

# THE INFLUENCE OF GESTATIONAL AGE AND BIRTH WEIGHT IN THE CLINICAL ASSESSMENT OF THE MUSCLE TONE OF HEALTHY TERM AND PRETERM NEWBORNS

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**ABSTRACT - Objective:** To evaluate the influence of gestational age (GA) and birth weight (BW) in the clinical assessment of the muscle tone of healthy term and preterm newborns. **Method:** Cross sectional study. The muscle tone of healthy 42 preterm and 47 term newborns was quantified and measured with a goniometer (an instrument for measuring angles) respectively between 7<sup>th</sup>-14<sup>th</sup> day of life and 24-48 hours of life. Newborns were grouped according to GA and BW and evaluated at fixed time intervals by one examiner. Preterm newborns were matched to term at 40 weeks postconceptional age (PCA). **Results:** The evolution of muscle tone in the preterm occurred gradually, following PCA, independent of birth weight. Preterm newborns had lower scores in all muscle tone indicators when compared to term at the first assessment. Differences were observed among preterm small for GA and adequate to GA for the indicator heel to ear ( $p < 0.001$ ). When compared at 40 weeks PCA, except for posture, all other indicators were significantly different ( $p < 0.001$ ) among groups. **Conclusion:** Prematurity and intrauterine malnutrition are influential factors in some indicators of the newborn muscle tone state. Muscle tone assessment of preterm infants does not seem to be influenced by birth weight, however evolution is clearly related to postconceptional age. When we compared term newborns AGA and SGA it seems to have a clear influence of the birth weight on some indicators of the muscle tone. The use of devices such as the goniometer allows the performance of a more objective assessment of muscle tone and helps to quantify findings.

**KEY WORDS:** preterm newborns, muscle tone, low birth weight, intrauterine malnutrition.

## A influência da idade gestacional e do peso ao nascimento na avaliação clínica do tônus muscular de recém nascidos a termo e prematuros hígidos

**RESUMO-Objetivo:** Verificar a influência da idade gestacional (IG) e do peso ao nascimento (PN) na avaliação do tônus muscular de recém nascidos (RN) a termo e prematuros hígidos. **Método:** Estudo transversal. O tônus muscular de 42 RN prematuros e 47 termo foi quantificado e mensurado com goniômetro (instrumento para medir ângulos), respectivamente entre 7-14 dias de vida e 24-48 horas de vida. Os RN foram agrupados de acordo com IG e PN, sendo avaliados em intervalos fixos. RN prematuros foram comparados aos a termo na 40<sup>a</sup> semana de idade concepcional (IC). **Resultados:** A evolução do tônus muscular nos RN prematuros ocorreu de forma gradual de acordo com IC e independente do PN. RN prematuros, na primeira avaliação apresentaram escores de tônus muscular inferiores aos de RN a termo em todos os indicadores. Foram observadas diferenças entre RN prematuros pequenos e adequados para a IG em relação ao indicador calcanhar-orelha ( $p < 0,001$ ). O pareamento dos grupos na 40<sup>a</sup> semana de IC mostra, exceto pela postura, diferença significativa entre os grupos ( $p < 0,001$ ) nos demais indicadores. **Conclusão:** A prematuridade e a desnutrição intrauterina são fatores que influenciam diferentes aspectos do tônus muscular. Em prematuros o tônus muscular não parece sofrer influência do peso de nascimento e sua evolução é relacionada ao aumento da IC. Quando comparados RN a termo PIG e AIG observa-se influencia do PN no tônus muscular. O uso de instrumentos como o goniômetro permite avaliação mais acurada do tônus muscular e auxilia na respectiva quantificação do mesmo.

**PALAVRAS-CHAVE:** prematuro, tônus muscular, baixo peso ao nascimento, desnutrição intrauterina.

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Advances in perinatal care and the increasing number of neonatal intensive care units with high level of technology have significantly contributed for the reduction of mortality and morbidity of high risk newborns. Despite the technological and scientific progress, newborns that require neonatal intensive assistance are estimated to be at higher risk to develop neurological problems<sup>1,2</sup>. Both, low birth weight and prematurity, as well as neonatal clinical problems like seizures, perinatal asphyxia, necrotizing enterocolitis, intraventricular hemorrhage and others, are considered frequent risk factors to neurological sequels and unfavorable neurological outcome<sup>2,3</sup>. Approximately two-thirds of all deaths occurring during the first month of life are related to prematurity placing it as the main cause of neonatal death. Intrauterine growth delay appears in second place with 14% of all the stillborn and 6% of all the neonatal deaths<sup>4</sup>. Recent studies concerning the influence of intrauterine growth restriction (IUGR) in morbidity and mortality of preterm newborns have observed that each marker of IUGR was associated with increased mortality and more adverse outcome<sup>5-8</sup>.

According to Lubchenco the importance of birth weight and gestational age in the prognosis of newborn babies is justified for the important role that both represent in the maturation of many systems in preterm infants<sup>9</sup>. Therefore, birth weight and gestational age are variants interrelated and possible deviations out of the range of normality in any of these parameters may predispose the appearance of neurological problems<sup>2</sup>. About 70% to 75% of newborns that are discharged from the intensive care units still present low to medium risk for problems in the neurological development and this ratio increases as the weight and gestational age decreases<sup>10</sup>. Intrauterine malnutrition seems to influence central nervous system (CNS) maturation anatomically and functionally<sup>11,12</sup>. Newborns with low birth weight frequently show abnormalities in their neurological outcome. These abnormalities might be transitory and expressed as depression in posture and movement, as well as diminished muscle tone and coarse motor functions retardation<sup>13</sup>. It has been previously established that the development of muscle tone of preterm and term newborns is intimately related to CNS maturation, therefore the clinical evaluation of muscle tone is a reliable indicator of the neurological status in the neonatal period<sup>13,14</sup>.

The aim of this study was to evaluate the influence of gestational age and birth weight in the de-

velopment of muscle tone in preterm newborns and also to compare the clinical assessment of muscle tone in preterm and term newborns matched at 40 weeks of conceptional age (CA). We propose the use of graduated scales and goniometry to measure the angles with the purpose to obtain more reliable and objective results.

## METHOD

A cross-sectional study associated to a prospective birth-cohort of preterm and fullterm infants was developed. Newborns were selected in the Neonatal Intensive Care Units (NICU) and in the Nurseries of Hospital São Lucas, University Hospital of the Pontifícia Universidade Católica do Rio Grande Do Sul (HSL - PUCRS) and the Hospital da Criança Nossa Senhora da Conceição (HCN-SC), both located in Porto Alegre - Brazil.

*Patients* – Newborns from the two institutions, admitted by the Brazilian social security system (SUS - Brazil), were selected over a 12 months period, consecutively included in the sample, and randomized to one of the study groups according to the following criteria: Groups I and II consisted of preterm newborns (gestational age <37 weeks), without neurological disorders, with birth weight respectively adequate for gestational age (AGA) or small for gestational age (SGA); Groups III and IV consisted of normal term newborns (gestational age ≥37 <42 weeks) AGA or SGA.

The nutritional status (birth weight) in relation to gestational age was classified in accordance to Battaglia and Lubchenco scales, which are widely used in our country<sup>15</sup>. The pediatric gestational age was calculated by the neonatologist using the Capurro method for term infants and the New Ballard method for preterm newborns<sup>16,17</sup>. Conceptional age was calculated as gestational age plus days/weeks of extra uterine life. Preterm newborns should have an Apgar score at the 5<sup>th</sup> minute higher than 7, term newborns should have Apgar scores higher than 7 at the 1<sup>st</sup> minute and higher than 8 at the 5<sup>th</sup> minute. Exclusion criteria for preterm newborns were the use of mechanical ventilation, the diagnosis of neurological disorders, cardiopathies, abandonment of the study before the 40<sup>th</sup> week of CA or be carrying out precocious stimulation. Exclusion criteria for term newborns were abnormal neurological examination or suspicion of any clinical or surgical neonatal problem.

The Ethics Committee of both hospitals approved the project and written informed consent was obtained from the parents authorizing the assessment of their child.

*Procedures* – The same person performed the first examination and follow-up. The first assessment of preterm newborns occurred between 7 and 14 days after birth, in the NICU, without clothing, inside the incubator or warm cradle. These newborns were follow-up un-

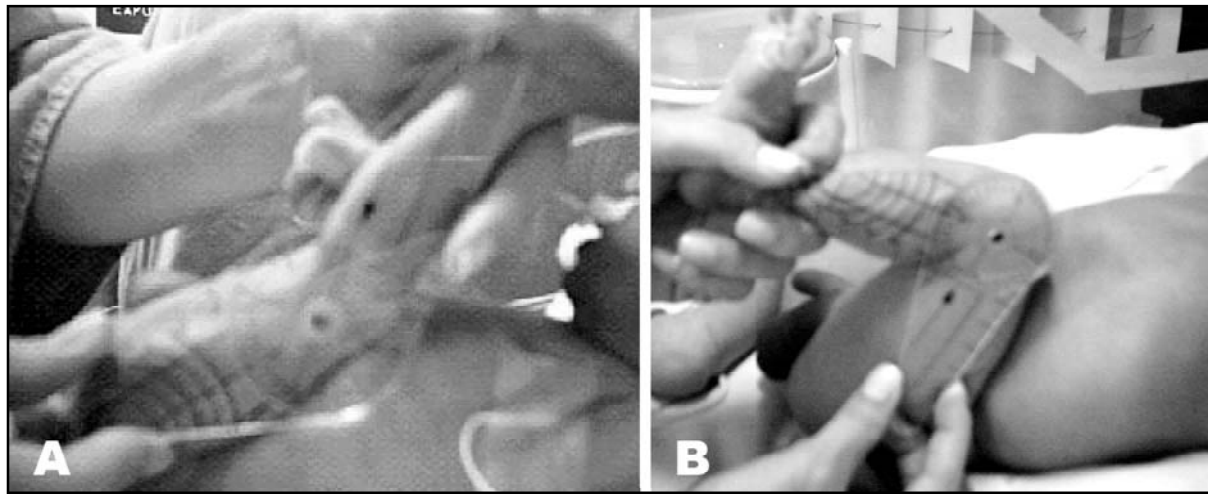


Fig 1. Measurement of popliteal angle with a goniometer in a) preterm newborn and b) term newborn.

Table 1. First assesment of muscle tone in groups I - IV.

Characteristics	G I preterm AGA n= 27	G II preterm SGA n= 15	G III term AGA n= 24	G IV term SGA n= 23	p
Posture (score 0-5)	3.0±0.6 <sup>b</sup>	3.3±0.8 <sup>a,b</sup>	3.7±0.6 <sup>a</sup>	3.5±0.6 <sup>a,b</sup>	0.006
Wrist-flexion (degrees 180-0°)	22.7±11.8 <sup>c</sup>	26.7±15.9 <sup>c</sup>	45.6±12.7 <sup>a</sup>	37.0±11.1 <sup>b</sup>	<0.001
Arm recoil (degrees 180-0°)	161.6±19.3 <sup>c</sup>	161.0±24.1 <sup>c</sup>	113.3±23.9 <sup>a</sup>	129.6±17.7 <sup>b</sup>	<0.001
Popliteal angle (degrees 0-180°)	143.3±14.8 <sup>c</sup>	142.0±11.9 <sup>c</sup>	107.5±12.3 <sup>a</sup>	123.0±12.1 <sup>b</sup>	<0.001
Scarf sign (score 0-5)	0.6±0.6 <sup>c</sup>	0.5±0.5 <sup>c</sup>	2.9±0.6 <sup>a</sup>	2.4±0.5 <sup>b</sup>	<0.001
Heel to ear (score 0-5)	2.3±0.5 <sup>c</sup>	1.9±0.7 <sup>d</sup>	3.3±0.6 <sup>a</sup>	2.7±0.5 <sup>b</sup>	<0.001

Data are presented as mean ± standard deviation. Non coincident index letters represent statistically significant differences to the Post Hoc test of Student-Newnaw-Keuls.

til they reached 40 weeks conceptional age. If they were discharged from hospital before reaching this age, the second evaluation was scheduled in the neurodevelopment outpatient clinic or at home. Term newborns were submitted to only one evaluation between 24 and 48 hours after birth, in the hospital, before discharge.

The neurological assessment was based on the protocol used in the Division of Neurology of the Hospital São Lucas - PUCRS<sup>18</sup>. Muscle tone evaluation was adapted for this research from the protocols proposed by Saint-Anne Dargassies, Ballard et al., Amiel - Tison and Goselin e Dubowitz et al.<sup>13,19</sup>. Six posture patterns were evaluated in the infants. Posture, scarf sign and heel-to-ear maneuver were measured through scores graduated from 0 to 5, in this graduation lower scores were related to immaturity. Wrist-flexion was measured with the goniometer, in degrees (from 90 to 0°), larger angles were related to immaturity. The angle resulting from the arm

recoil maneuver was also measured with the goniometer (from 180 to 0°) larger angles were related to immaturity. The popliteal angle was also measured in degrees through goniometry, and larger angles (close to 180°) were related to immaturity (Fig 1 A,B).

The examiner was not blind for the groups, when doing the muscle tone assessment, due to obvious visual differences between the newborns.

*Statistical analysis* – The comparison of muscle tone development in preterm newborns at 7-14 days of life and at 40<sup>th</sup> weeks was made with a non-parametric test (Wilcoxon for paired samples). The comparison of preterm newborns, matched to term newborns at 40 weeks post-conceptional age was analyzed through the variation analysis (ANOVA-Oneway). The localization of differences between the groups was determined through the test of multiple comparisons Post Hoc Student-Newnaw-Keuls.

Table 2. Muscle tone evolution in preterm infants AGA.

Characteristics	G I preterm AGA n= 27	G I preterm AGA (40 wks PCA) n=27	p
Posture (score 0-5)	3.0±0.6	3.6±0.4	0.002
Wrist-flexion (degrees 180-0°)	22.7±11.8	37.4±8.1	<0.001
Arm recoil (degrees 180-0°)	161.6±19.3	149.6±23.6	0.001
Popliteal angle (degrees 0-180°)	143.3±14.8	122.4±7.1	<0.001
Scarf sign (score 0-5)	0.6±0.6	1.1±0.4	<0.001
Heel to ear (score 0-5)	2.3±0.5	2.7±0.4	0.005

Data are presented as mean ± standard deviation. Test used ANOVA.

Table 3. Muscle tone evolution on preterm infants SGA.

Characteristics	G II preterm SGA n= 15	G II preterm SGA (40 wks) n=15	p
Posture (score 0-5)	3.3±0.8	3.8±0.5	0.033
Wrist-flexion (degrees 180-0°)	26.7±15.9	44.0±20.5	0.001
Arm recoil (degrees 180-0°)	161.0±24.1	144.0±27.7	0.016
Popliteal angle (degrees 0-180°)	142.0±11.9	125.6±14.7	0.001
Scarf sign (score 0-5)	0.5±0.5	1.0±0.5	0.005
Heel to ear (score 0-5)	1.9±0.7	2.6±0.6	0.001

Data are presented as mean ± standard deviation. Test used ANOVA.

Table 4. Comparison of muscle tone among the groups matched at 40 weeks post concepional AGE.

Characteristics	G I preterm AGA n=27	G II preterm SGA n=15	G III term AGA n= 24	G IV term SGA n= 23	p
Posture (score 0-6)	3.6±0.4 <sup>a</sup>	3.8±0.5 <sup>a</sup>	3.7±0.6 <sup>a</sup>	3.5±0.6 <sup>a</sup>	0.390
Wrist-flexion (degrees 180-0°)	37.4±8.1 <sup>a</sup>	44.0±20.5 <sup>a</sup>	45.6±12.7 <sup>a</sup>	37.0±11.1 <sup>a</sup>	0.133
Arm recoil (degrees 180-0°)	149.6±23.6 <sup>c</sup>	144.0±27.7 <sup>c</sup>	113.3±23.9 <sup>a</sup>	129.6±17.7 <sup>b</sup>	<0.001
Popliteal angle (degrees 0-180°)	122.4±7.1 <sup>b</sup>	125.6±14.7 <sup>b</sup>	107.5±12.3 <sup>a</sup>	123.0±12.1 <sup>b</sup>	<0.001
Scarf sign (score 0-6)	1.1±0.4 <sup>c</sup>	1.0±0.5 <sup>c</sup>	2.9±0.6 <sup>a</sup>	2.4±0.5 <sup>b</sup>	<0.001
Heel to ear (score 0-6)	2.7±0.4 <sup>b</sup>	2.6±0.6 <sup>b</sup>	3.3±0.6 <sup>a</sup>	2.7±0.5 <sup>b</sup>	<0.001

Data are presented as mean ± standard deviation. Non coincident index letters represent statistically significant differences to the test of Post Hoc of Student-Newnaw-Keuls.

Sample size was previously estimated in order to reach the significance level adopted of 0.05. The database was mounted in the Excell program and the statistical analysis was performed with SPSS program version 11.0.

## RESULTS

After the first assessment two preterm SGA newborns died and one presented seizures and evolved to mechanical ventilation. Four preterm infants, being three of them AGA and one SGA did not returned to the 40th week postconceptional age visit and were lost for follow up. A final sample of 89 newborns (27 males and 62 females) was reached. Group I (preterm AGA) consisted of 27 infants with gestational age ranging from 31 to 35 weeks (mean  $33.5 \pm 1.1$ ), Group II (preterm SGA) consisted of 15 infants with gestational age between 32 and 36 weeks (mean  $33.9 \pm 1.6$ ), Group III (term AGA) was constituted by 24 newborns with gestational age of 40 weeks and Group IV (term SGA) consisted of 23 infants with gestational age between 39 and 40 weeks (mean  $39.9 \pm 0.3$ ).

Table 1 shows the first assessment of muscle tone in preterm newborns compared to term, significant differences were observed in all scores. When evaluating the influence of birth weight (preterm AGA compared to SGA) significant differences were observed only in the heel to ear maneuver. However, when comparing term AGA to term SGA newborns, significant differences were observed on 5/6 measurements, suggesting an influence of intrauterine malnutrition in the muscle tone of term newborns.

Tables 2 and 3 shows muscle tone evolution of preterm infants between the first and the second evaluation (40<sup>th</sup> weeks). Both groups presented significant differences when comparing the first to the second evaluation, suggesting an influence of conceptional age on muscle tone.

Table 4 shows the results of the 4 groups matched at 40 weeks CA. Except for posture and wrist flexion significant differences were observed between the groups. The arm recoil maneuver and the scarf sign showed similar results between preterm groups (AGA and SGA). However, significant differences were observed between term groups (AGA and SGA) and between preterm and term newborns. Measurements of popliteal angle and heel-to-ear maneuver had similar scores between preterm newborns (AGA and SGA) and SGA term newborns and were significantly different from term AGA.

## DISCUSSION

The present study had as objective to evaluate

the influence of gestational age and birth weight in the muscle tone of newborns. Possibly, the most important aspect of our study, and the difference from previous studies was the use of the goniometry for the measurement of the muscle tone indicators, since this method allows greater precision. Most of the studies related to the maturation of muscle tone are based on visual observations of the researcher.

Comparing preterm and term newborns, we have observed that preterm AGA and SGA have presented muscle tone more immature than their term counterparts (term AGA and SGA). Our findings were similar to van-Kranen-Mastenbrock and collaborators<sup>20</sup>. Palmer and collaborators observed that preterm infants presented a more extended posture in the first and fifth day of life when compared to term infants and later when paired at 40 weeks conceptional age<sup>21</sup>. Differences between our study and the former can be explained as 34% of the preterm newborns evaluated by these authors had gestational age lower than 32 weeks. Besides, they did not exclude serious complications related to prematurity, like hyaline membrane disease and septicemia. Another justification could be related to the stress of delivery. In our study the preterm infants were evaluated between 7 and 14 days of life and the term newborns between 24-48 hours of life to avoid stress of delivery and more severe clinical instability while in the previous study this evaluation was made between the 1<sup>st</sup> and 5<sup>th</sup> day of life.

The influence of birth weight on the indicators of muscle tone was observed when we compared term AGA to SGA newborns. Term SGA newborns presented diminished muscle tone in all indicators studied, except for posture. Curiously, the heel to ear maneuver was also the only one to suffer the influence of birth weight when we compared preterm AGA to SGA newborns. This finding suggests that nutritional status exerts some influence on the distal maturation of the muscle tone in preterm newborns.

When analyzing the evolution of muscle tone in the preterm groups from birth to 40 weeks postconceptional age, both preterm groups presented significant increase in all the indicators of muscle tone demonstrating that its maturation occurs gradually, following postconceptional, independent of the initial nutritional status. The comparison of muscle tone among groups matched at 40 weeks postconceptional age showed significant differences. Except for the indicators posture and wrist - flexi-

on, term AGA newborns had better scores than term SGA or preterm newborns, suggesting that the association of prematurity and low birth weight magnifies its influence on muscle tone.

In a previous study, Knobloch, did not observed any posture that characterized a specifically gestational age<sup>22</sup>. Prechtl and Beintema agree that there is not an age-dependent posture<sup>23</sup>. Our findings are similar to these authors since the posture indicator does not presented significant difference between the studied groups. However, the classical study of Saint-Anne Dargassies showed different results. She observed an increased joint mobility promoting a more extended posture in preterm newborns when matched with term newborns<sup>13</sup>.

Kurtzberg and collaborators reported reduced flexor tone (posture, arm traction, arm recoil and leg recoil) in preterm newborns at 40 weeks<sup>24</sup>. Palmer and collaborators observed significant difference concerning arm recoil<sup>21</sup>. In our study the arm recoil maneuver was significantly different between the matched preterm and term groups. According to Saint-Anne Dargassies this fact can be possibly explained by the intrauterine space that does not offer limit and resistance to the joints<sup>13</sup>.

Kurtzberg and collaborators have observed differences in the popliteal angle between term and preterm newborns. In their study approximately 90% of the term newborns and 54% of preterm newborns presented popliteal angle smaller than 120 degrees<sup>24</sup>. Our results did not differ from literature. In the group of AGA term infants, the popliteal angle had a median  $107.5 \pm 12.3$  degrees, while preterm AGA and SGA presented a median angle of  $122.4 \pm 7.1$  and  $125.6 \pm 14.7$  degrees respectively.

Concerning the scarf sign maneuver, our results were in accordance to the previous findings of Saint-Anne Dargassies<sup>13</sup> as preterm newborns presented significantly bigger displacements of the elbow in relation to the trunk than the term infants.

In a recent study authors compared obstetric, pediatric and a neurological scale based on muscle tone assessment to evaluate gestational age in preterm infants. The neurological scale was as accurate as the others<sup>25</sup>.

The influence of extra-uterine development in preterm newborns has been a subject of many previous papers, mainly in the field of neurophysiology. However, differences in methodology have lead to divergent opinions. Some researchers agree that CNS maturation occurs independently of the extra

uterine development<sup>26-28</sup>, in the other hand others have showed delayed EEG features in preterm newborns when matched with term<sup>29</sup>. When analyzing both approaches (neurphysiological and muscle tone assessment) it seems that the last methodology is more sensitive to detect differences between preterm and term newborns, when matched at term.

In a recent paper, Sarnat has demonstrated that corticospinal and corticobulbar tracts are immature at birth in terms of myelination and terminal axonal sprouting and this immaturity can influence muscle tone and posture<sup>30</sup>. These findings might explain the modifications observed in our study among the first and second assessment in the preterm groups.

Muscle tone assessment of preterm infants does not seem to be influenced by birth weight, however evolution is clearly related to postconceptional age. On the other hand, when we compared the two groups of term newborns among themselves (AGA and SGA) it seems to have a clear influence of the birth weight on some indicators of the muscle tone.

In conclusion, we have observed that prematurity and intrauterine malnutrition are influential factors in some indicators of the newborn muscle tone state. The evolution of muscle tone in preterm newborns occurs gradually according to the increase of postconceptional age, independent of birth weight. Muscle tone in term newborns is influenced by birth weight. The use of scales and devices such as the goniometer allowed us to perform a more reliable and objective assessment of muscle tone and helped to quantify our findings.

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