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assessed with the Alberta Infant Motor Scale

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Cross-cultural analysis of the motor development of Brazilian, Greek and Canadian infants assessed with the Alberta Infant Motor Scale

Análise transcultural do desenvolvimento motor de crianças brasileiras, gregas e canadenses avaliadas com a Alberta Infant Motor Scale

Análisis transcultural del desarrollo motor de niños brasileños, griegos y canadienses evaluados con la Alberta Infant Motor Scale

Raquel Saccani¹, Nadia Cristina Valentini²

ABSTRACT

Objective: To compare the motor development of infants from three population samples (Brazil, Canada and Greece), to investigate differences in the percentile curves of motor development in these samples, and to investigate the prevalence of motor delays in Brazilian children.

Methods: Observational, descriptive and cross-sectional study with 795 Brazilian infants from zero to 18 months of age, assessed by the Alberta Infant Motor Scale (AIMS) at day care centers, nurseries, basic health units and at home. The Brazilian infants' motor scores were compared to the results of two population samples from Greece (424 infants) and Canada (2,400 infants). Descriptive statistics was used, with one-sample *t*-test and binomial tests, being significant $p \leq 0.05$.

Results: 65.4% of Brazilian children showed typical motor development, although with lower mean scores. In the beginning of the second year of life, the differences in the motor development among Brazilian, Canadian and Greek infants were milder; at 15 months of age, the motor development became similar in the three groups. A non-linear motor development trend was observed.

Conclusions: The lowest motor percentiles of the Brazilian sample emphasized the need for national norms in order to correctly categorize the infant motor development. The different ways of motor development may be a consequence of cultural differences in infant care.

Key-words: child development; performance tests; motor skills.

RESUMO

Objetivo: Comparar o desempenho motor de crianças de três amostras populacionais (Brasil, Canadá e Grécia), verificar as diferenças nas curvas de percentis do desenvolvimento motor para essas amostras e investigar a prevalência de atrasos motores em crianças brasileiras.

Métodos: Estudo observacional, descritivo e transversal, do qual participaram 795 crianças brasileiras com idade entre zero e 18 meses, avaliadas com a *Alberta Infant Motor Scale* (AIMS) nas escolas infantis, maternidades, unidades de saúde pública e em domicílio. Os escores motores de crianças brasileiras foram comparados aos resultados de pesquisas com os grupos populacionais da Grécia (424 crianças) e do Canadá (2.400 crianças). Utilizou-se estatística descritiva, com os testes *one-sample t-test* e binomial, sendo significante $p \leq 0,05$.

Resultados: Observou-se que 65,4% das crianças brasileiras apresentaram desempenho motor normal, embora com escores médios mais baixos que os outros grupos. No início do segundo ano de vida, as diferenças de desempenho entre as crianças brasileiras, canadenses e gregas diminuíram e, aos 15 meses, o desempenho motor tornou-se semelhante. Verificou-se tendência de aquisições motoras não lineares.

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Conclusões: Os percentis mais baixos da amostra brasileira reforçam a necessidade de se usarem normas nacionais para categorizar adequadamente o desempenho motor. As diferentes trajetórias do desenvolvimento motor são possivelmente decorrentes de diferenças culturais no cuidado das crianças.

Palavras-chave: desenvolvimento infantil; provas de rendimento; destreza motora.

RESUMEN

Objetivo: Comparar el desarrollo motor de niños de tres muestras poblacionales (Brasil, Canadá y Grecia), verificar las diferencias en las curvas de percentiles del desarrollo motor para esas muestras e investigar la prevalencia de retardos motores en niños brasileños.

Métodos: Estudio observacional, descriptivo y transversal, del que participaron 795 niños brasileños con edad entre 0 y 18 meses, evaluados con la *Alberta Infant Motor Scale* (AIMS) en las escuelas infantiles, maternidades, unidades de salud pública y en domicilio. Los scores motores de niños brasileños fueron comparados a los resultados de investigaciones con los grupos poblacionales de Grecia (424 niños) y de Canadá (2.400 niños). Se utilizó la estadística descriptiva, con las pruebas *one-sample t-test* y binominal, siendo significativa $p \leq 0,05$.

Resultados: Se observó que el 65,4% de los niños brasileños presentaron desempeño motor normal, aunque con scores medianos más bajos que los otros grupos. En el inicio del segundo año de vida, las diferencias de desempeño entre los niños brasileños, canadienses y griegos se redujeron y, a los 15 meses, el desempeño motor se hizo semejante. Se verificó tendencia de adquisiciones motoras no lineales.

Conclusiones: Los percentiles más bajos de la muestra brasileña reforzaron la necesidad de usarse normas nacionales para categorizar adecuadamente el desempeño motor. Los distintos recorridos del desarrollo motor son posiblemente decorrentes de diferencias culturales en el cuidado del niño.

Palabras clave: desarrollo infantil; pruebas de rendimiento; destreza motora

Introduction

In early childhood, the acquisition of postural skills is extremely variable from child to child, since different biological and environmental factors may influence development over

time⁽¹⁾. This variability has been a challenge for professionals who direct their studies to assess motor development, especially considering clinical, diagnosis, intervention, and monitoring studies on children⁽²⁻⁴⁾. Motor evaluations are usually performed with different purposes, including detection and discrimination of delays, implementation of prevention policies for children exposed to risks, and monitoring the achievement of milestones and new skills over time⁽⁵⁾.

During the first year of life, when the child has great potential for preventing or minimizing the installation of disorders, an evaluation is essential⁽⁶⁾. The diagnosis of abnormalities enables the organization of appropriate interventions for each child in his or her context, such as the family home⁽⁷⁾, nurseries⁽⁸⁾, or Basic Health Units⁽⁹⁾. Therefore, proper diagnosis allows the inclusion of children in compensatory programs, which aim to minimize the consequences of short-, mid- and long-term motor disorders⁽⁸⁾.

Different tools are used for motor assessment of children in early childhood⁽⁵⁾, among which the Alberta Infant Motor Scale (AIMS) stands out, a Canadian observational assessment scale, whose main aim is to measure gross motor maturation, assessing the sequence of motor development and control of antigravity muscles in different postures⁽¹⁰⁾. Due to the easy applicability and metric characteristics, the AIMS has become an important tool for research support⁽⁵⁾, clinical practice⁽¹¹⁻¹³⁾, and intervention^(8,14).

The increasing use of AIMS, although considered gold standard to identify delays in the first months of life⁽¹⁵⁾, has raised concerns for researchers from various countries. First, it is questionable whether the interference of cultural and economic factors could explain different motor trajectories in the development of children assessed with the AIMS^(12,13,16-20). Moreover, researchers question whether adaptations and new standards, in other cultures, are necessary for the instrument^(12,16,17,19,20-22).

One way to answer these questions is by means of studies which, using the AIMS, seek to identify children at risk or with abnormalities already installed, in different cultures and with different socioeconomic levels^(12,13,16-18,20,23). For instance, the results of national surveys aligned to this goal demonstrate delays in postural development in Brazilian children^(17-19,21).

This study proposes another way to investigate this phenomenon. We developed a cross-cultural analysis of the AIMS scores and percentiles obtained from the evaluation of Brazilian, Canadian, and Greek children, from birth to 18 months of age. Thus, this study aimed to: a) compare

the motor performance of children assessed with the AIMS in three large population samples; b) detect differences in performance curves of children from the three countries in the 5th, 10th, 25th, 50th, 75th, and 90th percentiles; c) investigate the prevalence of motor delays in the group of Brazilian children. Considering the results of national studies, the observation of lower performance in Brazilian children when compared to children from other countries with different economic and socio-cultural characteristics was established as a hypothesis, and the high prevalence of children with inappropriate motor development to age.

Method

This was a cross-sectional, descriptive, and comparative study, approved by the Research Ethics Committee of Universidade Federal do Rio Grande do Sul (UFRGS), under protocol n. 14.126. The study included 795 children from zero to 18 months old, from different municipalities in the southern region of Brazil (Porto Alegre, São Leopoldo, Erechim, Caxias do Sul and Antônio Prado), from 2009 to 2011.

Among the total number of participants, 407 were female and 388 male, 658 were term infants and 137, pre-term, from different socioeconomic classes. Family income ranged from R\$ 300.00 to R\$ 7,100.00, resulting in a mean of R\$ 1,401.00 (standard-deviation – $SD \pm 1,305.00$) and median of R\$ 750.00 (25th percentile=650.00; 75th percentile = 1,775.00). Regarding the biological characteristics of the sample, the children presented the following means: a) weeks of gestation: 37.3 ± 3.62 ; b) birth weight (in grams): $2,938 \pm 758$; c) birth length (in centimeters): 47.8 ± 3.9 ; and d) head circumference at birth (in centimeters): 33.6 ± 2.9 .

Children were included consecutively, with the permission of institutions (kindergartens, hospitals, and Basic Health Units) and the signature of consent by those responsible, according to inclusion criteria (aged zero to 18 months and non-participation in intervention programs). Children with congenital malformation, acute diseases, and musculoskeletal disorders, such as fractures, peripheral nerve injury, musculoskeletal infection, among others, were excluded. In data collection, 37 children were excluded, and the three main causes were participating in interventional activities, acute diseases (pneumonia, bronchiolitis) and inability to complete the assessment by crying and clinical condition.

The sample calculation was carried out in the Program for Epidemiologists, version 4.0. For a confidence level of 95%, a response rate of 50% and an error rate of 4%, the

assessment of at least 600 children would be necessary. We sought to maintain a similar distribution of children in each age group, to enable comparison between population groups (Brazil, Canada and Greece) in each of the age groups.

As parameters for comparison, data from two studies on regulation of AIMS in different population groups were used: a sample of 2,400 Canadian children⁽²⁴⁾ born at term and pre-term, from different regions and different socioeconomic status, and a sample of 424 Greek children⁽²⁰⁾, born at term, aged between 7 days and 18 months, from all socioeconomic classes (children with a history of perinatal problems, neurological diseases, as well as any acute or chronic disease were excluded).

The AIMS, target-instrument of this study, has been validated for the Brazilian population⁽²¹⁾, with results that demonstrate content validity — content validity index (CVI) for clarity between 66.7 and 92.8; CVI for relevance higher than 98.0; temporal stability – Spearman correlation (ρ) 0.85; $p < 0.001$; internal consistency – Cronbach's coefficient alpha (α_{total}) 0.88, $\alpha_{\text{prone}} = 0.86$, $\alpha_{\text{supine}} = 0.89$, $\alpha_{\text{seated}} = 0.80$, $\alpha_{\text{standing}} = 0.85$, and discriminating power (-4.842 ; $p < 0.001$).

AIMS assesses motor development of infants from birth to independent walking and consists of 58 motor criteria, distributed in four subscales that describe the development of spontaneous movement and motor skills in prone⁽²¹⁾, supine⁽⁹⁾, seated⁽¹²⁾, and standing⁽¹⁶⁾ postures. Each item observed in the motor repertoire of the child receives score one if the child performs all key motor criteria; each item not observed receives score zero. At the end of the evaluation, the gross score is obtained from the sum of the score in each of the subscales, which can be converted into percentiles⁽²⁴⁾. The percentiles allow for determining the motor development of the infant, categorized according to the following criteria: a) normal/expected motor performance, when the result in the test is above the 25th percentile in the curve; b) suspect motor development, when the result is from 25 to 6% in the curve; c) abnormal motor development, when the result is less than or equal to 5% in the percentile curve.

Tests were conducted on children's home institutions, making the first contact to schedule visits and delivery of the term of free and informed consent for parents, besides the identification form for data collection. With the signed terms, children were evaluated for about 20 minutes, and the whole process was filmed for further analysis of motor performance in the four postures. Analyzes were conducted by three independent evaluators, in a single moment, considering the free movements of children and focusing

on aspects such as body surface that supports the weight, posture, and antigravity movements. Through the analysis of the footage, the concordance index was calculated, whose values of interclass correlation ranged from $\alpha=0.86$ to $\alpha=0.99$, indicating high levels of agreement. Furthermore, according to the Friedman and Wilcoxon tests, no significant difference was found between the responses of the three evaluators ($p>0.05$).

To characterize the sample, a questionnaire was delivered to the parents, with the following items: date of birth, sex, type of delivery, gestational age, Apgar score at 5 minutes, birth weight, birth length, head circumference and monthly family income. Parents and/or guardians answered the questionnaire and forwarded it to the researcher.

Analyses were carried out in the Statistical Package for the Social Sciences (SPSS), version 17.0. The gross score of the AIMS was described as mean, median, standard deviation, minimum, maximum, and percentiles for the total sample. For comparison of total scores in the population groups, the one sample t-test was used, and for the comparison of percentiles, the binomial test of comparison was applied. The level of significance was established at 5% ($p\leq 0.05$).

Results

Motor development of Brazilian children was lower than expected in 34.6% of the sample, 83 (10.4%) children presented motor delay and 192 (24.2%), suspected motor delay. However, most participants (520; 65.4%) presented normal motor development.

The performance results of Brazilian children showed, according to Table 1, lower gross scores, when compared to values in studies with Canadian and Greek children. Comparing Brazilian and Canadian children, only at 18 months of age it was observed significant greater values for motor development in Brazilian children. In other age groups, Canadian children presented higher scores. When performance was compared with Greek children, Brazilians showed lower scores in all age groups.

It can be observed lower performance in the development of Brazilian children by the curves of Figure 1, in which the national sample remained always below the Canadian and Greek reference scores. However, this variability decreases at the age extremes, being lower in newborns and in children over 15 months of age. From 13 months, overlapping curves

Table 1 - Comparison of motor development of Brazilian, Canadian, and Greek children, in gross scores of the Alberta Infant Motor Scale (AIMS)

Age (months)	M±SD			BRxCA		BRxGR	
	n	F/M	BR	CA	GR	p-value	p-value
0-<1	33	17/16	4.3±1.3	4.5±1.3	5±1.4	0.36	0.007*
1-<2	35	17/18	6.2±1.3	7.3±1.9	7.7±1.2	<0.0001*	<0.001*
2-<3	35	17/18	8.4±1.9	9.8±2.45	10.6±1.9	<0.0001*	<0.001*
3-<4	31	13/18	11.2±2.9	12.6±3.3	13±2.8	0.012*	0.002*
4-<5	44	23/21	14.9±3.5	17.8±4.1	16.9±3.2	<0.0001*	<0.001*
5-<6	49	24/25	18.0±5.7	23.2±4.7	23.4±3.8	<0.0001*	<0.001*
6-<7	42	20/22	22.6±6.4	28.3±5.5	28±5.0	<0.0001*	<0.001*
7-<8	52	28/24	30.7±5.5	32.2 ±6.8	31.5±6.8	0.43	0.28
8-<9	47	17/30	36.8±7.7	39.7 ±8.7	37.1±8.6	0.12	0.81
9-<10	43	23/20	40.8±8.7	45.4 ±7.4	43.9±7.3	0.001*	0.025*
10-<11	45	26/19	43.4±8.1	49.3±5.9	49.4±4.5	<0.0001*	<0.001*
11-<12	48	27/21	49.3±4.8	51.2±7.1	51.2±3.2	0.008*	0.01*
12-<13	35	21/14	53.4±3.4	55.5±4.5	54±2.2	0.01*	0.28
13-<14	54	25/29	54.0±3.9	55.6±5.0	55.9 ±2.2	0.005*	0.001*
14-<15	44	19/25	56.3±2.9	56.8±1.9	57.4±1.4	0.18	0.012*
15-<16	41	19/22	56.9±2.0	57.8±0.4	57.9±0.3	0.008*	0.003*
16-<17	46	21/25	57.8±0.6	57.8±0.5	57.7±1.1	0.96	0.23
17-<18	33	10/23	57.8±0.9	57.8±0.3	58±0	0.84	0.24
18-<19	38	21/17	57.9±0.5	57.7±0.6	—	0.035*	—

BR: Brazil; CA: Canada (data published by Piper *et al*⁽¹⁰⁾); GR: Greece (data published by Syrengelas *et al*⁽²⁰⁾); M±SD: mean±standard-deviation; F/M: female/male

begin to appear. In addition, there was greater similarity among the newborns of the three sample groups and there were an increasing number of motor skills in the following months. However, a non-linear motor development trend was observed in Brazilian children, tending to stabilize from 16 months of age, as observed in the scores of Canadian and Greek children from this age.

The overall mean of percentiles of the studied children was 42.38 (SD=27.52), 424 infants (53.34%) were below the 50th percentile. In Tables 2 and 3, the values of the 5th, 10th, 25th, 50th, 75th and 90th percentiles in the studied populations, demonstrating lower values in Brazilian children compared to Greek (Table 2) and Canadian (Table 3) children in all percentiles analyzed. Less variability between countries was identified in the 75th and 90th percentiles.

Figure 2 shows that the similarities in the performance of Brazilian, Greek, and Canadian children occurred in the 75th and 90th percentiles. The curves for 5th, 10th, 25th and 50th percentiles demonstrated greater disparity between infant motor performances of the three countries, with Brazilian children below the other two groups. The analysis by age group showed greater similarity among newborn children in all percentiles.

Discussion

The development of motor skills in children investigated in this study occurs differently from Canadian and Greek children. National studies indicated motor delays in Brazilian children and reported lower motor scores when compared to the Canadian standard established by AIMS^(17-19,21). For instance, Formiga and Linhares⁽¹⁷⁾, while describing the motor development of preterm children, demonstrated that the development curves, in a group of 308 infants from zero to 12 months old, denoted underperformance for age. A similar trend was previously reported in several studies of children of different age groups^(18,19,21). A study with children from northeastern Brazil, is to date, one of the few studies that have found similarities in motor performance of northeastern and Canadian children⁽²⁵⁾.

In this work, the different motor trajectories of Brazilian children may have been determined by risk factors that increase vulnerability and predisposition to motor abnormalities⁽²⁶⁾. Children in developing countries have greater exposure to biological risk factors, such as prematurity and malnutrition^(13,26), and local conditions, such as low demand for health services⁽²⁷⁾, inappropriate maternal practices⁽²⁸⁻³⁰⁾,

as well as low maternal and paternal education, socioeconomic vulnerability, and little stimulation at home^(31,32). This exposure has negative repercussion on the acquisition of motor milestones of childhood. For instance, a recent national study⁽³³⁾ showed that children with motor development levels below those expected for their age had been breastfed for a short time and were from low-income families, where the father was absent. Therefore, the quality of the stimulus offered at home is determining to the development of motor behaviors⁽³¹⁾, one of the possible mechanisms by which low income, factor present in developing countries, adversely affects children's behavioral acquisitions⁽²⁶⁾ and may be responsible for the observed differences.

Although this is a plausible explanation for the observed differences, it draws the attention of researchers in performance observed also in developed countries such as, for instance, Netherlands and Australia. Fleuren *et al*⁽¹⁶⁾, assessed Dutch children up to 12 months of age, and showed that 75% were below the 50th percentile, and scores were lower in all age groups. A study with 800 Dutch children converged to similar results of lower scores in preterm infants, even using corrected age⁽¹³⁾. A longitudinal study developed in Australia found a similar trend, when analyzing preterm and term infants at 4, 8, and 12 months, demonstrating inferiority in performance levels, regardless of gestational age⁽¹²⁾.

In Greece, however, Syrengelas *et al*⁽²⁰⁾, in a study with 424 children, showed that the curves of motor development in Greek and Canadian babies are similar, highlighting that the AIMS reference values can be used without loss of important clinical information. This contradiction of international

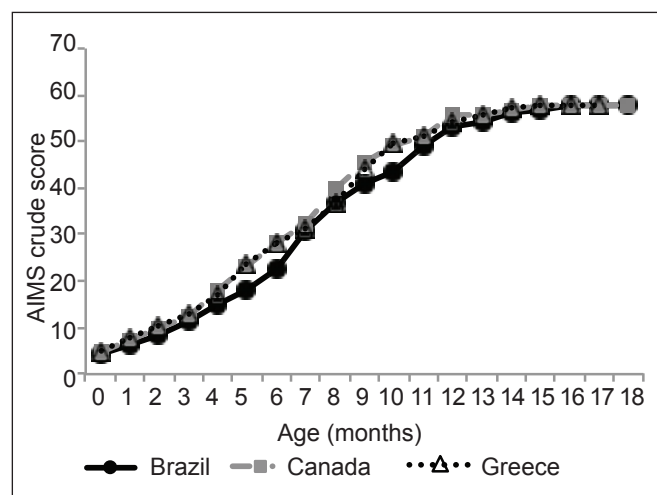


Figure 1 - Curves of motor development of Brazilian, Greek and Canadian children: Mean age, using the gross scores of Alberta Infant Motor Scale (AIMS)

Table 2 - Performance comparison between Brazil (BR) and Greece (GR), considering the mean of the 5th, 10th, 25th, 50th, 75th and 90th percentiles from the Alberta Infant Motor Scale (AIMS)

Age (months)	Groups of Percentiles											
	5			10			25			50		
	n	BR	GR	p-value	BR	GR	p-value	BR	GR	p-value	BR	GR
0-<1	33	3	3	1	3	3	1.0	3	3.7	0.05	4	5
1-<2	35	4	4.5	0.5	5	6.5	<0.001	5	7	<0.001	6	8
2-<3	35	6	8	<0.001	6	8	<0.001	7	9	<0.001	8	10.5
3-<4	41	6.6	10	<0.001	7	10	<0.001	9	11.2	<0.001	11	13
4-<5	44	10	12.5	<0.001	10	13	<0.001	13	14.7	<0.001	14	17
5-<6	49	9	17.3	<0.001	10	19	<0.001	13.5	21	<0.001	18	22.5
6-<7	42	11.1	18.4	<0.001	13	21.9	<0.001	18	24	<0.001	22.5	27.5
7-<8	52	21	23	0.01	22.3	23	0.3	27.2	25	0.1	31.5	32
8-<9	47	25	24.3	0.3	25.8	26	0.5	31	30.7	0.1	36	35
9-<10	43	22	29.2	0.06	28	34	0.003	34	37.2	0.1	43	45
10-<11	45	29.3	38	<0.001	31.6	40	<0.001	34	49	<0.001	45	51
11-<12	48	38.2	40.7	0.6	43	47.4	<0.001	45.2	50	<0.001	50	52
12-<13	35	47.8	52	<0.001	48	52	<0.001	51	52	0.08	53	53.5
13-<14	54	45.7	52	<0.001	49	52.2	<0.001	51	52.2	0.03	54	57
14-<15	44	50.2	-	-	51.5	-	-	54.7	-	-	58	-
15-<16	41	52	-	-	53	-	-	57	-	-	58	-
16-<17	46	56.3	-	-	57	-	-	58	-	-	58	-
17-<18	33	55.8	-	-	58	-	-	58	-	-	58	-
18-<19	38	56	-	-	57.9	-	-	58	-	-	58	-

The data concerning the Greek sample were published by Syrengelas et al⁽²⁰⁾**Table 3** - Performance Comparison between Brazil (BR) and Canada (CA), considering the mean of the 5th, 10th, 25th, 50th, 75th and 90th percentiles from the Alberta Infant Motor Scale (AIMS)

Age (months)	Groups of Percentiles											
	5			10			25			50		
	n	BR	CA	p-value	BR	CA	p-value	BR	CA	p-value	BR	CA
0-<1	33	3	2.2	0.2	3	2.7	0.03	3	3.6	0.05	4	4.5
1-<2	35	4	4.1	0.5	5	4.8	0.3	5	6	<0.001	6	7.3
2-<3	35	6	5.8	0.2	6	6.7	0.02	7	8.2	<0.001	8	9.8
3-<4	41	6.6	7.2	0.02	7	8.4	0.08	9	10.4	<0.001	11	12.6
4-<5	44	10	11.1	0.001	10	12.6	0.03	13	15.1	<0.001	14	17.9
5-<6	49	9	15.4	<0.001	10	17.1	<0.001	13.5	20	<0.001	18	23.2
6-<7	42	11.1	19.3	<0.001	13	21.2	<0.001	18	24.6	<0.001	22.5	26.4
7-<8	52	21	21	0.5	22.3	23.5	0.3	27.25	27.7	0.6	31.5	32.3
8-<9	47	25	25.5	0.2	25.8	28.7	0.2	31	33.9	0.1	36	39.8
9-<10	43	22	33.2	<0.001	28	35.9	0.001	34	40.5	0.01	43	45.5
10-<11	45	29.3	29.6	<0.001	31.6	41.7	<0.001	34	45.3	<0.001	45	49.3
11-<12	48	38.2	39.6	0.6	43	42.2	0.3	45.25	46.5	0.4	50	51.3
12-<13	35	47.8	47.2	0.5	48	48.8	0.5	51	51.6	0.2	53	54.6
13-<14	54	45.7	47.4	0.5	49	49.2	0.5	51	52.2	0.03	54	55.6
14-<15	44	50.2	-	-	51.5	-	-	54.75	-	-	58	-
15-<16	41	52	-	-	53	-	-	57	-	-	58	-
16-<17	46	56.35	-	-	57	-	-	58	-	-	58	-
17-<18	33	55.8	-	-	58	-	-	58	-	-	58	-
18-<19	38	56	-	-	57.9	-	-	58	-	-	58	-

The sample data were published by Piper et al⁽¹⁰⁾

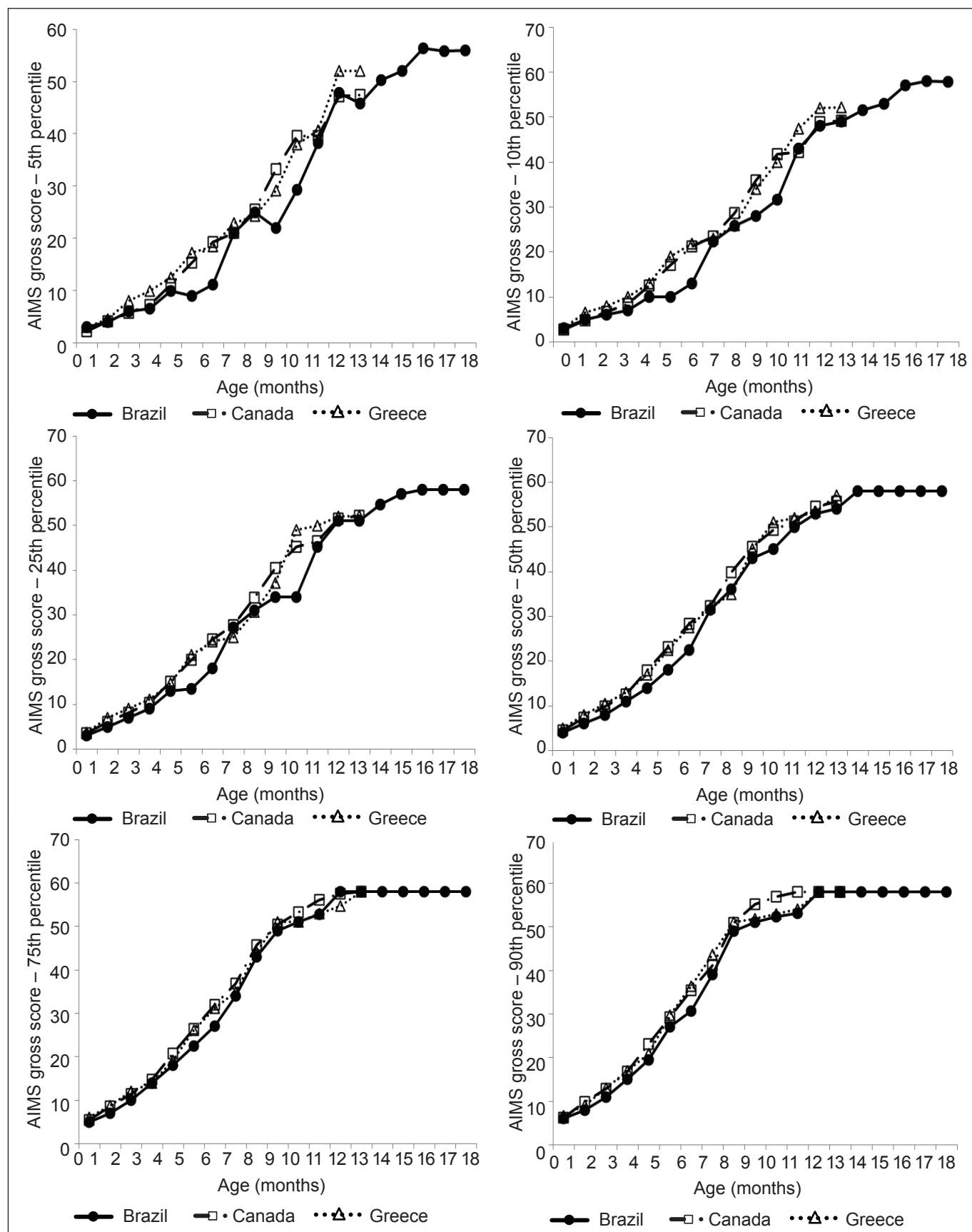


Figure 2 - Curves of motor development of Brazilian, Greek, and Canadian children, considering the percentile analyses (5th, 10th, 25th, 50th, 75th and 90th). Means by age, using the gross scores of the Alberta Infant Motor Scale (AIMS)

results emphasizes that the properties of evaluation tools such as the AIMS suffer interference in the results in the face of adaption to another environment and to distinct socioeconomic, ethnic, and cultural factors^(16,34).

The mean and variability of gross scores indicated a tendency in stabilization of motor skills from the age of 16 months, in the three countries. We highlight the interference of the limited number of items on the AIMS to assess motor performance in the age extremes, reducing, thus, the scale's parameters of difficulty^(21,35). Valentini and Saccani reported the poor sensitivity of the AIMS in the age extremes until 2 months of age and after 15 months, as also observed in the Canadian reference values^(21,24) and in an Australian study by Pin *et al*⁽¹²⁾. It is observed, therefore, with the use of the AIMS, the "ceiling effect" in behavioral acquisitions of children from 15 months of age.

The results showed that after 15 months, Brazilian children present a similar performance to the other two population samples. A possible explanation lies in the further exploration and interaction with the environment, after the advent of independent walking, which makes the child more independent and less dependent on parental stimulation. This possibility should be considered, once a national study showed similar performance of Brazilian children compared to the U.S. children from 6 months, using the Bayley scale⁽³⁴⁾ as an assessment tool. This explanation should be further investigated, especially after the acquisition of independent walking. Although performance differences prevailed between the investigated samples, moments of similarity can be observed in the motor performance of children from the three countries; only in specific percentiles (for example, in Brazilian and Greek children aged 4 months in the 90th percentile and Brazilian and Canadian children at nine months in the 50th and 75th percentiles). These data are challenging, and point to the need for further research on the comparisons in specific percentiles.

Another interesting aspect of this study was the observation of nonlinear motor performance and periods of greater stability in motor skill acquisitions, as noted in previous studies^(17,18). This instability in motor skill acquisition signals the importance of monitoring the child over time to identify the actual motor changes and direct the intervention to the needs observed, providing better quality of life for many children.

The present study presents a unique and original contribution to existing knowledge, since it is the first research to compare the percentiles in three population groups. However, the lack of detailed characterization of Canadian

and Greek samples limited, in part, the comparison of population samples, as well as the discussion regarding the peculiarities of biologic and environmental impacts. The heterogeneity of the samples from Brazil, Canada, and Greece, although it may represent a bias, justifies the importance of the study and encourages the use of national parameters in research development performance. It is noteworthy that the generalization of the results to the entire Brazilian population will only be possible after further research, including different regions of the country and that ensure control over the existing cultural variations. However, the results of this study point to a possible inaccurate categorization of the performance of Brazilian children, and, therefore, they should be considered, especially for samples of the national population with socioeconomic and cultural characteristics similar to those presented.

The cross-sectional design of the study can be seen as a limitation by some researchers, but some essential advantages were established with this design. It allowed the investigation of a large group of participants, readiness to collect information about the investigated phenomenon and lower sample loss. Cross-sectional studies define demographic and clinical characteristics and are regarded as adequate in the study of prevalence of delays and risk factors, object of this work. Future research may, from this research, determine a sample for cohort and/or clinical trials.

In conclusion, the differences between Brazilian, Canadian, and Greek children were prevalent until 15 months of age and a representative number of the Brazilian sample presented performance below the expected for age (34.6%). The results may represent a different trajectory in motor development, due, possibly, to the influence of sociocultural factors, which reinforces the need to use the Brazilian rules to categorize the motor performance of children.

To recognize the differences in performance between population groups is critical to understand the vulnerability of specific groups of children with motor delays, which impact on quality of life and on daily life of the population investigated. These information, are, therefore, essential to implement compensatory programs and public policies aimed at reducing the occurrence or the effect of motor problems on the child and family, especially in low-income populations. The identification of inadequate motor behaviors allows programs to be designed, offering possible adjustments in the child's everyday life, which promote development and prevent delays, which lead to the need for less health care assistance and lower costs to public health.

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