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A Comparison of the Touwen Infant Neurological Examination, General Movement Assessment and Alberta Infant Motor Scale in Infants Born Preterm

Prematüre Bebeklerde Touwen İnfant Nörolojik Değerlendirmesi, General Movements Değerlendirmesi ve Alberta İnfant Skalasının Karşılaştırılması

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ABSTRACT

Objective: Infants born preterm are known to be at risk of moderate to severe developmental problems. The study aimed to compare Touwen Infant Neurologic Examination (TINE), General Movement Assessment (GMA) and Alberta Infant Motor Scale (AIMS) scores assessed on the same day at 3-to-5 months-of-corrected-age in infants separated by gestational week. Materials and Methods: We included a total of 78 infants with a history of preterm birth, as very preterm (<32 weeks, n = 26), moderate preterm ($32^{0/7}$ to $33^{6/7}$ weeks, n = 30) and late preterm ($34^{0/7}$ to $36^{6/7}$ weeks, n = 22), at 3 to 5 months-of-corrected-age. The study compared the results of TINE, AIMS and GMA in preterm infants separated by gestational age, and analysed AIMS scores according to GMA results. In addition the association between TINE and AIMS scores was assessed. Results: There was statistical significance between the prone motor performances of the groups, due to the statistical difference between infants born late preterm and infants born very preterm; the prone motor performance of infants born late preterm was significantly higher than infants born very preterm. Infants with normal fidgety movements had higher prone (p=0.043) and supine (p= 0.037) motor performance scores than infants with aberrant fidgety movements. A significant negative low correlation was found between TINE findings and total AIMS scores. Conclusions: Infants with absent and abnormal fidgety movements have lower AIMS score and gestational age might affect AIMS score. Additionally, it has been showed that abnormal neurologic findings, according to TINE, are negatively related to AIMS score.
Keywords: *General movements, Minor Neurological Dysfunction, Preterm*

ÖZ

Amaç: Prematüre bebeklerin orta ila ciddi gelişimsel sorunlar açısından risk altında olduğu bilinmektedir. Çalışmanın amacı, gestasyonel yaşlarına göre ayrılan prematüre bebeklerin düzeltilmiş 3 ila 5 aylık iken aynı gün içerisinde değerlendirilen Touwen İnfant Nörolojik Değerlendirmesi (TİND), General Movement Değerlendirmesi (GMs) ve Alberta İnfant Motor Skalası (AİMS) skorlarını karşılaştırmaktır.
Materyal ve Metot: 3-5 ay düzeltilmiş yaşlarında gestasyonel yaşlarına göre erken prematüre (<32 hafta, n = 26), orta prematüre ($32^{0/7}$ ila $33^{6/7}$ hafta, n = 30) ve geç prematüre ($34^{0/7}$ ila $36^{6/7}$ hafta, n = 22) olmak üzere toplam 78 prematüre bebek çalışmaya dahil edilmiştir. Çalışmada gestasyonel yaşa göre ayrılan prematüre bebekler arasında TİND, AİMS ve GMs değerlendirmesi sonuçları karşılaştırılmış ve GMs sonuçlarına göre AİMS skorları incelenmiştir. Ayrıca TİND ve AİMS skorları arasındaki ilişki de değerlendirilmiştir. Bulgular: AİMS sonuçlarına göre; grupların yüzüstü motor performansları arasında geç prematüre bebekler ile erken prematüre bebeklerden kaynaklanan bir fark bulundu; geç prematüre bebeklerin yüzüstü motor performansı erken prematüre bebeklerden daha yüksekti. GMs değerlendirmesine göre; normal *fidgety* hareketleri görülen bebeklerin AİMS'ten aldıkları yüzüstü (p=0,043) ve sırtüstü (p= 0,037) motor performans skorları, anormal *fidgety* hareketleri görülen bebeklerden daha yüksekti. TİND ile toplam AİMS skorları arasında negatif düşük bir korelasyon bulundu. Sonuç: Sonuç olarak, *fidgety* hareketleri görülmeyen ya da anormal olan prematüre bebeklerin AİMS skoru yani motor performanslarının daha kötü olduğu ve gestasyonel yaşın AİMS skorunu etkileyebileceği görüldü. Ayrıca, TİND'a göre anormal nörolojik bulgular arttıkça AİMS skorunun düştüğü bulundu.
Anahtar Kelimeler: *General movements değerlendirmesi, Minör nörolojik disfonksiyon, Prematüre*

INTRODUCTION

Preterm birth, which is defined by the World Health Organization (WHO) as birth before 37 gestational weeks or 259 days, is a main indicator of morbidity and mortality in the newborn, and can have long-term adverse effects on infant health (1). Complications of preterm birth are the leading cause of death in children under 5 years of age. In 2014, preterm birth was estimated to affect 10.6% of all births globally, and it was reported that preterm birth rates ranged from 5% to 18% across 184 countries (2, 3). Although there are various classifications related to preterm birth, the general classification is extremely preterm (<28 weeks), very preterm ($28^{0/7}$ to $31^{6/7}$ weeks), moderate preterm ($32^{0/7}$ to $33^{6/7}$ weeks), and late preterm ($34^{0/7}$ to $36^{6/7}$ weeks) (4). The rates of morbidities such as low birthweight, intraventricular hemorrhage, respiratory distress syndrome, bronchopulmonary dysplasia, and associated morbidities are seen at higher rates in infants born preterm than term infants (5-6). In addition, 50% of these infants have the risk of future motor coordination problems, cognitive disorders, attention deficits, and minor neurological dysfunction (MND), and 5-15% have a high risk of cerebral palsy (CP) (4, 7).

Neurological symptoms which emerge in the absence of evident neurological pathology are defined as MND and have been reported as being seen at a much higher rate in preterm infants (8). Delayed development of fine and gross motor skills, permanent neuromotor abnormalities, speech problems, intellectual delay, attention-deficit hyperactivity disorder, and learning problems which lower academic success are seen in children associated with MND (9). It is difficult to diagnose MND during early infancy, and a diagnosis of MND is often not made until preschool age. The study of Hadders Algra et al. (10) concluded that MND could be determined reliably during infancy with the Touwen Infant Neurologic Examination (TINE) and the presence of MND in infancy is a risk for developmental dysfunction in later life and highlights the need for careful follow-up. TINE is not widely used in clinical and research studies; however, earliest diagnosis of children with MND may provide early intervention for improving functional developmental outcomes (10).

The aim of this study was to compare motor and neurologic outcome assessed on the same day at 3 to 5 months-of-corrected-age in infants born preterm at three different gestational age (GA) periods on three standardized assessments; TINE, General Movement Assessment (GMA) and Alberta Infant Motor Scale (AIMS). In consideration of the extant literature, our hypothesis was that GA may influence both gross motor and neurological outcomes, as well as early motor performance, in premature infants. The aforementioned three assessments were selected to assess different aspects of development, and the research questions were established; (i) Are there differences in the motor and neurological outcome of preterm infants born at different GA? (ii) Is there a difference between the motor performances of preterm infants according to GMA analysis (normal and abnormal)? (iii) Are the neurological status (TINE) and motor performance (AIMS) of preterm infants related?

MATERIAL and METHOD

Participants

The study was conducted in the Developmental and Early Physiotherapy Unit of Hacettepe University, between February 2018 and December 2019, and it was approved by the Non-Interventional Clinical Research Ethics Committee of Hacettepe University (decision no: GO18/149, dated:06/02/2018). Criteria for inclusion were a GA of less than 37 weeks and a corrected age of 3-5 months. The exclusion criteria included infants with chromosome malformations, malignant disorders, or congenital syndrome whose families did not want to participate in the study and infants with a history of periventricular leukomalacia (PVL), hypoxic-ischemic encephalopathy (HİE), and intraventricular hemorrhage (IVH). Written informed consent for participation in the study was obtained from the parents of all the infants. The preterm infants at a corrected age of 3-5 months were included and classified according to GA as very preterm (VPT): <32 weeks, moderate preterm (MPT): $32^{0/7}$ to $33^{6/7}$ weeks, and late preterm (LPT): $34^{0/7}$ to $36^{6/7}$ weeks. The study included a total of 78 infants born at different GA periods; 26 in the VPT group, 30 in the MPT group, and 22 in the LPT group. The mean birth weight and assessment age of the infants were 1827 g and 14.2 weeks, respectively. The infant and mother data are presented in Table I.

Procedure

We conducted a prospective study of preterm infants born at different GA between a corrected age of 3 to 5 months old. As soon as the infant came to our clinic, first GMA was recorded (5-10 minutes) and then TINE (15-20 minutes) and AIMS (20-30 minutes) assessments were performed, respectively with resting periods in between. The video recordings for GMA were performed during periods of active wakefulness of the infant with the infants lying in a supine position and partly dressed without crying or fussing. The infants were then assessed using TINE and AIMS. All assessments were performed on the same day. Assessors were experienced paediatric physiotherapists, who were blind to the infant's clinical history.

Touwen Infant Neurological Examination (TINE)

The TINE was used to assess the neurological status of the infants. The assessment is made by observing the infant when awake and calm, in prone, supine and sitting positions, and motor behaviours when reaching and grasping. TINE is one of the standardized infant neurological assessments with good psychometric properties, including good reliability in a sample of infants aged 3 to 12 months (inter-assessor agreement k = 0.83, 95% CI 0.68-0.99) (10). The findings of the TINE were classified according to age-specific norms into clusters of dysfunction as follows: (i) dysfunctional reaching and grasping (goal directed motility arms, type of grasping, delayed development of grasping, arm/hand posture during reaching and grasping, quality of reaching motility etc.); (ii) dysfunctional gross motor function (tremor, head balance, motility in supine and prone position, performance at pull-to-sit manoeuvre, etc.); (iii) signs of brainstem dysfunction (dysfunctional glabella and masseter reflex, Doll's eye phenomenon and Moro reaction, etc.); (iv) visuomotor dysfunction (deviant fixation of eyes and eye movements, visual pursuit, strabism, sunset, etc.); and (v) sensorimotor dysfunction (deviant muscle tone, regulation of tendon reflexes, foot sole response, etc.). The total number of dysfunctional clusters is calculated in order to determine the neurological function classification. The classifications are as follows: normal, normal sub-optimal, minor neurological dysfunction, or abnormal (The score range is 0–3 respectively, with 0 indicating normal function). The TINE administration took 15-20 minutes. The assessor (D.P. and M.A.) first learned the TINE procedure, and then practiced to gain experience (at least 50 assessments) and to learn the distinction between 'typical' and 'sign of MND' as reported by Hadders-Algra et al. (10). TINE was conducted on all infants included in the study.

General Movements Assessments

GMA is one of the most predictive tools for detecting an infant's later neurodevelopmental outcome, particularly CP, before 5 months of corrected age (11). The excellent predictive power of GMA, especially in a population at high risk of CP, is mainly based on fidgety movements with sensitivity values from 95% to 98% and specificity values from 89% to 96% (11, 12). As a part of GMA, fidgety movements are continuous small amplitude, moderate speed movements of shoulders, wrists, hips, and ankles in all directions and of variable accelerations in typically developing infants at 3–5 months post-term age (13). In the assessment, fidgety movements were examined and scored as present and normal (F+), absent (F-) and abnormal (AF) (13). Seven video recordings for GMA could not be performed as the infant was irritable or sleepy: 3 in infants born VPT, 3 in infants born MPT, and 1 in infants born LPT. The video recordings were assessed by A.M. and H.A., who are GMA certified and experienced paediatric physiotherapists blinded to the infants' clinical histories. Inter-assessor Cohen's kappa coefficient for GMA was statistically significant and showed high agreement ($\kappa = 0.93$, $p < 0.001$).

Alberta Infant Motor Scale (AIMS)

Gross motor performance of infants assessed with the AIMS, which is a norm-referenced tool with high predictive validity for long-term motor outcomes and excellent intrarater- interrater reliability in children born preterm (14). The movements of the infant are observed when supine, prone, sitting, and standing. The components tested for each item are based on 3 elements of movement: weight bearing, posture, and antigravity movements. The last and the most mature items are identified in every position, these two items constitute the developmental "window" and then score every item in the "window" as "observed" (1 point) or "not observed (0 points). The sum of all items observed gives a total raw AIMS score ranging from 0 to 58 and the total points are converted to age-based centile values. Scores are marked on the AIMS forms, which consist of 58 items in 4 subscales. High percentile ranks indicate the maturity of the infant's gross motor skills. Infants with a centile score of ≤5 are assessed as abnormal. Since "sitting" and "standing" positions are beyond the motor development of infants at a corrected age of 3-5 months, the infant was held in that position by the assessor and observed as follows: weight-bearing on the feet, the position of the head, active control of the trunk, and variable movements of the legs according to gravity (14, 15). An assessor (D.P.) performed the assessment and it took about 20 minutes. AIMS was conducted on all infants included in the study.

Data Analysis

Statistical analyses were performed using SPSS software version 24 (IBM ®, Armonk, NY, USA). To achieve 80% power to detect a difference with 95% confidence using a two-tailed test, based on effect size of d=0.392 (16), a sample size of 25 participants was required for each group. The variables were investigated using visual (histogram, probability plots) and analytic methods (Kolmogorov-Simirnov/Shapiro-Wilk's test) to determine whether or not they are normally distributed. One-way ANOVA was used to compare AIMS scores among groups (VPT, MPT, LPT) and if at least one of the groups did not show normal distribution, the Kruskal Wallis test was used. Post-hoc corrections were used when there was a difference between the AIMS scores of VPT, MPT, and LPT infants. The Chi-Square test was used to compare TINE and GMA proportions in different groups. Independent sample t-tests were used to compare AIMS scores according to GMA groups (F+/(F-and AF)), and when at least one group did not show normal distribution, the Mann Whitney U-test was used. Finally, while investigating the associations between TINE and AIMS scores, the correlation coefficients and their significance were calculated using the Spearman rank order correlation. According to the correlation coefficient, correlations were interpreted as 0.05-0.4: low correlation, 0.4-0.7: moderate correlation, and 0.7-1.0: strong correlation (17).

RESULTS

The baseline data on the characteristics and risk factors of the infants are given in Table I. Of those included in the study, 5.1% were categorized as MND on the TINE and 11.3% (8.5% absent and 2.8% abnormal) showed aberrant (absent or abnormal) fidgety movements on GMA (Table I).

Table 1: Characteristics and Risk Factors of Infants

		Mean (SD)	(Min-Max) (n=78)
Birth weight (gr)		1827 (660.2)	730-3200
Height (cm)		61 (3.9)	52-70
Birth weight (gr)		1827 (660.2)	730-3200
Assessment age (week)/n=78		14.2 (2.1)	12-20
Assessment age (week)	Very preterm	14 (2)	12-20
	Moderate preterm	14.4 (2)	12-20
	Late Preterm	14.5 (2.2)	12-18
Gestational age (week)	Very preterm	28.7 (1.6)	25-31
	Moderate preterm	33.0 (0.9)	32-34
	Late Preterm	36.0 (0.8)	35-36
		n	**(%)**
Gender	Male	41	(52.6)
	Female	37	(47.4)
Risk Factors	Respiratory Distress Syndrome	3	(3.8)
	Bronchopulmonary Dysplasia	1	(1.3)
	Patent Ductus Arteriosus	2	(2.6)
	Necrotizing Enterocolitis	1	(1.3)
	Periventricular Leukomalacia	0	(0)
	Intraventricular Haemorrhage	0	(0)
Maternal Illness During Pregnancy	Pre-eclampsia	13	(16.7)
	Gestational Diabetes	6	(7.7)
	Hyperbilirubinemia	10	(12.8)
Type of Birth	NVB	10	(12.8)
	C/S	68	(87.2)
Type of Pregnancy	N	57	(73.0)
	IVF	21	(27.0)
Multiple Gestation	Single	41	(52.5)
	Twins	33	(42.3)
	Triplets	3	(5.2)
AIMS Total Score		9.1 (3.6)	NA
GMA	F+	63	(88.7)
	F-	6	(8.5)
	AF	2	(2.8)
TINE	Neurologically normal	42	(53.8)
	Sub-optimal, i.e. 1-2 Dysfunctional Clusters	30	(38.5)
	MND, i.e. > 2 Dysfunctional Clusters	4	(5.1)
	Abnormal, i.e. Clear Neurological Syndrome	2	(2.6)

AF; Abnormal fidgety, F-; Absent fidgety, F+; Normal fidgety, C/S; cesarean section, GMA; General Movement Assessment, IVF; in vitro fertilization, MND: minor neurologic dysfunction, N; normal, NVB; normal vaginal birth, NA = Not applicable, SD; standard deviation, TINE; Touwen Infant Neurological Examination.

The comparisons outcomes of TINE of the infants and the results of GMA according to GA are shown in Table II. According to TINE, there was no significant difference between the groups ($p>0.05$). Of all infants, 53.8% of infants born VPT, 33.3% of infants born MPT and 54.5% of infants born LPT were scored suboptimal to abnormal on the TINE. According to GMA, there were 8 infants with aberrant fidgety movements; 4 out of 23 (17.4%) in the VPT group, 2 out of 27 (7.4%) in the MPT group and 2 out of 21 (9.5%) in the LPT group.

Table 2: Comparison Of The TINE And GMA Of The Infants Included In The Study According To The Gestational Ages At Birth

		Gestational Age				
		Very preterm <32 wk	Moderate preterm 32-34 wk	Late preterm >34 wk	X^2	p
		n (%)	n (%)	n (%)		
TOUWEN	Neurologically normal	12 (46.2)	20 (66.7)	10 (45.5)	3.22	0.19
	Suboptimal/MND or Abnormal	14 (53.8)	10 (33.3)	12 (54.5)		
GMA	F+	19 (82,6)	25 (92,6)	19 (90,5)	2.33	0.67
	F- / AF	4 (17,4)	2 (7,4)	2 (9,5)		

X^2; Chi-Square test, AF; Abnormal fidgety, F-; Absent fidgety, F+; Normal fidgety, GMA; General Movement Assessment, wk: weeks

The comparisons of the AIMS scores of the infants according to GA are shown in Table III. At prone position, the mean values of the AIMS raw scores were significantly higher in infants born LPT than that of the other groups (p<0.01). No significant difference was determined between the groups in respect of the mean raw values of the AIMS subcategories and the AIMS centile scores (p>0.05) (Table III).

Table 3: Comparison of The AIMS Scores of The Infants In Corrected 3 To 5 Months According To The Gestational Ages At Birth

	Gestational Age at Birth								
	Very preterm <32 wk (n=26)		Moderate preterm 32-34 wk (n=30)		Late preterm >34 wk (n=22)		F	p	Post-Hoc
	Mean	SD	Mean	SD	Mean	SD			
AIMS total	8.5	3.4	9.3	3.1	9.5	4.5	0.51	0.598	
AIMS prone	2.2	1.1	3.2	1.6	3.6	2.3	4.11	**0.020***	<32 wk->34 wk
AIMS supine	3.4	1.6	3.5	1.3	3.6	1.8	0.05	0.944	
AIMS sitting	1.7	1.0	1.6	0.9	1.3	.8	1.62	0.205	
AIMS standing	1.2	1.0	1.1	0.4	1.0	0.5	0.73	0.481	
	Median (%25-75 IQR)		Median (%25-75 IQR)		Median (%25-75 IQR)		X^2	p	
AIMS centile scores	10 (0-25)		10 (5-25)		10 (0-10)		1.06	0.58	

F; One-way ANOVA, X^2; Kruskal Wallis, AIMS; Alberta Infant Motor Scale, SD; standard deviation, IQR; Interquartile Range,*p <0.05, wk: weeks

Comparison of the AIMS scores of the infants according to GMA statistics are shown in Table IV. Statistical significance was found in favor of infants with normal fidgety movements for the "prone" and "supine" subparameters (p<0.05). No statistical significance was found for the other sub-parameters (p>0.05).

Table 4: Comparison of The AIMS Scores of The Infants According To GMA Characteristics

	GMA					
	F+ (n=63)		F- and AF (n=8)		t	p
	Mean	SD	Mean	SD		
AIMS total	9.4	3.5	7.6	4.1	1.69	0.095
AIMS prone	3.1	1.8	2.7	1.6	0.78	**0.043***
AIMS supine	3.7	1.4	2.7	1.9	2.12	**0.037***
AIMS sitting	1.6	0.9	1.1	0.9	1.82	0.072
AIMS standing	1.1	0.7	1.1	0.6	0.12	0.903
	Median (%25-75 IQR)		Median (%25-75 IQR)		Z	p
AIMS centile scores	10 (0-25)		0 (0-10)		-1.87	0.061

t;Independent sample t test, Z;Mann-Whitney U test, AIMS; Alberta Infant Motor Scale, GMA; General Movements Assessment, F-; Absent fidgety, AF; Abnormal fidgety, F+; Normal fidgety, SD; standard deviation, IQR; Interquartile Range.

The relationship between the TINE and AIMS scores of the infants are shown in Table V. A negative, low-level statistically signficant correlation was determined between the TINE and the total, prone, supine, sitting, and centile values of the AIMS (p<0.05).

Table V. The Relationship Between TINE and AIMS Scores of The Infants Included In The Study

	TINE	
	r	p
AIMS total	-0.33	**<0.001****
AIMS prone	-0.25	**0.002***
AIMS supine	-0.32	**<0.001****
AIMS sitting	-0.25	**0.002***
AIMS standing	-0.07	0.490
AIMS centile scores	-0.29	**0.001***

AIMS; Alberta Infant Motor Scale, r; Spearman correlation test,*p <0.05, **p <0.01

DISCUSSION and CONCLUSION

The current study compared the motor and neurologic outcomes of infants born preterm at 3 to 5 months-of-corrected-age according to GA with three different assessments -TINE, GMA, and AIMS- that were performed on the same day. The results demonstrated that the infants born LPT had better motor performance than the infants born VPT. Assessment of neurologic and motor outcomes according to TINE and GMA showed no difference between groups. In addition, aberrant fidgety movements and worse neurological scores on TINE were associated with worse AIMS performance.

To the best of our knowledge, no study exist which used TINE, GMA, and AIMS together on the same time, in fidgety periods at a corrected age of 3-5 months. Only one study by Olsen et al. (18) also used those three assessments and Neurological, Sensory, Motor, Developmental Assessment (NSMDA), in which they associated GMA in the preterm and term period with the neurodevelopmental outcome assessed by TINE and AIMS at 12 months-of-corrected-age for infants born VPT. They (18) reported that abnormal GMA quality in the preterm and term periods was associated with adverse TINE and AIMS scores at a corrected age of 12 months.

The neurological condition in infancy is prone to change due to the developmental transformations of the infant brain (19). If the infant does not have a clear neurological dysfunction, early prediction is best when it is based on multiple assessments (10). There is scant evidence and research about the concept of MND in infancy. However, Hadders Algra et al. (10) reported that MND can be assessed reliably during infancy with the TINE and with good psychometric properties, including a good inter-assessor reliability. A relationship between preterm birth and MND seen in infancy has been shown in previous studies (10, 20). It is reported that as comorbidities increase when GA decreases, the rate of MND also increases (10, 20). Hsu et al. (20) in a cohort with 151 infants born preterm found that the proportion of MND at a corrected age of 6 months was 21.6% for infants born before 28 weeks, 13.2% for 29 to 32 weeks and 8.2% for 33 to 36 weeks. The present study revealed that the TINE scores were comparable between the groups separated by GA. Our expectation was that the rate of MND in infants born VPT was higher than in infants born MPT and LPT. However, this finding may be attributed to the low neurological risk and low neonatal morbidity rate observed in the VPT group included in this study.

It was shown in studies (21-23) that infants born preterm were more likely to have abnormal GMA as well as a poorer quality of early motor repertoire than infants born at term. In our study we compared the GMA results of infants born preterm according to GA and the findings were similar between groups. This can be explained by the fact that our study population, including infants in the VPT group, consisted of relatively low-risk infants and therefore there was no difference between the groups. Additionally, previous studies (21-23) generally compare the GMA results of infants born VPT and infants born at term. In our study, we compared infants born at VPT, MPT, and MPT among themselves. Therefore, we could not compare the outcomes we found in our study with the studies that included moderate and late preterm infants.

We found that our group of infants born preterm had a high percentage of aberrant fidgety movements (11,3%, n=8/78). This percentage is rather high compared to findings of Salavati et al. (22) (9.4%) in infants born VPT and Peyton et al. (24) (6%) in infants born MLP at 32-36 weeks gestation with no risk factors. However Yardımcı-Lokmanoğlu et al. (25) reported that 18.1% of the infants born preterm (GA between 23 and 36 weeks) showed aberrant fidgety movements and Zang et al. (26) stated that 23% of preterm infants born ≤34 weeks displayed aberrant fidgety movements. The varying rates of aberrant fidgety movements observed in these studies conducted in countries with disparate socioeconomic levels may be attributed to the presence of additional risk factors beyond prematurity. Furhermore, the high percentage of aberrant fidgety movements observed in our study may be indicative of potential neurodevelopmental issues, necessitating long-term follow-up to ascertain the long-term outcomes.

As GA and birthweight decrease, the rate of neurodevelopmental problems in the infants increases (27, 28). Infants born at <32 weeks and with a birthweight of <1500g are at notably higher risk (28, 29). In a systematic review by Fuentefria et al. (30), it was reported that differences were seen in the gross motor performances of preterm and full-term infants at different ages, and a relationship was noted between atypical motor performance in AIMS and risk factors such as prematurity-related low birthweight, peri-intraventricular hemorrhage, and chronic lung disease. In the current study, except for the AIMS prone scores, the motor performances of the groups were similar. The prone motor performance was higher in infants born at $34^{0/7}$ to $36^{6/7}$ weeks than infants born at <32 weeks. Consistent with these findings, Pin et al. (31) reported that delayed motor development became more evident with progression from the 4th month to the 8th month in preterm infants compared to term infants. Other studies by Van Haastert et al. (32) and Syrengelas et al. (33) reported that the AIMS scores of preterm infants were lower than full term infants at all age levels. In a study by Valentini et al. (34) it was found that preterm infants had higher scores in supine and standing postures in the first trimester of life compared with full term infants, but in the following months the full term infants had more proficient movements in demanding postures. Combined with ours, these results demonstrate the variability of movement patterns in preterm infants. But the most important point that distinguishes our study from those above was that we compared preterm infants among themselves according to their GA. The possible explanation of higher scores in a prone position in infants born LPT stem from the hypotonia observed in infants born VPT (35) Less prone positioning of the preterm infants and more time spent in neonatal intensive care units for medical treatment may negatively affect the acquisition of movements in supine and prone posture or bring higher rates of neonatal complications than the other groups.

It was also reported that the abnormal GMA of infants born at <32 weeks GA were associated with worse AIMS motor scores at 12 months corrected age (18). In the study of Snider et al. (36), which investigated the construct validity of GMA with newborn/infant measures in infants of <32 weeks GA, the correlation between traditional neonatal and infant motor assessments at preterm, term, and post term ages was generally low, and the relationship between GMA and AIMS was not found. We found that infants with normal fidgety movements had better motor performance than infants with aberrant fidgety movements in the prone and supine subparameters of AIMS. In the age range of our study population fewer items can be observed in the sitting and standing subparameters as they require more advanced motor skills. Therefore, it was an expected result that there was, as yet, no difference in the sitting and standing positions between the groups. Also, due to the low number of participants the difference may not be reflected in the statistics.

A negative relationship was determined between the outcome of TINE and the AIMS total, prone, supine, sitting, and centile values. Thus, it can be seen that as the outcome of TINE deteriorated in the infants, the motor scores also decreased. However, as there were only 6 preterm infants in total showing MND in the TINE assessment and abnormal neurological syndrome, this may have prevented the determination of any relationship according to GA.

There were some limitations to this study. First, the number of infants in the GA groups was low implying that the results can not be generalized. In addition there could have been more detailed classification of the infants according to GA, such as birth at <28 weeks.

GA affects motor performance, and infants with aberrant fidgety movements have also been found to have lower motor performance. It has also been shown that abnormal neurologic findings according to TINE are negatively related to motor performance. Assessment of TINE, GMA, and AIMS together provides a detailed and complementary neuromotor assessment in preterm infants, and detecting atypical development such as MND can guide clinicians in their referalls to age-specific early intervention programs.

Declaration of Ethical Code: In this study, we undertake that all the rules required to be followed within the scope of the "Higher Education Institutions Scientific Research and Publication Ethics Directive" are complied with, and that none of the actions stated under the heading "Actions Against Scientific Research and Publication Ethics" are not carried out.

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