Small-for-gestational-age newborn infant: repercussion on fine motor skills

Recém-nascido pequeno para a idade gestacional: repercussão nas habilidades motoras finas

Pequeño para la edad gestacional: repercusión en las habilidades motoras finas

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ABSTRACT

Objective: To compare the fine motor skills of full-term small-for-gestational-age (SGA) and appropriate-for-gestational-age (AGA) infants in the third month of life.

Methods: This observational cross-sectional study enrolled 67 infants (21 SGA and 46 AGA) in the third month of life. Infants presenting genetic syndromes, congenital malformations, congenital infections and those who needed neonatal intensive care were excluded. The Bayley Scales of Infant Development-II were used, with emphasis on items that evaluate the fine motor skills.

Results: No differences were observed between groups for motor (p=0.21) and mental (p=0.45) scales in the third month. There was a significant difference between the groups on the item "Reaches for Suspended Ring" (Fisher's exact test; p-value=0.02): a higher percentage of SGA infants accomplished this item in the third month of life.

Conclusions: We hypothesize that the difference found in the item "Reaches for Suspended Ring" could be attributed to an increased frequency of arm movements observed in SGA infants and not to a better neurodevelopment of this group.

Key-words: fetal growth retardation; infant behavior; psychomotor performance; motor skills.

RESUMO

Objetivo: Comparar as habilidades motoras finas de lactentes nascidos a termo pequenos para a idade gestacional (PIG) com as habilidades dos nascidos adequados para a idade gestacional (AIG) no terceiro mês de vida.

Métodos: Realizou-se um estudo observacional de corte transversal. Avaliaram-se 67 lactentes (21 PIG e 46 AIG) no terceiro mês de vida. Portadores de síndromes genéticas, malformações congênitas, infecções congênitas e aqueles que necessitaram de unidade de terapia intensiva neonatal foram excluídos. As Escalas Bayley II de Desenvolvimento Infantil foram utilizadas, com ênfase nos itens que avaliam as habilidades motoras finas.

Resultados: Não se observaram diferenças entre os grupos na escala motora (p=0,21) e mental (p=0,45) no terceiro mês de vida. No item "Alcança o Aro Suspenso", houve diferença significativa (teste Exato de Fisher; p=0,02), demonstrando maior frequência de execução para o grupo PIG no terceiro mês de vida.

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Conclusões: Supõe-se que a diferença encontrada no item "Alcança o Aro Suspenso" possa ser atribuída à grande ocorrência de movimentos dos braços observada no grupo PIG e não a uma condição melhor de desenvolvimento desse grupo.

Palavras-chave: retardo do crescimento fetal; comportamento do lactente; desempenho psicomotor; destreza motora.

RESUMEN

Objetivo: Comparar las habilidades motoras finas de lactantes nacidos a término pequeños para la edad gestacional (PEG) con adecuados para la edad gestacional (AEG) en el 3er mes de vida.

Métodos: Se realizó un estudio observacional de corte transversal. Se evaluaron a 67 lactantes (21 PEG y 46 AEG) en el 3er mes de vida. Síndromes genéticos, malformaciones congénitas, infecciones congénitas y aquellos que necesitaron de unidad de terapia intensiva neonatal fueron excluidos. Las Escalas Bayley II y de Desarrollo Infantil fueron utilizadas, con énfasis en los ítems que evalúan las habilidades motoras finas.

Resultados: No se observaron diferencias entre los grupos en la escala motora (p=0,21) y mental (p=0,45) en el 3er mes de vida. En el ítem "alcanza aro suspendido" hubo diferencia significativa (p=0,02; prueba Exacta de Fisher), demostrando mayor frecuencia de ejecución para el grupo PEG en el 3er mes de vida.

Conclusiones: Se supone que la diferencia encontrada en el ítem "alcanza el aro suspendido" pueda ser atribuida a la gran ocurrencia de movimientos de los brazos observada en el grupo PEG y no a una condición mejor de desarrollo en este grupo.

Palabras-clave: retraso del crecimiento fetal, comportamiento del lactante, desempeño psicomotor, destreza motora.

Introduction

the development of small-for-gestational-age (SGA) newborns has continually been target of research because it is considered a model of malnutrition at early age. Since the 1960s and 70s, the attention of researchers has been caught by the fact that SGA infants suffer from a certain degree of malnutrition, a condition that could permanently limit their intellectual capacity in a technologically advanced world[1]. Intrauterine malnutrition, which is defined as birth weight below the 10th percentile of the birthweight-for-gestational-age reference curve, affects 23.8%, or approximately 30 million newborns per year. Overall, nearly 75% of all affected newborns are born in Asia, mainly in South-central Asia, 20% in Africa, and approximately 5% in Latin America. Although some of them are healthy, in most developing countries a large proportion of newborns suffer from some degree of intrauterine malnutrition[2].

While the neurodevelopment of preterm SGA and appropriate-for-gestational-age (AGA) children has been extensively studied during the past decades, much less attention has been paid to term SGA children. Although there is some evidences that SGA term infants may be associated with an increased risk of cerebral palsy, this affects very few children, being more common the neurodevelopmental deficits[3]. Some authors have reported motor delay at some stages in infancy[4-10], a higher prevalence of motor problems related to academic achievement in adolescents, and professional attainment in adults[11]; however, other studies do not support these findings[12, 13].

Early identification of children with motor impairments is important in order to provide support and intervention for the child (and parents) as early as possible. Optimal treatment for motor problems may reduce academic and psychosocial problems[14]. Very little research has attempted to assess specifically fine motor skills in full-term SGA infants. They consist in an important ability in early development and can provide a warning to the delayed motor development. For instance, object exploration plays a central role in the early development of perception, action, and memory. By seeing and touching objects, by bringing them to the mouth, and by manipulating them, infants can learn about their physical properties, remember their specific characteristics, and use this newly acquired knowledge to plan future actions[15]. The importance of these skills is reported to the older children too. Children spend 31 to 60% of their school day performing handwriting and other fine motor tasks, and difficulty in this area can interfere with their academic achievement. Fine motor control, bilateral and visual-motor integration, motor planning, in-hand manipulation, proprioception, visual perception, sustained attention, and sensory awareness of the fingers are some of the component skills that may interfere with future performance of handwriting[16]. The first months of life have been seen as an important period for early detection of neuromotor developmental disorders. Some studies showed that the observation of generalized

spontaneous movements, between two and four months postterm, has predictive power for the development of coordination problems and fine manipulative disability in later childhood[17, 18].

Taking to account that there are few studies related to SGA infants in developing countries, especially studies with regard to fine motor skill, that identifying infants with less obvious delays can be a challenge, because such disabilities only become obvious gradually over time[19]; and that identifying infants at risk during the first trimester of life provides the opportunity of early referral for interventional services[20], this study was designed to increase knowledge about the fine motor skill of an understudied group, with possible clinical perspective of early detection. The purpose of this study was to compare the fine motor skills between full-term SGA with AGA infants in the 3rd month of life.

Methods

The research design consisted of an observational cross-sectional study of two cohorts of full-term infants, one of full-term SGA group and another of control AGA group. This project was approved by the Research Ethics Committee at the Faculty of Medical Sciences of the University of Campinas (Unicamp), according to the provisions and principles of resolution 196/96 of the National Health Council.

A neonatologist selected 125 neonates delivered at Neonatology Service of the Center of Integral Attention to the Woman's Health (Caism/Unicamp), São Paulo, Brazil, between May 2000 and July 2003. When a SGA neonate was chosen, the following two AGA neonates were selected. The subjects were selected using the following criteria: 1) subjects living in the metropolitan area of Campinas; 2) newborns of single-fetus pregnancies, 3) considered to be in good health, allowing they go home within two days of birth; 4) gestational age categorized as full-term (37-41 weeks)[21] by the Capurro method; 5) expected birth weight categorized by the Battaglia and Lubchenco method[22]; birth weight less than 10th percentile for the SGA group and between 10th and 90th percentiles for the AGA group; and 6) parents were willing to sign the consent forms. Neonates with genetic syndromes, multiple congenital malformations and congenital infections (syphilis, toxoplasmosis, rubella, cytomegalovirus and herpes) were excluded.

From the initial selected sample (125), 95 (33 PIG e 62 AIG) infants returned for at least one assessment during the first year, at 3rd month 67 full term infants (21 SGA and 46 AGA) were assessed and integrated the studied group. The number of participants selected for the study was signed during the three years of project development, considering the period of selection and assessment of subjects consistent with the deadlines for commencement and completion of the project and consistent with the demand of hospitalizations for pregnancy resolution in CAISM/UNICAMP. The number of participants was composed of all subjects who met the criteria for inclusion in the current period of the project, who joined the study and were evaluated at 3 months of life.

Accurate tools for measuring development are central in identification, classification and diagnosis of neurodevelopmental delays. Among these, the Bayley Scales of Infant Development (BSID-II) are commonly used in scientific studies and are considered gold standard for assessing children's development[23]. In this study, the instrument used for examining the developmental functioning of infants was the BSID–II, which consists of three scales – mental, motor and behavior rating scales[24]. Considering that BSID-II allows to study skill related items, in order to understand specific functional abilities of infants, the items *"manipulates ring"*, *"reaches for suspended ring"*, *"grasps suspended ring"* and *"carries ring to mouth"* were selected to investigate the fine motor skills in the 3rd month.

The infant's score for each item was registered in the motor and mental scale record forms. The BSID-II motor and mental scale scores were obtained from the number of tests undergone by the infant. By summing the number of tests equivalent to earlier ages, the raw score (RS) was obtained. The RS score was converted into standardized points, obtaining an index score (IS) with a mean of 100 and a standard deviation of 15. Based on their IS, infants can be classified as having accelerated performance (IS ≥ 115), within normal performance limits (IS 85 to 114), mildly delayed performance (IS 70 to 84) or significantly delayed performance (IS ≤ 69). The motor and mental IS indicate the performance of infant at a given age on BSID-II. To further aid interpretation of infant's performance, it may also be examined the infant's performance on an item or set of items in isolation to gain more insight into that performance and it could allow more precise research[24].

All infants were assessed at the Laboratory for Study of Child Development of Unicamp. The testing room was quiet, well lit, well ventilated, without bright or colorful pictures, and free of distractions. All infants were assessed in the presence of their mothers during intervals between feeds, when infants were alert and cooperative. The infants were

evaluated at three months of age and the range permitted was seven days before or after the respective age of assessment[24].

Assessments were performed by an examiner and simultaneously monitored by two observers who were unaware of the classification of the neonate's group. The testers comprised a pediatric neurologist, a pediatrician and a physical therapist, members of the Interdisciplinary Group for Infant Development Evaluation (GIADI). Prior to the assessments, the testers participated in the reliability training for the BSID-II, consisting of a didactic session of approximately 20 hours; each tester observed 12 videotaped tests and scored independently. The intraclass correlation coefficient was 0.95 ($p<0.001$), with a 95% confidence interval of 0.88-0.98.

All the materials necessary for testing the infants were included in the test kit, the material used was a red ring with string. Each item contains explicit instructions with all of the information necessary to administer that item properly. The study items are briefly described below:

"Manipulates Ring": place the ring in the child's hand. Observe the child to see if they shake the ring, move it into his field of vision, tilt it back and forth in one hand, or use both hands to finger it. Give credit if the child exhibits any manipulation of the ring beyond mere grasping; this includes ring mouthing.

"Reaches for Suspended Ring": suspend the ring by its string so that the lower edge of the ring is at the child's midline and approximately 20 to 25 centimeters directly above their eyes. Move the ring slightly to attract the child's attention; then hold it in stationary position. If the child does not reach for the ring, place the ring in one of the child's hands and allow them to manipulate it for a short time to generate interest in it; afterwards, repeat this item. Give credit if the child purposely moves their arm(s) in the ring direction while looking at the ring.

"Grasps Suspended Ring": suspend the ring by its string so that the lower edge of the ring is at the child's midline and approximately 20 to 25 centimeters directly above their eyes. Move the ring slightly to attract the child's attention; then hold it in stationary position. If the child does not reach for the ring, place the ring in the child's hand and allow them to manipulate it for a short time to generate interest in it; then repeat this item. Give credit if the child uses one or both hands to grasp the ring for at least two seconds.

"Carries Ring to Mouth": place the ring in the child's hand and observe what he does with it during this free-play period. Give credit if the child purposely carries the ring to their mouth.

Statistical analyses were performed using the Statistical Package for Social Sciences for Personal Computer (SPSS/PC 11.0). The probability level adopted for rejection of the null hypothesis was $p<0.05$. The Mann-Whitney test was used to investigated birthweight, Apgar index, gestational age and to determine the relation between continuous variables (mental and motor IS). The relation between categorical variables (fine motor skills items, gender) was investigated using the Chi-Square or Fisher's exact test.

Results

A total of 67 infants were studied. The sample for the observational cross-sectional study consisted of 21 SGA and 46 AGA infants in the 3rd month of life.

Table 1 shows the newborn characteristics of the SGA and AGA groups (birthweight, Apgar scores in the 1st and 5th min, gestational age). As expected, groups were different regarding birthweight. Regarding to gender, no differences were observed between SGA and AGA groups (female: 52.4% in the SGA group and 56.5% in the AGA group; p=0,751).

TABLE 1 - Profile of birth conditions of the population

Data of Newborns	Groups	n	Mean	SD	Minimum	Median	Maximum	p-value[(a)]
Weight (grams)	SGA	21	2.386	149.2	2.125	2.380	2.620	<0.001
	AGA	46	3.138	305.0	2.345	3.137	3.850	
Apgar scores 1st´	SGA	20*	8.15	1.57	3	8.50	10	0.599
	AGA	44**	8.00	1.61	1	8.00	9	
Apgar scores 5th´	SGA	20*	9.40	0.60	8	9.00	10	0.719
	AGA	44**	9.45	0.59	8	9.50	10	
GA (weeks)	SGA	21	39.52	0.92	37.6	39.50	41.1	0.849
	AGA	46	39.44	1.04	37.1	39.45	41.6	

(a) Mann-Whitney test; n-number of infants; SD-standard deviation, 1st´- 1º minute; 5th´- 5º minute; GA-gestational age; AGA-appropriate-for-gestational-age; SGA-small-for-gestational-age; *1 SGA and **2 AGA without evaluation

TABLE 2 - Socio-demographic profile of the family

Variables	SGA	AGA	p-value
	f (%)	*f* (%)	
Maternal age			
≤ 20 years	7 (33.3)	12 (26.1)	0.541[(a)]
21-35 years	12 (57.2)	33 (71.7)	
> 35 years	2 (9.5)	1 (2.2)	
Total	21	46	
Maternal education*			
< 8 years of study	17 (81)	21 (47)	0,011[(b)]
≥ 8 years of study	4 (19)	23 (53)	
Total	21	44	
Maternal occupation**			
Employee	3 (15)	19 (41.3)	0.037[(c)]
Unemployed	17 (85)	27 (58.7)	
Total	20	46	
Paternal occupation***			
Employee	17 (85)	37 (82.2)	1.000[(d)]
Unemployed	3 (15)	8 (17.8)	
Total	20	45	
Family income/per capita†			
≤ 0,5 mw	12 (80)	25 (58.139)	0.129[(e)]
> 0,5 mw	3 (20)	18 (41.9)	
Total	15	43	
Mother's marital status††			
Mother without partner	3 (16.7)	3 (7. 3)	0.356[(d)]
Mother with partner	15 (83.3)	38 (92.7)	
Total	18	41	

SGA-small-for-gestational-age; AGA-appropriate-for-gestational-age; ¦-observed frequency; mw - minimum wage; Unavailable information (* two cases; ** one case; *** two cases; † 9 cases; †† 8 cases); (a) c2 comparing ≤ 20 years with > 20 years: c2=0.37; (b)c2=6.46; (c) c2=4.34; (d)Fisher's tests

Table 2 shows the distribution of socio-demographic profile of the family. The SGA and AGA groups had homogeneous distribution of the variables, except for maternal education and occupation, with a greater frequency of SGA group mothers presenting fewer than 8 years of study and not working outside home.

Figure 1 and Figure 2 show distribution motor and mental IS in the 3rd month. Regarding to mental IS, the SGA and

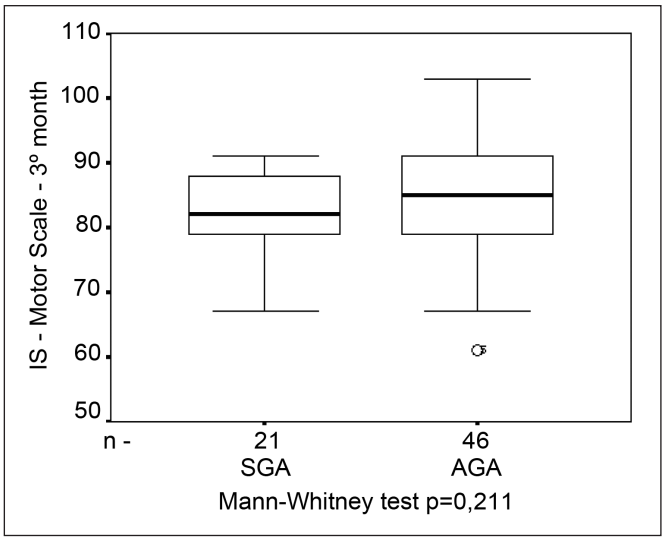

Figure 1: Distribution of motor IS at 3rd month between SGA and AGA groups

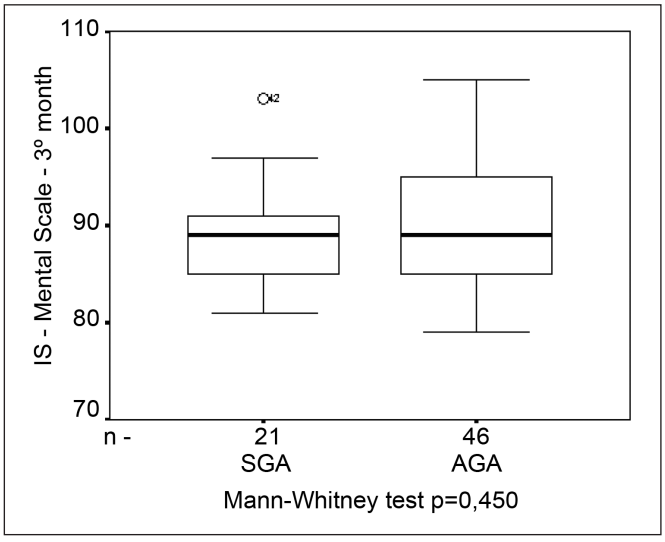

Figure 2: Distribution of mental IS at 3rd month between SGA and AGA groups

AGA groups were within the normal range (100±15). Contrasting to mental IS, both groups presented motor IS below 85 at 3rd month of age. It is important to note that infants scored below the BSID-II mean for the period measured. Although the SGA group presented lower mean motor scores compared to the AGA group at 3 months of life. There were not differences between SGA and AGA groups.

Table 3 shows the distribution of frequency for each item successfully performed by SGA and AGA groups. There were differences between SGA and AGA groups for the item

TABLE 3 – Fine motor skills items for SGA and control group

Items	Groups	n	Not Perform	Perform	p-value
			f (%)	*f* (%)	
"Manipulates ring"	SGA	20	14 (70.00)	6 (30.00)	0.464[(a)]
	AGA	43	26 (60.47)	17 (39.53)	
"Reaches for suspended ring"	SGA	18	14 (77.78)	4 (22.22)	0.022[(b)]
	AGA	44	43 (97.73)	1 (2.27)	
"Grasps suspended ring"	SGA	18	18 (100.00)	0 (0.00)	1.000[(b)]
	AGA	44	43 (97.73)	1 (2.27)	
"Carries ring to mouth"	SGA	18	12 (66.67)	6 (33.33)	0.769[(c)]
	AGA	44	31 (70.45)	13 (29.55)	

SGA-small-for-gestational-age; AGA-appropriate-for-gestational-age; n-number of infants; ¦-observed frequency; (a)c^2=0,20; (b)Fisher's exact tests; (c)c^2= 0,09

"reaches for suspended ring". The SGA group showed higher frequency in comparison with the AGA group.

Discussion

The assessment and detection of children with less obvious delays of development in the first trimester of life can be a challenge for health professionals and researchers, because such disabilities only become obvious gradually over time[19, 20]. Therefore, the present cross-sectional study compared the fine motor skills of full-term SGA with AGA infants in the 3rd month of life.

In this study the SGA and AGA groups had homogeneous distribution for profiles of birth conditions of the infants, except for birthweight. These results indicate the effectiveness of the method used for subject selection and classification into the groups. Regarding to family characteristics, there was a greater frequency of SGA group mothers who presented fewer than 8 years of study (81%) and did not work outside of the home (85%). Taking into account that parents tend to be super-protective and cautious when their children have some biological risk[25, 26], and that children whose mothers with a lower level of education are less likely to be stimulated[27], these factors could have influenced negatively the performance of the SGA group.

SGA and AGA groups were similar regarding to mental and motor IS in the 3rd month. The same results were also observed between other studies, not showing differences in cognitive and motor developments between SGA and AGA groups[28,29]. Conversely, some studies have found significant differences between SGA and AGA infants concerning neurodevelopment[30], attention/arousal and motor quality[6], and cognitive and school performances[31, 32]. The conflicting results probably occur because of the heterogeneity of the groups from one study to another. In some studies, newborns with risk factors for developmental abnormalities were included; in others, preterm SGA newborns were selected. Moreover, a variety of developmental characteristics and assessment at different ages were investigated[33].

Concerning a series of items administered to investigate fine motor skills, there was a significant difference in the item *"reaches for suspended ring"*, i.e. the SGA group (22.2%) showed higher frequency in comparison with the AGA group (2.3%). However, most SGA (77.8%) and AGA (97.7 %) infants did not accomplish this item in the 3rd month.

To give credit in the execution of this item the infant must move their arm(s) in the ring direction while looking at the ring. To try to understand the highest score of the SGA group in this situation we pointed for one situation. Full-term SGA infants shows greater movement of the arms compared to the control group[34], which may have led the SGA group to launch his arm(s) toward the ring accidentally, with no real purpose to achieve it, more often than the AGA group.

This fact observed in the item *"reaches for suspended ring"* does not mean a better performance of the SGA group compared to the AGA group, since in the other assessed items (*"manipulates ring"; "grasps suspended ring"; "carries ring to mouth"*), there were no significant difference between groups. Probably, these items require higher skills ('manipulation', 'reach', followed by 'carries the object to mouth') and consequently the SGA group found them more difficult to perform. In these items, since the increased arm movement frequency is not enough. In these items, a higher level of fine motor skills is necessary and only the increased arm(s) movement frequency was not enough to maintain the SGA group higher frequency in comparison with the AGA group.

Similar results were found when visual function and fine motor control were compared using BSID-II in the first

semester of life. The SGA group showed higher frequency of fine motor control items in the 1st month ("attempts to bring hands to mouth") and in the 3rd month (*"reaches for suspended ring"*). Those differences were attributed to a great speed and great occurrence of arm movements observed in SGA group[7]. The literature points out to differences in the quality of movement, corroborating this explanation. It has been reported an increased incidence of convulsive movements, jerking and trembling in full-term SGA infants[34]. These movements have been described as "windmill motions of the arms"[35], or "wind-milling arm movement"[36], or "cycling movements"[37], or "arm movements in circles"[38].

The BSID-II results for the studied sample showed that the infants were within the normal range concerning mental IS (100±15). Conversely, regarding motor IS, the infants scored below the BSID-II mean at the 3rd month, at least lower than expected for typical well-developing infants. This raises the question of what might account for this difference. The lack of validation of the developmental tests in developing countries may have contributed to the disadvantages observed in the groups studied[39].

From a longitudinal study with monthly monitoring of the 1st to the 12th month of age, Santos, Gabbard and Gonçalves (2001)[39] investigated the characteristics of motor development in Brazilian children during the first year of life by comparing the results with the North American sample used in the validation of the BSID-II. Although the results were similar in most months, the Brazilian sample showed significantly lower mean score than the North American sample in the 3rd, 4th and 5th month, especially related to the skills to sit and hold. It is argued that the differences may be related to differences in practices used in daily care with Brazilian infants reflected in lower scores on scales not validated in Brazil[39]. Likewise, it is suggested that the differences found in the 3rd month in both groups may be a reflection of not validating the BSID-II in our country.

The present study has certain limitations that need to be taken into. First, the cross-sectional design does not permit analysis of changes over time. Second the sample size could at least in part influence the results. A larger sample should be considered in future research. Third, this was a quantitative study of some aspects of the fine motor skill. Future research should be directed to evaluate other facets, such as quality and frequency of arm movement. Fourth, there are conflicting results in the literature regarding neurodevelopment of infants exposed to intrauterine malnutrition[33] because of the heterogeneity of the groups studied (inclusion of premature newborns), different assessment instruments and the duration of the follow-up period.

The results indicate that intrauterine malnutrition may have influenced the fine motor skills in the infants studied, with a need for greater attention concerning the development of SGA infants. Whether such difference found at 3rd month is of clinical significance is uncertain, as well as its influence on future fine motor skills. For the sample studied, SGA and AGA groups were similar regarding mental and motor IS in the 3rd month. There was a significant difference for fine motor skills between the groups when observing the item *"reaches for suspended ring"*. We hypothesize that this difference could be attributed to a greater occurrence of arm movement observed in the SGA group and not to a better motor performance of this group.

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