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Original Article

Seasonality and risk factors associated with motor development of full-term infants

Sazonalidade e fatores de risco associados ao desenvolvimento motor de lactentes nascidos a termo

Letícia Hermes[a], Fabiane Kurtz Martins[a], Natiele Camponogara Righi[a], Thais Helena Oliveira Böck[a], Claudia Morais Trevisan[a], Angela Regina Maciel Weinmann[b], Nadia Cristina Valentini[c]

[a]Universidade Federal de Santa Maria – UFSM, Santa Maria, RS, Brasil.
[b]The Hospital for Sick Children Foundation, University of Toronto, Canada.
[c]Universidade Federal do Rio Grande do Sul – UFRGS, Porto Alegre, RS, Brasil.

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ABSTRACT

Introduction: Different factors affect motor development in the first year of life; the interference of seasonal variation lacks further investigation. **Objective:** To investigate the influence of seasonality and the protective and risk factors on the motor development of full-term infants, at 7 months and 10 months of age. **Method:** This study included full-term infants (N=174) who experienced developmental milestones to the 2nd and 3td quarters in summer or winter. Medical records, interviews, and the Alberta Infant Motor Scale were used. **Results:** The acquisition of setting and crawling was later in the post-winter groups (p<0,001). Regarding groups at risk and without risk of motor delays, a low prevalence of pregnancy planning (p=0.015), a short duration of breastfeeding (p=0.004), and breastfeeding time (p=0.012) was found in the risk group at 7 months. At 10 months, children in the risk group had shorter gestational age (p=0.040), were children of older mothers (p=0.020), had more siblings (p=0.002), higher levels of poverty (p=0.002), and more restrictions of movement (p=0.000). Logistic regression showed that, at 7 months of age, breastfeeding was the variable associated with motor development, while at 10 months, the number of children, poverty, and infant movement restriction were significantly explained the variation in motor development. **Conclusion:** The cold climate was not an isolated determinant for the risk of delayed motor development; environmental variables were more relevant in the model.

Keywords: Risk Factors, Growth and Development, Protective Factors, Motor Skills, Maternal Behavior.

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RESUMO

Introdução: Diferentes fatores afetam o desenvolvimento motor no primeiro ano de vida, tendo sido pouco estudada a interferência da variação sazonal. **Objetivo:** Investigar a influência da sazonalidade e de fatores de risco e proteção para o desenvolvimento motor de lactentes nascidos a termo, aos 7 e 10 meses de idade. **Método:** Foram incluídos no estudo lactentes a termo (N=174) que vivenciaram os marcos de desenvolvimento referentes ao 2º e 3º trimestres no período de verão ou de inverno. Prontuários, entrevistas, e a *Alberta Infant Motor Scale* foram utilizados. **Resultados:** A aquisição do sentar-se e engatinhar foi mais tardia nos grupos pós-inverno ($p < 0,001$). Quanto aos grupos de risco e sem risco para o desenvolvimento motor, observou-se, aos 7 meses, menor prevalência de planejamento da gravidez ($p=0,015$), menor tempo de aleitamento materno exclusivo ($p=0,004$) e de amamentação ($p=0,012$) no grupo com risco. Aos 10 meses, os lactentes do grupo de risco se caracterizaram pela menor idade gestacional ($p=0,040$), por serem filhos de mães mais velhas ($p=0,020$), maior número de irmãos ($p=0,002$), níveis mais elevados de pobreza ($p=0,002$) e maiores restrições de movimento ($p=0,000$). A regressão logística evidenciou que, aos 7 meses, o aleitamento materno foi a variável associada ao desenvolvimento motor, enquanto aos 10 meses, o número de filhos, a pobreza e a restrição de movimento do lactente explicaram a variação no desenvolvimento motor. **Conclusão:** O clima frio não se mostrou um determinante isolado para o risco de atraso motor, variáveis ambientais foram mais influentes no modelo.

Palavras-chave: Fator de Risco, Crescimento e Desenvolvimento, Fator de Proteção, Habilidades Motoras, Padrões de Cuidado Materno, Sazonalidade.

Introduction

Risk factors for delays in motor development, especially socio-environmental ones, may prevail over or predispose to biological risk (Panceri et al., 2020; Pereira et al., 2016; Zajonz et al., 2008). The combination of biological and environmental hazards exacerbates unwanted development outcomes. Understanding this complex dynamic between risk and protective factors provides an understanding of typical and atypical development, guiding interventional practices. Among the risk factors, few studies in Brazil highlight the seasonal interference to which the child population, in cities with a cold climate, is exposed throughout the first year of life. Previous studies carried out in Israel, the United States of America, and Japan show acceleration in the development of infants in the summer period, and limited motor acquisition in the cold periods, coinciding with important milestones in child development (Atun-Einy et al., 2013; Benson, 1993; Tsuchiya et al., 2012).

Two explanations are more recurrent in the literature, the layers of clothing that limit active movement (Hayashi, 1992; Théveniau et al., 2014) and the reduced opportunities for infants to explore the floor due to the cold floor in the prone position (Abbott & Bartlett, 2001). In this sense, the study by Hayashi (1992), with 7-month-old infants, showed that the child's clothing and bedding (blanket), combined, were associated with delays in the acquisition of the rolling motor milestones, crawling,

playing with toys in the prone position, and taking the foot supine. Théveniau et al. (2014) observed that the highest number of garments negatively affected the speed and stride length of infants aged 6 to 18 months. Also, more restricted environments, equipment such as trolleys, fences, and others, used more frequently in cold climates, avoiding the ground, harm gross motor acquisitions in the first year of life (Abbott & Bartlett, 2001).

Although the aforementioned studies show the relationship between motor delays and seasonality, they were conducted without considering intervening factors, restricting the ability to attribute variability in infant development to this isolated event. The lowest family income (Chiquetti et al., 2018; Ronfani et al., 2015; Valadi & Gabbard, 2020), the number of children (Halpern et al., 2000), the birth weight (Sampaio et al., 2015), prematurity (Carniel et al., 2017; Chiquetti et al., 2018; Maggi et al., 2014; Smithers et al., 2015), low education and maternal age (Valadi & Gabbard, 2020), and drug use during pregnancy (Singer et al., 2016) are risk factors for developmental delay. In contrast, breastfeeding (Leventakou et al., 2015; McCrory & Murray, 2013; Oddy et al., 2011; Sacker et al., 2006), the positive interaction with parents, the variability of stimulation and the availability of toys, critical indicators for the quality of this environment (Defilipo et al., 2012), are protective factors for their development.

Furthermore, we need to consider that a high prevalence of delays has been reported for Brazilian children born at term, throughout the first year of life (Saccani & Valentini, 2013; Zajonz et al., 2008) and that environmental factors can compensate, optimize or even aggravate pre-established clinical and risk conditions at birth (Panceri et al., 2020; Pereira et al., 2016). The investigation of different risk factors is necessary, with seasonality as one of the factors with limited investigation. It is noteworthy that seasonality should be investigated not as an isolated risk contribution to delays, but rather in combination with other risk factors or protection for the infant. Therefore, the study aimed to investigate the influence of seasonality, in a region with a cold climate and/or considerable temperature variation, and risk and protective factors for the motor development of term infants, at 7 and 10 months of age.

Method

Participants

The study included infants born at term during August/September and May/June (occurrence of motor milestones of the 2nd and 3rd trimesters of life in the summer period), and those born in February/March and November/December (occurrence of milestones of the 2nd and 3rd quarters of life in the winter period), which were evaluated, respectively, at 7 and 10 months of age. The sample was of convenience since contact was made with the families to invite them to participate in the study, and the contacts were collected from the records made in the maternity hospital of a public hospital of the Unified Health System. The ages of 7- and 10-month targets were determined as they occur immediately after the acquisition of important motor milestones referring to the 2nd and 3rd quarters

(Valentini et al., 2019). Exclusion criteria were prematurity, birth weight less than 2,500g, genetic syndrome, congenital malformations, neurological disorders, and the presence of viruses and respiratory tract infections at the time of evaluation. The study was carried out in a region characterized by cold winters, with minimums between 8°C and 10°C (average temperature between 13°C and 15°C), and hot summers, with absolute maximums around 39°C (average temperature above 24°C); average annual temperatures are between 16°C and 20°C (Facco et al., 2012).

Instruments

To assess motor development, we used the Alberta Infant Motor Scale – AIMS AIMS (Piper & Darrah, 1994), validated for Brazilian infants (Valentini & Saccani, 2011). The AIMS is a dichotomous observational scale of broad motor acquisitions, from birth to independent walking, consisting of 58 items, organized into postures: prone (21 items), supine (9 items), sitting (12 items), and standing (16 items). Raw scores, in percentile, and motor performance characterization are obtained (motor performance within the normal range: above the 25th percentile; suspect motor performance: between the 6th and 25th percentile; motor performance outside the normal range: 5th percentile and below). For the formation of groups, AIMS cutoff points were adopted, with risk of motor delay (up to P25) and without risk of motor delay (above P50).

Direct observation of the infants' motor milestones was performed in an acclimatized neutral room (temperature 21-27ºC) and recorded with a camera (SONY®, DCR-SR47) for further analysis. During this observation, family members interacted with the child for five minutes, as usual during the awake periods. Parents were instructed to let the child move freely and, for the beginning of the observation, the 7-month-old infants should be seated and the 10-month-old infants in the prone position. Coriat (2001) indicates, as an important milestone of postural stabilization inherent in the second trimester, bimanual support, on both sides of the body, with the upper limbs semi-flexed, when the infant is placed in a sitting position. Its head no longer oscillates, except in occasional rotations, and when unbalanced it always falls forward. In the third trimester, the same author highlights that it is not common for infants to fully reach the ways of moving from the prone position, which we call crawling. Based on this, the parents were instructed to let the child move freely, and, for the beginning of the observation, they should place the 7-month-old infants in the sitting position, and the 10-month-old infants in the prone position (a posture that precedes crawling). These motor milestones were adopted later for the analyses.

An interview with family members was conducted using a structured questionnaire containing relevant information regarding prenatal history, socioeconomic and cultural profile, and maternal practices. The questionnaire was converted to the EpiInfoTM platform (7.1.5.2) and used on a tablet (HP® Stream 7), with automatic conversion to a database. The infant's weight and height were

obtained using a pediatric scale with a digital panel (Urano® UBB 20/2) and a wooden stadiometer (1.50 meters).

Procedures

Initially, a survey of all births was carried out at the university hospital, which concentrated all births in the public system, and, using the criteria defined for inclusion/exclusion, we carried out an initial analysis of the records of each birth. For simple random selection, the infants were listed and numbered in order of birth in an Excel spreadsheet, and, subsequently, the order of telephone contact for the invitation to participate was defined. The family of potential participants was contacted by telephone, in random order, one week before the date the child would complete the target ages, and up to one week later, in daily attempts, when necessary. Unanswered or refused calls received three attempts, on different days.

During the telephone contact, the researcher described the study and scheduled a time for the child's assessment, if the parents agreed. The assessments were carried out in the presence of family members, in an appropriate environment, at the university of origin (quiet, air-conditioned room, a large mat that allowed the child to move freely), respecting the child's meal and rest schedules, and accommodating the family's needs. Two trained evaluators who are physical therapists with three years of experience in the application of the AIMS assessed infants after the summer period (March and April) and the other after the winter period (September and October). Interobserver agreement was high (Kappa coefficient: 0.92). All assessments were recorded. The research that originated this article was approved by the Research Ethics Committee of the Federal University of Santa Maria – CAAE 52531016.6.0000.5346, under nº 1487549 and the Informed Consent Form was signed by the parents of the participating infants.

Data analysis

Adherence to the normality of the variables was verified using the Shapiro-Wilk test. Quantitative variables, with symmetrical distribution, are presented as mean and standard deviation, asymmetric quantitative variables are presented as a median and interquartile range, and qualitative variables are described as percentages. We used parametric or non-parametric statistics, depending on the distribution of variables. We also used Student-t test, Mann-Whitney, Fisher, and Chi-Square tests. Univariate and multiple logistic regression analysis determined the association between (independent) variables with risk to motor development (dependent variable) in the groups (7 and 10 months). In the univariate analysis, each independent variable was crossed with the dependent one, and only associations that presented a level of $p < 0.25$ participated in the multivariate analysis.

Results

During the target birth months, there were 1120 births at the university hospital. Of these, 303 were excluded for not residing in the municipality of Santa Maria, 284 for inadequate records, and 146 for the impossibility of contact. Of the remaining 387

infants, 213 did not attend the assessment and did not respond to a new contact attempt. Thus, 174 infants participated in the study.

The results show that, at 10 months, the infants evaluated in the post-winter period showed higher height and weight than the group of children evaluated in the post-summer period (p=0.009 and p=0.038, respectively). Regarding the acquisition of motor milestones, the group of 7-month-old infants, evaluated in the post-summer, showed significantly higher performance than the group evaluated in the post-winter, in the standing postures (AIMS; p=0.001). At 10 months of age, the group of children assessed in the post-summer period reached the milestone of crawling earlier than the post-winter group (p=0.004). Table 1 presents the group results for biological and motor factors.

Table 1. Biological factors at birth and motor scores for the 7- and 10-month-old groups: Post-summer and post-winter assessment.

Biological Factors & Motor scores		Seven months old			10 months old		
		Post-summer	Post-winter	p	Post-summer	Post-winter	p
		N = 45	N = 52		N = 45	N = 32	
Gender N (%)	Female	23(51.1)	18(34.6)	0.100	24(53.3)	17(53.1)	0.985
	Male	22(48.9)	34(65.4)		21(46.7)	15(46.9)	
Birth N (%)	Cesarean	24(53.3)	28(53.8)	0.960	27(60.0)	16(50.0)	0.384
	Vaginal	21(46.7)	24(46.1)		18(40.0)	16(50.0)	
GA at birth (weeks) Md (IIQ)		39.1(37.6-40.6)	38.7(37.9-39.5)	0.314	38,7(1.1)	39,0(1.0)	0.387
APGAR 5 minutes Md (IIQ)		9(9-10)	9(9 - 10)	0.250	10(9 - 10)	10(9-10)	0.901
Birth Weight (g) M(SD)		3412(318)	3305(504)	0.219	3199(331)	3353(430)	0.079
Height in the evaluation (cm) M(SD)		67.9(2.8)	67.9(2.7)	0.947	71,02(3.0)	72.8(2.7)	**0.009***
Weight in the evaluation (g) Md (IIQ)		8320(7450-9615)	8117(7562-9082)	0.458	8610(7945-9600)	9342(8921-10395)	**0.038****
Acquisition of Marco Motor N (%)	2 months	14(31.1)	7(13.5)	0.075	25(55.6)	6(18.7)	**0.004*****
	1 month	26(57.8)	33(63.5)		12(26.7)	13(40.6)	
	not acquired	5(11.1)	12(23.1)		8(17.8)	13(40.6)	
AIMS Postures Md (IIQ)	Prone	10(8-12)	10(7-13)	0.805	21(13-21)	19(13-21)	0.268
	Bench press	9(7-9)	8(8-9)	0.750	9(9-9)	9(9-9)	0.594
	Seated	10(8-12)	10(8-11)	0.241	12(12-12)	12(12-12)	0.630
	Standing	5(4-5)	4(3-5)	**0.001****	8(6-8)	6,5(6-8)	0.112
AIMS M(SD)/Md (IIQ)	Total	33(8.0)	31(8,5)	0.318	49(42-50)	46 (39-50)	0.194
Risk categorization N (%)	Up to P25	9(20)	14(26,9)	0.424	15(33,3)	15(46.9)	0.230
	More than P25	36(80)	38(73.1)		30(66.7)	17(53.1)	

Note. GA: Gestational Age; [1]7 months-sitting and 10 months-crawling; AIMS: *Alberta Infant Motor Scale*; [2]Saccani & Valentini (2012); M: Mean; SD: Standard Deviation; Md: Median: IIQ: Interquartile Range; Up to P25: with risk; More than P25: Without risk; *T-test; **Mann-Whitney; ***Chi^2.

Regarding socio-economic factors, maternal education was higher in the 7-month post-winter group (p=0.034), and the highest number of layers of clothing was observed

for the post-winter group, both at 7 and 10 months old (p<0.0001). Table 2 shows the results of the groups for socioeconomic, maternal, and pregnancy factors.

Table 2. Socioeconomic, maternal, and pregnancy factors: Groups of 7 and 10 months old, post-summer and post-winter.

Socioeconomic factors, pregnancy & maternal practice		7 months old			10 months old		
		Post-summer	Post-winter	p	Post-summer	Post-winter	p
Maternal age Md (IIQ)		25(21-33)	27(24-32)	0.194	27(21-32)	30(24-34)	0.142
Maternal Education Md(IIQ)		10(9-11)	11(9-13)	**0.034****	11(9-11)	11(8-11)	0.679
Socioeconomic Benefit N(%)		6(13.3)	11(21,1)	0.312	8(17.8)	9(28.1)	0.281
Family income N(%)	< 2 wages	27(60.0)	28(53.8)	0.542	19(42.2)	14(43.7)	0.894
	> 2 wages	18(40.0)	24(46.1)		26(57.8)	18(56.2)	
Property Type N(%)	House	37(82.2)	48(92.3)	0.132	44(97.8)	30(93.7)	0.373
	Apartment	8(17.7)	4(7.7)		1(2.2)	2(6.2)	
Planned Pregnancy N(%)		18(40.0)	19(36.5)	0.726	17(37.8)	12(37.5)	0.980
Adequate prenatal care N(%)		40(88.9)	43(82.7)	0.386	39(88.6)	27(84.4)	0.587
Smoking during pregnancy N(%)		6(13.3)	9(17.3)	0.589	2(4.4)	5(15.6)	0.101
Alcohol during pregnancy N(%)		7(15.6)	5(9.6)	0.312	2(4.4)	6(18.7)	0.503
Number of children Md(IIQ)		2(1-2)	2(1-3)	0.704	1(1-2)	2(1-3)	0.063
Main caregiver mother N(%)		36(80)	42(80.8)	0.924	37(82.2)	24(75)	0.441
Work outside the home N(%)	Father/Mother/None	34(75.6)	40(76.9)	0.531	34(75.6)	23(71.9)	0.717
	Both	11(24.4)	12(23.1)		11(24.4)	9(28.1)	
Breastfeeding (BF)	Yes N (%)	44(97.8)	48(92.3)	0.224	44(97.8)	30(93.7)	0.373
	(days) Md (IIQ)	150(60-210)	210(165-210)	0.124	300(120-300)	300(60-300)	0.268
Exclusive BF (days)	Md (IIQ)	120(30-150)	120(75-150)	0.572	120(90-180)	150(30-180)	0.884
Place permanence when awake N (%)	+ Free	24(53.4)	17(36.5)		35(77.8)	22(68.7)	0.428
	+ Restricted	21(46.7)	33(63.5)		10(22.2)	10(31.2)	
Pediatra N (%)	Public	42(93.3)	42(80.8)	0.070	39(86.7)	23(71.9)	0.106
	Private	3(6.7)	10(19.2)		6(13.3)	9(28.1)	
Pediatrician guidance on MD N (%)		17(37.8)	13(25)	0.174	11(24.4)	4(12.5)	0.156
Contact with pets N (%)		17(37.8)	17(32.7)	0.600	23(51.1)	12(37.5)	0.237
Maximum number of layers of clothing Md (IIQ)		1(1-1)	3(3-4)	**0.000****	1(1-1)	3.5(3-4)	**0.000****

Note. Md: median; IIQ: interquartile range; + Free: Floor, bed / fence; + Restricted: lap, chair, trolley; **Mann-Whitney Test.

The results show that the group of 10-month-old infants, at risk of motor delay, had a lower gestational age. Regarding the acquisition of motor milestones, this occurred later for the group of children at risk of motor delay at 7 (sitting, p=0.009) and 10 (crawling, p=0.015) months of age. Table 3 shows the results of the groups with and without risk for biological factors at birth, motor scores, socioeconomic factors, pregnancy, and maternal practice.

Table 3. Biological factors at birth, motor scores, socioeconomic factors, pregnancy, and maternal practice: Groups of 7 and 10 months old, with and without risk of motor delays.

Biological, Motors, Socioeconomic Factors, Pregnancy & Maternal Practice		7 months old			10 months old		
		with risk	Without risk	p	with risk	Without risk	p
		N = 23(23.71%)	N = 74(76,29%)		N = 30(38.96%)	N = 47(61.04%)	
Group n(%) Evaluation	Post-summer	9(39.1)	36(48.6)	0.424	15(50)	30(63.8)	0.230
	Post-Winter	14(60.8)	38(51.3)		15(50)	17(36.1)	
Gender n(%)	Female	10(43.4)	31(41.8)	0.893	19(63.3)	22(46.8)	0.156
	Male	13(56.5)	43(58.1)		11(36.6)	25(53.1)	
Birth n(%)	Cesarean	10(43.4)	42(56.7)	0.265	19(63.3)	24(51.0)	0.290
	Vaginal	13(56.5)	32(43.2)		11(36.6)	23(48.9)	
GA Md (IIQ)		39 (37.6-40)	38,7(37.8-40)	0.969	38,5(0.9)	39,0(1.1)	**0.040***
APGAR 5 minutes Md (IIQ)		9(9-10)	9(9-10)	0.865	10(9-10)	10(9-10)	0.917
Birth Weight (g) M (SD)		3235(403)	3392(433)	0.125	3209(354)	3297(397)	0.328
Current weight M (SD)		8268(7515-9356)	8297(7585-9150)	0.973	8750(8025-9650)	8995(8140-10150)	0.471
Current height M (SD)		67.6(2.6)	67.9(2.7)	0.640	71,0(3.16)	72,2(2.8)	0.062
Acquisition of Marco Motor n(%)	2 months	10(43.4)	54(72.9)	**0.009****	7(23.3)	24(51.1)	**0.015****
	Recently/Not acquired	13(56.5)	20(27)		23(76.6)	23(48.9)	
Maternal age Md (IIQ)		27(25-35)	25(21-32)	0.303	32(26-35)	27(21-31)	**0.020***
Maternal education Md (IIQ)		11(8-12)	11(9-11)	0.895	11(9-11)	11(8-12)	0.524
Government benefit N(%)		5(21.7)	12(16.2)	0.543	12(40)	5(10.6)	**0.002****
Family income N(%)	Up to 2 wages	15(65.2)	40(54)	0.345	13(43.3)	20(42.5)	0.946
	>2 wages	8(34.7)	34(45.9)		17(56.6)	27(57.4)	
Property Type N(%)	House	21(91.3)	64(86.4)	0.421	29 (96.6)	45(95.7)	0.665
	Apartment	2(8.7)	10(13.5)		1 (3.3)	2(4.2)	
Planned Pregnancy N(%)		4(17.3)	21(44.5)	**0.015****	10(33.3)	19(40.4)	0.531
Adequate prenatal care N(%)		18(78.2)	65(87.8)	0.135	26 86.6)	40(86.9)	0.971
Smoking during pregnancy N(%)		3(13)	12(16.2)	0.501	4(13.3)	3(6.3)	0.261
Alcohol during pregnancy N(%)		3(13)	9(12.1)	0.579	4(13.3)	4(8.5)	0.377
Number of children Md(IIQ)		2(1-3)	2(1-2)	0.638	2(1-4)	1(1-2)	**0.002***
main caregiver mother N(%)		17(73.9)	61(82.4)	0.368	23(76.6)	38(80.8)	0.659
Work outside the home N(%)	Father/Mother/None	20(87)	54(73)	0.135	22(73.3)	35(74.4)	0.912
	Both	3(13)	20(27)		8(26.6)	12(25.5)	
Breastfeeding (BF)	Yes N(%)	20(86.9)	72(97.3)	0.085	30(100)	44(93.6)	0.222
	(days) Md(IIQ)	120(7-210)	210(120-210)	**0.012***	300(120-300)	300(60-300)	0.551
Exclusive BF-days Md(IIQ)		60(3-120)	120(90-150)	**0.004***	120(60-180)	120(45-180)	0.790

Table 3. Continued...

Biological, Motors, Socioeconomic Factors, Pregnancy & Maternal Practice		7 months old			10 months old		
		with risk	Without risk	p	with risk	Without risk	p
		N = 23(23.71%)	N = 74(76,29%)		N = 30(38.96%)	N = 47(61.04%)	
Place permanence when awake N(%)	+ Free	10(43.4)	33(44.5)	0.925	15(50)	42(89.3)	**0.000****
	+ Restricted	13(56.5)	41(55.4)		15(50)	5(10.6)	
Public Pediatrician N(%)		20(86.9)	64(86.4)	0.631	26(86.6)	36(76.6)	0.216
Pediatrician Guidance on MD N(%)		6(26.1)	24(32.4)	0.565	3(10)	12(25.5)	0.081
Contact with pets N(%)		8(34.7)	26(35.1)	0.975	11(36.6)	24(51.1)	0.216
Maximum Number of Clothes Layers Md(IIQ)		3(1-3)	2(1-3)	0.703	1(1-4)	1(1-3)	0.190

Note. Marco Motor acquisition of sitting at 7 months and crawling at 10 months; *T-test; ** Chi-Square Test; AIMS: *Alberta Infant Motor Scale;* + Free: floor, bed/fence; + Restricted: lap, chair, trolley.

The results also showed that, for infants at risk of motor delay, at 7 months, a smaller number of parents planned the pregnancy (p=0.015), the duration of breastfeeding was shorter (p=0.012), as well as the time in exclusive breastfeeding (p=0.004). At 10 months old, infants at risk of motor delay had a higher maternal age (p=0.020), a greater number of families receiving government financial assistance (p=0.002), and a greater number of siblings (p=0.002); these infants were also kept, when awake, in places with greater restriction of movement (lap, chair, trolley; p<0.0001), when compared to infants who were not at risk and who remained in other places with less restricted mobility (floor, bed or fence).

In the univariate logistic regression analysis, considering the risk to motor development as the dependent variable, the results showed that the chances of the child having motor delay, at 7 months old, was associated with a family income of less than two monthly minimum wages (OR: 1.8 and 95% CI: 0.6-5.4), maternal age ≤ 20 years old (OR: 0.3 and 95% CI: 0.0 - 2.3), birth weight < 3000g (OR: 2.2 and 95% CI: 0.6 - 7.7), not having been breastfed (OR: 7.1 and 95% CI: 1.1 - 46.2), breastfeeding duration less than 90 days (OR: 5.5 and 95% CI: 1.7 - 17.5) and with the time of acquisition of the sitting milestone having occurred less than two months ago (OR: 6.2 and 95% CI: 0.8- 49.5). At 10 months old, the increased chances of delay in motor development were associated with breastfeeding duration of fewer than 90 days (OR: 0.4 and 95% CI: 0.1 - 1.3), with the place where the infant stayed, when awake, be more limited (OR: 16.7 and CI95%: 4.7 - 60.0), having acquired the crawler motor mark less than two months ago (OR: 3.5 and CI95%: 1.2 -10.1) and having experienced the acquisition of this milestone during the winter (OR:1.9 and 95%CI: 0.7-4.9). Not receiving the government benefit (OR: 0.3 and 95% CI: 0.1-0.8) was a protection factor, as it was associated with a higher family income. The variable breastfeeding, in the 10-month group, was excluded from the analysis because only three infants were not breastfed, while breastfeeding duration was maintained in the model. Table 4 presents the univariate logistic regression results for the 7- and 10-month-old groups.

Table 4. Univariate logistic regression: dependent variable risk of motor delay, at 7 and 10 months old.

Variables		7 months old		10 months old	
		***OR* (IC 95%)**	**p**	***OR* (IC 95%)**	**p**
Governmental Benefit	No	Reference (-)	-	Reference (-)	
	Yes	0.5(0.1-1.7)	0.267	0.3(0.1-0.8)	**0.024***
Monthly Family Income	> 2 wages	-	-	-	
	< 2 wages	1.8(0.6-5.4)	0.255	1.1(0.4-2.9)	0.783
Property Type	House	-		-	
	Apartment	0.3(0.0-2.8)	0.315	0.9 (0.1-10.7)	0.949
Maternal age	21-30 years old	-	-	-	-
	≤ 20 years old	0.3(0.0 -2.3)	0.228	2.3(0.5-9.5)	0.260
	31-35 years old	0.9(0.2-4.0)	0.949	6.9(1.8-25.8)	**0.004***
	> 35 years old	0.9(0.2-3.6)	0.854	5.0(1.1-22.0)	**0.034***
Number of children	≤3 children	-		-	-
	≥4 children	2.9(0.4-19.0)	0.267	14.1(2.8-71.0)	**0.001***
Smoking during pregnancy	No	-	-	-	
	Yes	1.0(0.2-4.1)	0.965	1.4 (0.2-7.7)	0.707
Alcohol during pregnancy	No	-		-	
	Yes	0.8(0.2-4.0)	0.786	2.0 (0.4-8.7)	0.357
GA at birth	38-40 weeks	-		-	-
	37-37,9 weeks	1.2(0.4-3.8)	0.755	1.9 (0.6-6.4)	0.270
	> 40 weeks	0.7(0.2-2.7)	0.572	0.3 (0.0-2.9)	0.313
Birth weight	3000-3499g	-		-	-
	2500-2999g	2.2(0.6-7.7)	0.216	1.8 (0.6-5.6)	0.290
	> 3500g	1.1(0.3- 3.6)	0.874	0.5 (0.1-1.7)	0.276
Work outside home	One/none	-		-	
	Both	0.5(0.1-2.1)	0.371	1.3 (0.5-3.8)	0.591
Main caregiver	Mother	-	-	-	-
	Other	1.1(0.3-3.9)	0.858	1.6 (0.5-5.9)	0.416
Breastfeeding (BF)	Yes	-	-	-	-
	No	7.1(1.1-46.2)	**0.039***	-	-
BF time	>180 days	-		-	-
	0-90 days	5.5(1.7-17.5)	**0.004***	0.4 (0.1-1.3)	0.119
	91-180 days	3.0(0.6 -13.9)	0.174	1.1 (0.2-5.6)	0.885
Place of stay when awake	+ Free	-		-	-
	+ Restricted	1.1(0.4 -3.1)	0.828	16.7(4.7-60.0)	**0.0001***
Acquisition of motor milestone	2 months	-		-	-
	Recently	6.2(0.8-49.5)	0.085	3.5(1.2-10.1)	**0.021***
Climate in which they experienced acquisitions	Summer	-		-	-
	Winter	1.6(0.6-4.6)	0.355	0.8 (0.2 – 4.5)	0.846

Note. OR: *Odds Ratio*; + Free: floor, bed/fence; + Restricted: lap, chair, trolley, *T-test.

Table 5 shows the results of the multiple logistic regression analysis, which included the independent variables that were significant in the simple analysis ($p < 0.25$), for the dependent variable risk for motor development, at 7 and 10 months old. At 7 months old, the variables breastfeeding (OR: 6.4 and 95% CI: 1.0-42.4) and breastfeeding duration less than 90 days (OR: 8.9 and 95% CI: 2.0 – 40.4) were the only ones that remained significant in the model, increasing the chances of motor delay. At 10 months old, not receiving government benefit (OR: 0.1 and 95% CI: 0.4-0.7) remained a risk protection factor, while the number of children was greater than three (OR: 19.9 and 95% CI: 1.9 – 202.9) and the most restricted place of permanence (lap, chair, trolley)

of the child, when awake (OR: 14.6 and 95%CI: 3.7-57.4), remained significant in the model, increasing the chances of risk of motor delays. Table 5 presents the results of the multivariate logistic regression for the 7- and 10-month-old groups.

Table 5. Multiple logistic regression model with significant independent variables in the univariate: dependent variable risk of motor delays, at 7 and 10 months old.

Logistic Regression		***OR* (CI 95%)**	**p**
7 months old - Motor Delay Risk (dependent variable)			
Monthly Family Income	> 2 wages	-	-
	< 2 wages	1.7(0.6-5.0)	0.355
Maternal age	21-30 years old	-	-
	≤ 20 years old	0.2(0.0-2.4)	0.215
Birth weight	3000-3499g	-	-
	2500-2999g	3.9(0.7-20.4)	0.104
Breastfeeding	Yes	-	
	No	6.4(1.0-42.4)	0.053
Breastfeeding Time	>180 days	-	-
	0-90 days	8.9(2.0-40.4)	**0.005***
	91-180 days	4.0(0.7-23.2)	0.117
Last Milestone Acquisition Time	2 months	-	-
	Recently	6.4(0.7-61.8)	0.106
10 months old - Motor delay risk (dependent variable)			
Maternal age	21-30 years old	-	-
	31-35 years old	1.6(0.2-15.4)	0.696
	> 35 years old	2.1(0.2-19.1)	0.500
Number of children	≤ 3 children	-	-
	≥ 4 children	19.9(1.9-202.9)	**0.011***
Government benefit	No	-	-
	Yes	6.5(1.0-42.6)	**0.049***
Breastfeeding Time	> 180 days	-	-
	0-90 days	0.4(0.1-3.1)	0.406
	91-180 days	1.8(0.2-16.0)	0.583
Place of stay when awake	+ Free	-	-
	+ Restrcited	22.3(4.0-122.7)	**0.0001***
Last Milestone Acquisition Time	2 months	-	-
	Recently	4.6(0.7-31.5)	0.116
Climate in which he experienced motor acquisitions	Summer	-	-
	Winter	0.8(0.2-4.5)	0.846

Note. OR: *Odds Ratio*; + Free: Floor, bed/fence; + Restricted: lap, chair, trolley, *T- test.

Discussion

Seasonality, risk and protective factors: Post-summer and post-winter groups

We evaluated two groups of infants immediately after the 2nd and 3rd trimester of life, in the post-summer and post-winter period, at 7 and 10 months old. The groups evaluated post-summer (born in winter) and post-winter (born in summer) were similar in most of the investigated variables. We observed higher weight and height in children evaluated in the post-winter period, at 10 months old. The restriction of outdoor

activities and the consumption of a more caloric diet due to the cold, are possible explanations for the higher weight in this group.

As for motor development, infants in the post-summer group show higher scores in the standing postures, at 7 months old, and earlier acquisition of crawling, at 10 months old. We observed that infants in the post-winter group had a higher number of layers of clothing, at 7 and 10 months old, showing a possible interference of seasonality. The results of this study join those previously reported in Japan (Hayashi, 1992) and the United States (Benson, 1993), as well as with more recent studies in Europe and Israel (Atun-Einy et al., 2013; McGrath et al., 2006; Tsuchiya et al., 2012). The climatic conditions of Santa Maria are similar to those reported in the study from Israel (9-17ºC in winter), which also had similar repercussions on the acquisition of crawling.

The limitation arising from the various layers of clothing was one of the restrictive factors to free movement and acquisition of motor milestones, as no differences were observed between the groups regarding the equipment used in the care of the infant (example: bed, chair, floor), similar to previous studies (Atun-Einy et al., 2013; Hayashi, 1992). Multilayers of clothing can restrict exploration possibilities and, consequently, motor acquisitions (Atun-Einy et al., 2013; Bartlett, 1998; Hayashi, 1992). Therefore, the results provide evidence for motor advantages in infants who reach the 2nd and 3rd trimesters of life in summer, in cold regions of the southern hemisphere. However, no differences were observed in the prevalence of risks for motor delays between the post-summer and post-winter groups. A higher motor score in the standing and crawling postures was observed in the groups evaluated at 7 and 10 months old, in the post-summer, although the prevalence of risks for delays was similar in the groups ($p=0.424$ and $p=0.230$, respectively).

The interview with the parents provides an understanding of the context of the infants' development. Regarding infants who experienced the 2nd or 3rd trimester in cooler months, it was observed that, in the 7-month-old group, 77% of infants who reached the P90 score on the AIMS had heating at home, and only about 10% in groups with scores between P50-P75, and P25 (at risk). In the 10-month-old group, none reached the P90 score, although the houses had some type of heating (82% in infants with a P25 score; 44% in those with a score between P50-75); in this group, all caregivers used heating only for bathing and not during play routines.

Risk and protective factors: groups at risk and without risk of motor delays

The results showed that in infants at risk of motor delay, at 7 months old, a smaller number of parents planned the pregnancy, the prevalence of mothers who breastfed was lower, and children were breastfed for less time than those without risk. Previous studies highlight the importance of breastfeeding in protecting infants from motor delay (Chiu et al., 2011; Leventakou et al., 2015; McCrory & Murray, 2013; Oddy et al., 2011).

At-risk, 10-month-old infants came from poor families, dependent on government aid, similar to previous studies (Chiquetti et al., 2018; Ronfani et al., 2015; Valadi & Gabbard, 2020). The gestational age of these children was lower, which has also been reported (Carniel et al., 2017; Chiquetti et al., 2018; Maggi et al., 2014; Sampaio et al., 2015; Smithers et al., 2015), had a greater number of siblings, another recognized risk

factor (Cheng et al., 2014; Koutra et al., 2012; Pereira et al., 2016) and they were children of older mothers, over 30 years old. Maternal age above 30 years old has been associated with low developmental scores, possibly due to a child's lower exposure to stimuli (Alvik, 2014). The 10-month-old infants, in our study, were more restricted in exploring the environment, kept more on the lap, chair, or trolley, a factor that directly affects motor development (De Borba et al., 2017; Pereira et al., 2016). The acquisition of the sitting and crawling motor milestones occurred earlier in the group without risk of motor delays, similar to previous studies (Pereira et al., 2016; Valentini et al., 2019).

Associations between variables and developmental risk

Logistic regression showed that, at 7 months old, both in univariate and multivariate analysis, the only two variables associated with the risk of motor delay were breastfeeding and the total duration of breastfeeding. Breastfeeding, in addition to higher nutritional quality, has a protective role for development (Chiu et al., 2011; Leventakou et al., 2015; McCrory & Murray, 2013; Oddy et al., 2011) including as an isolated protective effect, after adjusting for confounding variables for broad motor development, at 9 months old (Sacker et al., 2006), similar to this study.

At 10 months old, the variables that remained in the multivariate regression model associated with the risk of motor delay were the high number of children, low family income, the need to receive government benefits, and the opportunities, when awake, to stay in places with greater freedom of movement (floor, bed, and fences). The older age of the mother was associated with motor risk only in the univariate, not remaining as significant in the final model.

The families of children at risk receive support from the Bolsa Família Program (Brasil, 2004), they live in smaller houses, in neighborhoods with few resources and care, which can limit their children's mobility. At 10 months old, infants need wider and safer surfaces, such as the floor, to consolidate important motor acquisitions, such as crawling and changing postures. Restricting a child to trolleys and chairs, in homes with poor infrastructure, in cities with a cold climate, is a care strategy, although it impairs the infants' motor development. Adequate development opportunities offered to children in the home environment are directly associated with the family's financial resources and development outcomes in different age groups (Defilipo et al., 2012; Pereira et al., 2016; Valentini et al., 2019), which was also observed in our study.

Regarding the high number of siblings, previous studies have already shown the association with delay in motor development (Cheng et al., 2014; Halpern et al., 2000; Koutra et al., 2012; Pereira et al., 2016), possibly due to the reduced availability of the mother to provide care to the infant. Caregivers' time is divided between the number of children to be cared for and, consequently, the interaction between mother and infant is more restricted to food and hygiene (Müller et al., 2017). With less time to stimulate the child, who still does not have the autonomy to move independently, mothers choose to restrict the child's movement more and keep it in a safe place.

Considering the risk factors for motor development in this study, at 7 months old (breastfeeding) and 10 months old (number of children, poverty, restricted movement of the infant), it is suggested to families maintaining breastfeeding maternal over the first two years of life (Organização Pan-Americana da Saúde & Fundo de Emergência

Internacional das Nações Unidas para a Infância, 2018) and in the adaptation of home environments to enhance the opportunities for exploring the infant (Almeida & Valentini, 2013). Protection from the cold through mats and mattresses, the use of support benches or support devices to promote the exchange of positions (example: from the floor to higher positions - semi-kneeling, kneeling, and standing; from high positions for the floor), in a safe and comfortable environment for the child, does not need high resources, since the furniture in the house can be used.

In addition, guiding parents and caregivers to provide the infant with opportunities to play in a sitting position with different types of support, to change positions, perform tasks involving trunk rotation, rolling, weight transfer, and movements that challenge the balance of the infant; as well as encouraging crawling is crucial to optimizing infant development (Valentini et al., 2020). Considering that the high number of children was a risk factor, involving older siblings in the infant's play can compensate for the lack of time that parents of large families have to dedicate to these tasks. An environment rich in opportunities (Saccani et al., 2013), albeit under the influence of climate issues, can help to promote early childhood development, such as the available area of the house for the child to play.

Considering the association of delays with low income found in this study, the strategies suggested are easy to apply and do not represent a financial demand for low-income families. With this in mind, the implementation of periodic home visits for diagnosis and guidance on stimulation strategies compatible with the reality of families, educating parents and caregivers about the need for adjustments in the routine and in the environment where the child plays are essential. It is up to health professionals to devise strategies to guide families and insert them in monitoring programs in primary care, linked to childcare consultations or home visits in Family Health Strategies. Both accompaniments already exist and are contemplated in Public Health Policies; however, there are no specific strategies for monitoring and intervention focused on the motor development of infants.

Conclusion

The infants at risk in this study came mainly from families with an income of less than two minimum wages per month, a more vulnerable social class. Factors associated with the risk of motor delays were predominantly socioeconomic and maternal care. These factors can be offset with appropriate public policies for developing children and with the support and training of caregivers. Such strategies can be implemented and/or strengthened in partnerships with Higher Education Institutions, through extension programs, with direct actions with communities or indirect actions, working with potential multipliers.

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Author´s contributions

Letícia Hermes: design and writing of the text; organization of sources and/or analysis. Fabiane Kurtz Martins: literature review; data collection. Natiele Camponogara Righi: literature review; organization of sources and/or analysis; review of the text. Thais Helena Oliveira Böck: literature review; data collection. Claudia Morais Trevisan: text design and review. Angela Regina Maciel Weinmann: design and review of the text; organization of sources and/or analysis. Nadia Cristina Valentini: design and review of the text; organization of sources and/or analysis. All authors approved the final version of the article.

Corresponding author

Letícia Hermes
E-mail: letihermes1@gmail.com

Section editor

Prof. Dr. Milton Carlos Mariotti