

## ORIGINAL ARTICLE

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## CORRELATION OF BIRTH WEIGHT, GESTATIONAL AGE AND MUSCLE TONE WITH MOTOR DEVELOPMENT OF PRETERM INFANTS

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## ABSTRACT

**Background:** Muscle tone in Preterm infants (PTI) is lower actively and passively compared to full-term infants (FTI) due to reduced flexor muscle tone even at term age. They show more extension and difficulty moving against gravity due to maturation-related hypotonia which may affect the motor development of the child. Birth weight and gestational age signify the level of growth of various systems at birth which might impact the motor development. This study aims to correlate the effect of birth weight, gestational age and muscle tone with the motor development of PTI at eight months of corrected age.

**Methods:** This cross-sectional study included 39 PTI who met the criteria for eight months of corrected age. Subjects were recruited from Child Development Unit when the infant returned for developmental assessment. Birth weight and Gestational age were noted, and motor development was assessed with Peabody Developmental Motor scale (PDMS 2). Muscle tone was assessed using Amiel-Tison Angles (ATA) with a goniometer.

**Results:** Gestational age did not show a significant correlation, but birth weight showed a positive correlation and Muscle tone assessed with ATA showed significant negative correlation with Gross Motor Quotient (GMQ), Fine motor Quotient (FMQ) and Total Motor Quotient (TMQ) of PDMS with a p-value <0.05.

**Conclusion:** The study concludes that motor development is influenced significantly by birth weight and muscle tone and maturation-related hypotonia is found to be carried in PTI during the first year of life which has an impact on motor development. Clinicians should consider strategies to improve the muscle tone in the initial periods to prevent motor delays in these infants.

**Keywords:** preterm infant, muscle tone, maturation related hypotonia, Amiel Tison Angles, birth weight, corrected age.

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## INTRODUCTION

World Health Organization (WHO) defines Preterm as a birth that occurs at gestational age less than 37 weeks. Among the estimated fifteen million preterm births worldwide 60% of preterm birth occurred in sub-Saharan Africa and South Asia. As gestational age decreases from 37 weeks to 34 weeks, there is a significant increase in neonatal mortality and morbidity. Preterm birth is a major cause of death in children below five years as the direct birth complications of the preterm birth accounts for 35% of neonatal death. Deaths among late preterm babies are also high in countries with low and middle economic status [1,2]. In India, preterm birth complications account for 35% of neonatal death in 2014[3].

The causes of preterm birth are varied, approximately 45–50% is unknown, 30% are due to premature onset of labor and 15–20% is attributed to elective preterm deliveries. Preterm birth results in many acute complications due to immaturity, and they contribute to the high rates of neuromotor disorders like cerebral palsy, sensory deficits, and learning disabilities [4]. As per WHO, birth weight less than 2500gm is considered as Low birth weight. The two important factors which contribute to low birth weight are gestational age and rate of intrauterine growth [5]. Based on birth weight Preterm infants (PTI) can be classified into three categories - Small for gestational age, Appropriate for gestational age and Large for gestational age[6]. The decrease in birth weight directly conveys that there is a decrease in structural maturation which could influence the development of preterm in various aspects.

The maturation of the fetus is rapid during the second trimester. The body structure is approximately in proportion to the newborn by 20 weeks and in the third trimester the weight increases by two times and length increases by three times [7]. The complete maturation of motor system, autonomic system and self-regulatory system which takes place in the last trimester is interrupted in PTI. The motor system starts to develop after autonomic stability is achieved. Cerebral maturation results in continuous changes in muscle tone and reflexes during the third trimester [8].

Maturation of all the systems is incomplete in PTI which results in subtle developmental issues in these children identified in the early developmental age. MRI taken at the term age of PTI showed a major reduction in the cerebral cortical grey matter, deep nuclear gray matter and increased CSF volume in comparison with term infants which can result in developmental disabilities [9]. PTI is more prone to severe visual impairments due to Retinopathy of prematurity, optic atrophy and cerebral amblyopia which are often associated with other neurological impairment [10]. Extreme PTI faces difficulty in maintaining homeostasis as there is the incomplete maturation of the stratum corneum which acts as skin barrier and protects our body [11]. Developmental delay increases exponentially with decreasing gestational age in PTI as seen with Ages and Stages Questionnaire at three

years of age [12].

Full-term infants (FTI) are born with normal physiological flexion as myelination of the sub corticospinal system occurs from 24 to 34 weeks, which reflects passive flexor tone, followed by myelination of the corticospinal system after 34 weeks that lead to extensor tone. A period of maturational related hypotonia will be present during birth in PTI. An infant born at 28 weeks of gestational age is flaccid, their extremities are held in the extension which can have a later effect on posture and movement patterns without neurologic insult. Muscle tone is one of the important aspects of the motor development of PTI. As the PTI reach term, their flexor tone increases but even at term age, PTI tends to have flexor tone less than FTI [13].

Jorrit F. de Kieviet et al (2009) showed delayed motor development in PTI and found that they show different gross motor developmental patterns even with correction of age when compared with term infant [14]. A significant association between motor development, preterm birth, and the developmental impairments persist throughout the childhood as found by a meta-analysis on the motor development of very preterm children [15]. Though previous studies have concentrated on the motor development of PTI, the status of maturation-related hypotonia and the influence of birth weight, gestational age and muscle tone on the initial motor development of the child is not clear in the first year of life. The result of the study could help the clinician to understand the impact and address the subtle tonal deviations if required to prevent developmental motor delays in PTI.

## MATERIALS AND METHODS

PTI at eight months of corrected age were the subjects in this cross-sectional study to find the correlation of birth weight, muscle tone, and gestational age to motor development of the infants. The study was approved by the Ethics committee of Sri Ramachandra University (CSP/14/OCT/37/199). 39 Preterm infants which included 21 male children and 18 female children were recruited at eight months of corrected age from the Child Development Unit of Sri Ramachandra Medical Centre and Hospital. Subjects who had neurological impairments, congenital or acquired musculoskeletal problems and visual and auditory impairments were excluded from the study.

### INSTRUMENTATION:

#### PEABODY DEVELOPMENTAL MOTOR SCALE-2:

Peabody Developmental motor scale (PDMS-2) is a reliable outcome measure to assess the gross and fine motor development that measure interrelated motor abilities. It consists of six subtests reflexes, stationary, object manipulation, locomotion, grasping, a visual motor which measures the gross motor and fine motor development of the infants with 0-5 years of age.

#### GONIOMETER:

In this study, 360-degree Goniometer was used to measure the Amiel Tison angles in infants. A goniometer is an instrument that measures an angle formed at a joint which

has a stationary arm and a movable arm. The centre of the goniometer is aligned at the joint to be measured, and the arms are positioned on the body. Reliability of goniometry depends on various factors like motion measured, a method of application and variations in the different type of patients which made them adopt a standardized method of testing [16].

**PROCEDURE**

Subjects were screened for their inclusion criteria to enter into the study and informed consent was obtained from their caretakers. Birth weight and gestational age of the child was obtained from the birth records.

**Method of assessing motor development with PDMS 2:**

Chronological age of the infant was converted to corrected age before administering the PDMS-2. Depending on the corrected age the items in PDMS-2 scale were administered in each subtest according to the guidelines. The basal and ceiling scores are obtained, and the raw score is calculated. The obtained raw score for each subtest is converted to age equivalent, percentile and standard score which is finally converted into Gross motor quotient (GMQ), the Fine Motor Quotient (FMQ), and Total motor quotient (TMQ). Based on the standard scores and quotient scores the motor development is ranked whether it is very superior, superior, above average, average, below average or poor.

**Method of measuring Amiel Tison Angles:**

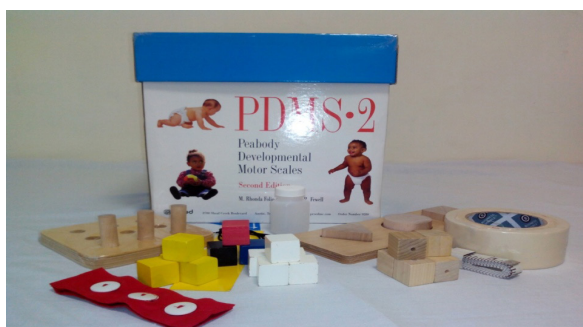
The goniometer was cleaned with sterile before and after every assessment. The child was without clothing, and the following method was adopted to measure the Amiel Tison angles (ATA).

**Adductor angle:** The infant is placed in supine position with the knees extended. The lower limbs are gently abducted, and the angle is measured by drawing an imaginary line along both inner thighs with the vertex at the symphysis pubis.

**Heel-to-ear:** The infant is placed in supine position with both knees extended and legs moved toward the head. Care is taken that pelvis does not lift off the table. The angle is measured from the table surface along the back of the leg.

**Popliteal angle:** The infant is placed in supine position with the buttocks flat on the table. The therapist places her hands over the knees, thighs are flexed, and then the lower leg is extended. The angle is measured between the thigh and calf simultaneously on both sides.

**FIGURES**



**Figure 1:** Peabody developmental motor scale 2



**Figure 2:** Goniometer

**RESULTS**

Data were analyzed with SPSS version 16.0. Pearson correlation was used to find out the correlation between the gestational age, birth weight and ATA with Peabody Developmental motor scores.

Correlation of gestational age and TMQ of PDMS-2 in PTI of 8 months corrected age did not show significant correlation whereas the correlation of Birth Weight and TMQ of PDMS-2 in PTI of 8 months corrected age showed a significant positive correlation at p-value <0.05 (Table 2). There was a negative correlation between adductor angle, Heel to ear, Popliteal angle and GMQ, FMQ, TMQ of PTI of 8 months corrected age with a statistically significant p-value <0.05 (Table 3-5)

**Table 1:** Demographic characteristics

Variables	Values
Gender	21(m/c) and (18 f/c)
Age (months)	8.00 ± 0.16
Birth weight (Kgs)	1.53 ± 0.41
Gestational age (weeks)	31.77 ± 1.99

**Table 2:** Correlation of gestational age and birth weight with TMQ of PDMS-2

Gestational Age		N	Mean	SD	r-value	p-value
		39	31.77	1.99		
PDMS-2 Score	TMQ		92.62	12.46	0.29	.067
Birth weight			1.53	0.41	0.64	.000*
PDMS-2 Score	TMQ		92.62	12.46		

\* Significant at p-value < 0.05

**Table 3:** Correlation of adductor angle with GMQ, FMQ, and TMQ of PDMS 2

Adductor angle		N	Mean	SD	r-value	p-value
		39	130.58	10.49		
PDMS-2 Score	GMQ		93.59	11.67	-0.72	.000*
	FMQ		93.23	11.58	-0.72	.000*
	TMQ		92.62	12.46	-0.73	.000*

\* Significant at p value < 0.05

**Table 4:** Correlation of heel to ear angle with GMQ, FMQ, and TMQ of PDMS-2

Hell to Ear		N	Mean	SD	r-value	p-value
		39	138.15	10.00		
PDMS-2 Score	GMQ		93.59	11.67	-0.68	.000*
	FMQ		93.23	11.58	-0.68	.000*
	TMQ		92.62	12.46	-0.69	.000*

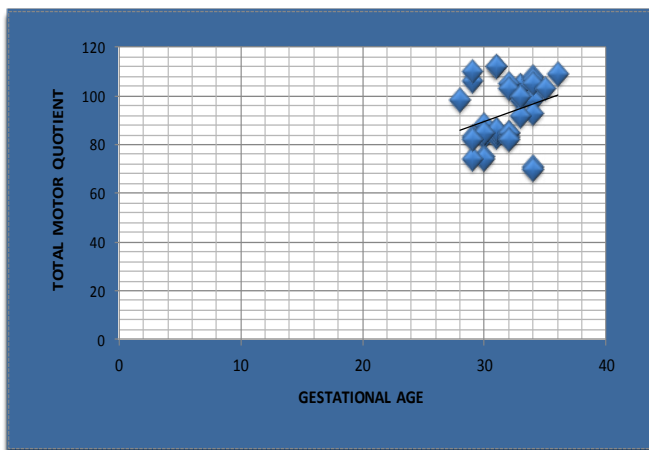
\* Significant at p value < 0.05

**Table 5:** Correlation of popliteal angle with GMQ, FMQ, and TMQ of PDMS-2

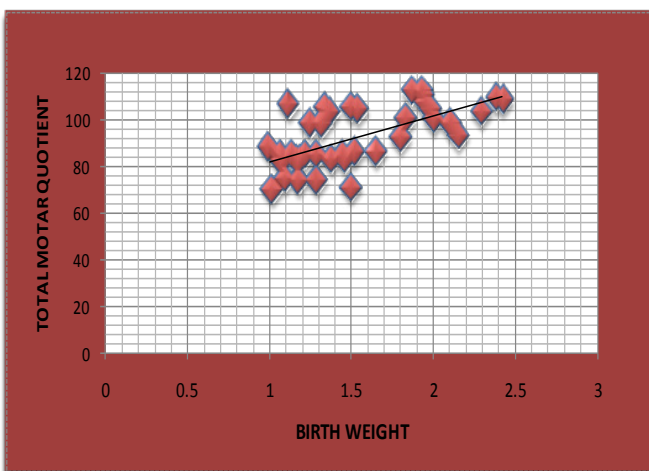
Popliteal angle		N	MEAN	SD	r-value	p-value
		39	138.03	11.64		
PDMS-2 Score	GMQ		93.59	11.67	-0.74	.000*
	FMQ		93.23	11.58	-0.72	.000*
	TMQ		92.62	12.46	-0.74	.000*

\* Significant at p value < 0.05

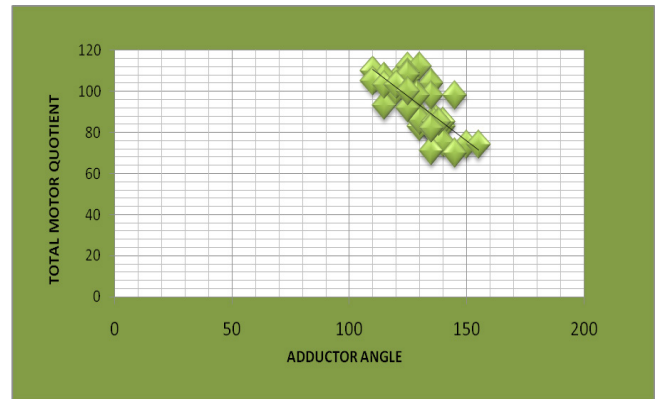
**Graph 1:** Correlation of gestational age with TMQ of PDMS - 2



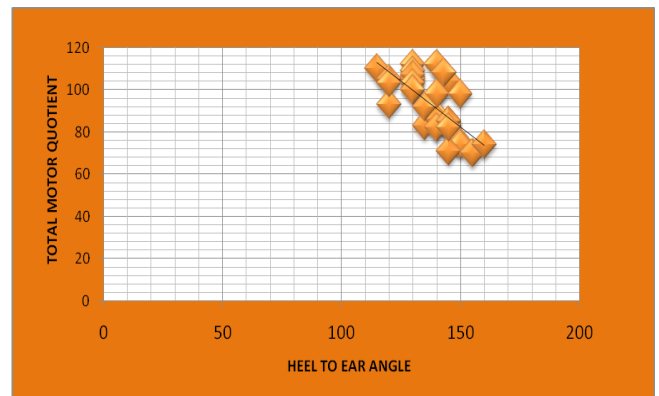
**Graph 2:** Correlation of birth weight with TMQ of PDMS - 2



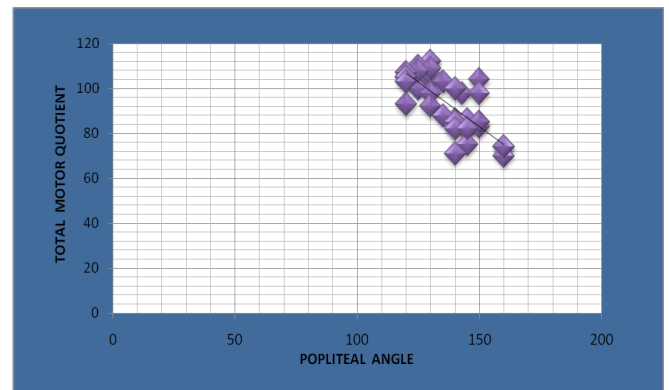
**Graph 3:** Correlation of adductor angle with TMQ of PDMS - 2



**Graph 4:** Correlation of heel to ear with TMQ of PDMS - 2



**Graph 5:** Correlation of popliteal angle with TMQ of PDMS - 2



## DISCUSSION

Developmental assessment of preterm infants is done at regular intervals to identify the delay in various domains which help the clinicians to initiate early intervention and enhance normal development. Muscle tone in PTI is lower actively and passively at birth. Though PTI was similar in muscle tone compared with FTI at 40 weeks of corrected gestational age, flexor tone is never achieved in full degree. They demonstrate more extension and difficulty moving against gravity due to maturation-related hypotonia in the first few months. The impact of this tonal deviation on the motor development of PTI was not explored. This study intended to find the correlation of gestational age, birth weight and muscle tone with motor development at eight months of corrected age in which 39 PTI with gestational age less than 36 weeks were included.



Correlation of gestational age and motor development did not show significance at eight months of corrected age (Table-2). This is in contrast with the study done by I.C. Van Haastert et al. (2006) [17] where PTI showed significantly lower scores in all levels compared to age-matched normative values and Tina et al. (2000) [18] analysed the Growth and development prospectively up to 56 months and found that small for gestational age was related to Developmental delay initially but decreased with increasing age. Both the studies looked at an age group of more than one year which showed a significant delay, but the current study was done at eight months.

Infants with decreased birth weight showed a delay in motor development as evident by positive correlation which is similar to the study done by Mary L Hediger et al. (2002) [19] where association of birth weight and motor and social development was done in children of 2-47 months of corrected age which showed small but measurable delay in motor and social development but the present study shows a significant correlation. Birth weight is directly proportional to the growth of all the systems in the newborn babies. Though a preterm baby increases in weight after birth based on the nutritional, environmental and social factors, their developmental pathways are found to be different compared to a child born full term.

The mean value of adductor, heel to ear, and popliteal is 130.58, 138.15, 138.03 which says that though they are within the normal physiological limits, they are at a higher end for eight months of corrected age. This shows that subtle maturation-related hypotonia in preterm is carried in the first year of life. This finding of muscle tone differed from a study done by Piper et al. 2008 [20] on motor development in PTI of two groups less than 32 and greater than 32 weeks of gestation at four months chronological and adjusted age which showed that both groups did not differ significantly in muscle tone.

The negative correlation of Adductor, heel to ear and popliteal with PDMS -2 GMQ, FMQ, TMQ conveys that subtle hypotonia has a direct impact on the motor development of PTI at eight months of corrected age. The combined muscle power present in shoulder and legs during the first year of life are found to be the best predictor of neuromotor behavior as described by Janny F Samson et al. (2002) [21]. As normal muscle tone forms the basis for normal muscle power, a decrease in muscle power could be due to the decrease in muscle tone resulting in decreased neuromotor development. Upper extremity muscle tone was not considered which could also influence the motor development and sample size could have been large with a follow up at 1 year of corrected age to know the status of muscle tone which could be the limitations of this study.

## CONCLUSION

The result of the study conveys that maturation-related hypotonia is carried in PTI during the first year of life and has an impact on motor development which insists the clinicians to consider strategies in improving the muscle

tone in the early stage to prevent motor delays in these infants.

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