcomes

None of the infants included in this study were diagnosed with any disorder, however, some of them are still followed as they are seen as risky in developmental domains. There were no significant differences in cognitive, language, or motor composite scores between twin and singleton infants ($p>0.05$) when we compared the developmental functioning outcomes (Table 2). Three twin infants were in the language domain and 1 infant was in the motor domain classified as borderline below 80 points according to the results of the Bayley-III assessment.

Table 1. Clinical characteristics of all moderate-to-late preterm children.

Variables	Twin infants (n = 40)	Singleton infants (n = 40)	p
Sex (female), n (%)	20 (50)	20 (50)	1.000[a]
Birth weight (grams), mean ± SD	2134.48 ± 359.95	2229.88 ± 500.79	0.331[b]
Gestational age (weeks), mean ± SD	33.9 ± 1.19	34.35 ± 1.05	0.077[b]
Recording age for GMA (weeks), median (minimum-maximum)	13 (10 – 18)	13 (10 – 16)	0.162[c]
Age at Bayley-III assessment (months), median (minimum-maximum)	28 (24 – 39.5)	27.75 (24 – 41.5)	0.806[c]
Assisted reproductive technology, n (%)	22 (55)	5 (12.5)	**<0.001[a]**
Risk Factors of Infants			
Large for Gestational Age (LGA), n (%)	0	0	**-**
Small for Gestational Age (SGA), n (%)	4 (10)	5 (12.5)	0.723[a]
Intrauterine growth restriction (IUGR), n (%)	2 (5)	8 (20)	**0.043[a]**
Respiratory Distress Syndrome (RDS), n (%)	0	0	-
Bronchopulmonary Dysplasia (BPD), n (%)	0	0	-
Patent Ductus Arteriosus (PDA), n (%)	5 (12.5)	3 (7.5)	0.712[a]
Necrotizing Enterocolitis (NEC), n (%)	2 (5)	0	0.494[a]
Hyperbilirubinemia[Φ], n (%)	2 (5)	2 (5)	1.000[a]
Periventricular Leukomalacia (PVL), ≥ III, n (%)	0	0	-
Intraventricular Hemorrhage (IVH), ≥ III, n (%)	0	0	-
Hypoxic-Ischemic Encephalopathy (HIE), ≥ II, n (%)	0	0	-

[a]Pearson Chi-Square test, [b]One-way Anova test, [c] Mann Whitney-u test. Bold values indicate statistically significant at the P <0.05 level.

[Φ]Total serum bilirubin (TSB) value >12.9 mg/dl.

Table 2. MOS and its subcategories between 9 and 20 post-term weeks, and results of the Bayley-III assessment between 24 and 42 months of age.

		Twin infants (n = 40)	Singleton infants (n = 40)	p
MOS and its subcategories				
MOS, median (minimum-maximum)		26 (10 – 28)	24.5 (18 – 28)	1.000[a]
Optimal (25–28), n (%)		22 (55)	19 (47.5)	0.215[b]
Mildly reduced (20–24), n (%)		14 (35)	20 (50)	
Moderately reduced (9–19), n (%)		4 (10)	1 (2.5)	
Severely reduced (5–8), n (%)		0	0	
Fidgety movements	**Normal, n (%)**	38 (95)	39 (97.5)	0.222[b]
	Abnormal, n (%)	0	1 (2.5)	
	Absent/Sporadic, n (%)	2 (5)	0	
Observed movement patterns	**N>A, n (%)**	38 (95)	39 (97.5)	0.603[b]
	N=A, n (%)	1 (2.5)	1 (2.5)	
	N<A, n (%)	1 (2.5)	0	
Age-adequate movement repertoire	**Age-adequate, n (%)**	22 (55)	22 (55)	1.000[b]
	Reduced, n (%)	10 (25)	10 (25)	
	Absent, n (%)	8 (20)	8 (20)	
Observed postural patterns	**N>A, n (%)**	26 (65)	29 (72.5)	0.308[b]
	N=A, n (%)	13 (32.5)	8 (20)	
	N<A, n (%)	1 (2.5)	3 (7.5)	
Movement character	**Smooth and fluent, n (%)**	12 (30)	11 (27.5)	0.805[b]
	Abnormal, not CS, n (%)	28 (70)	29 (72.5)	
	CS, n (%)	0	0	
Bayley-III assessment				
Cognitive composite score, median (minimum-maximum)		105 (80 – 145)	105 (90 – 145)	0.504[a]
Language composite score, median (minimum-maximum)		101.5 (74 – 138)	106 (83 – 153)	0.058[a]
Motor composite score, median (minimum-maximum)		100 (79 – 127)	97 (91 – 133)	0.333[a]

[a] *Mann Whitney-u test,* [b] *Pearson Chi-Square test.*

Bold values indicate statistically significant at the P <0.05 level.

N>A, more normal than abnormal patterns; N=A, an equal number of normal and abnormal patterns; N<A, fewer normal than abnormal patterns; CS, cramped-synchronized movement character; MOS, Motor Optimality Score.

DISCUSSION

The results of this study on early motor repertoire and developmental functioning outcomes demonstrated that moderate-to-late preterm twin infants did not differ from moderate-to-late preterm singleton infants either in the first months of life or in the later period.

A previous study conducted by Dostanic et al. (2018) revealed that only 4% of moderate-to-late preterm twin infants displayed no fidgety movements, while 58% of extremely and very preterm twin infants had absented or abnormal fidgety movements. When analyzing the effect of risk factors, it was also reported that only preterm birth was significantly related to the quality of GMs (Dostanic, Sustersic, and Paro-Panjan, 2018). There were also other studies reporting that the quality of fidgety movements was related to gestational age (Ma, Meng, Chen, et al., 2018). This could be the reason why there were no differences in the results of our study when comparing moderate-to-late preterm twin and singleton infants. Furthermore, the percentage of absent and abnormal fidgety movements in moderate-to-late preterm infants was reported as 6% in infants born with no other risk factors by Peyton et al. (2022), and 7.1% of infants without any diagnosis by Topal et al. (2023), which are consistent with our results. Peyton et al. (2022) also found that, as expected, these moderate-to-late preterm infants had more normal fidgety movements than high-risk infants. A study solely on late preterm infants reported that fidgety movements were significantly related to the presence of CP in late preterm infants (Brogna et al., 2013).

In addition to fidgety movements, Peyton et al. (2022) revealed that motor repertoire results without fidgety movements were higher in moderate-to-late

preterm infants than high-risk infants. These motor repertoire results without fidgety movements from a detailed GMA were found to be account for more than solely fidgety movements for later neurodevelopmental outcomes, including cognitive and language outcomes (Peyton, Einspieler, Fjørtoft et al., 2020). In our current study, we found that MOS subcategories except fidgety movements were similar in twin and singleton infants; we suggest that both twin and singleton infants who were born moderate-to-late preterm have the same risk of developmental problems excluding CP.

Early motor repertoire with fidgety movements results in MOS which has been reported to be higher in moderate-to-late preterm than in high-risk infants (Peyton, Millman, Rodriguez et al., 2022). MOS was found to be related to cognitive performance, attention, working memory, executive function, and motor function at 8 years in very preterm infants (Salavati et al., 2021), neurodevelopmental outcomes at 2 years in infants born extremely preterm or extremely-low-birthweight (Kwong et al., 2022), some gait characteristics in preterm children (Topal et al., 2023), and functional mobility levels in children with CP (Yang, Einspieler, Shi et al., 2012; Einspieler et al., 2019). The reason we did not find a difference between the moderate-to-late preterm twin and singleton infants was that there were no differences between the developmental parameters.

It is uncertain whether there are any independent risk factors for developmental problems in twins, in addition to preterm birth or other associated risk factors. Our findings showed that moderate-to-late twin and singleton infants had similar developmental processes in both early periods and later outcomes, so all these infants could bear similar risks in terms of developmental problems. In accordance with previous studies (Kyriakidou, Karagianni, Iliodromiti et al., 2013; Ylijoki, Haataja, Lind et al., 2020), twin infants did not have differences in developmental functioning at later age, including cognitive or motor development (Kyriakidou et al., 2013; Ylijoki et al., 2020), and twins catch up with their peers around 12 months of age (Nan, Piek, Warner et al., 2013). However, to the best of our knowledge, this is the first study to compare moderate-to-late twin and singleton infants and present early motor repertoire and later developmental functioning outcomes; our results could be due to the exclusion of very and extremely preterm twin infants. On the other hand, assisted reproductive technology (ART), which is known to be associated with multiple births, was higher in twin infants than singleton infants, as expected, in our study. However, other risk factors which are common in multiple births did not differ in our groups, except intrauterine growth restriction (IUGR), and this risk factor was higher in singleton infants than twin infants, which was contrary to expectations. All these risk factors need to be studied in more detail in this specific preterm population.

The first limitation of the present study was its retrospective nature, which included only infants who had performed all the assessments. Another possible limitation was the wide age range of developmental functioning assessment.

In conclusion, our study indicates that moderate-to-late preterm twin infants had similar developmental processes to moderate-to-late preterm singleton infants from early periods up to 3.5 years of age. Further studies should also investigate whether multiple births in extremely or very preterm infants cause additional risk factors for developmental problems.

Ethical Approval

The study was approved by the Non-Interventional Ethics Committee of Hacettepe University (Decision no: 2023/01-40).

Authors' Contribution

Idea/Concept: BNYL, AM; Design: BNYL, AM; Control/Supervision: AM; Data collection and/or Processing: BNYL; Analysis and/or interpretation: BNYL; Literature review: BNYL; Writing the Article: BNYL; Critical Review: AM

Conflicts of Interest Statement

None of the authors report having a conflict of interest.

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