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ORIGINAL RESEARCH

Biopsychosocial factors contributing to delayed motor development in children: a longitudinal study

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Abstract

Introduction: Biopsychosocial conditions may influence childhood motor skill acquisition.

Objective: To analyse the biopsychosocial profiles of children with delayed motor development.

Methods: Employ quantitative descriptive research under longitudinal analysis. Seventeen students with motor development classified as lower than expected after two evaluations were investigated. A biopsychosocial questionnaire was applied to analyse risk factors in the form of an interview for the parents, and the Motor Development Scale (MDS) was applied to evaluate subject motor patterns.

Results: Biological and environmental risk factors, such as difficulties in school learning and low socioeconomic status may have contributed to delays in motor development.

Conclusion: Childhood motor development may be influenced by biological and environmental risk factors such as gestational age at birth, type of birth, family socioeconomic status, and parental education level.

Keywords: motor skills, child development, social conditions.

INTRODUCTION

Research on developmental disorders has increased in recent years, particularly investigations of motor disorders associated with multiple biological or environmental factors[1]. Environmental conditions are thought to impact the acquisition of motor skills, and the effects can be positive or negative. Environment may also enhance the effects of biological risks during the course of childhood motor development[2].

Mancini et al.[3] describe a range of studies on the interaction between biological and environmental risk factors for infant development, and argue that the influence of both types of factors is modified and enhanced when acting jointly, causing negative consequences for development.

Saraiva and Barreiros[4] suggest that a wide range of biosocial variables can contribute to the understanding of childhood motor development, including gestational age, birth weight, chronological age and sex, socioeconomic status, maternal education, family size, residence type, degree of urbanization, climate, and cultural factors. The authors also indicate a strong link between general childhood development and the opportunity and practical conditions for physical and recreational activities provided by family, school, and friend groups.

The increase in motor coordination during infancy is easily perceptible. Children acquire a wide range of motor skills, allowing them to better control body posture (i.e., static and dynamic), environmental mobility in various contexts (e.g., walking, running, jumping), and the ability to manipulate various objects and instruments (e.g., catching a ball, throwing a rock, kicking, writing)[5]. During pre-school and elementary school, capabilities expand to include a repertoire of movements considered as prerequisites for other motor skills. By six years of age, children have the developmental potential to possess most of the fundamental adult motor skills[6]. The school environment thus becomes conducive to detecting changes in patterns of child development, whereby behavioural, motor, cognitive, and emotional problems may be indicative of a developmental disorder[7].

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Individual development largely depends on the implementation of appropriate contexts, including social and cultural conditions, motivation, educational context, and past experience[8]. To address these relationships, we analysed biopsychosocial profiles of children with developmental motor delay.

METHODS

We employed a quantitative descriptive study via longitudinal analysis, with the aim of investigating possible risk factors contributing to changes in patterns of motor development in children. Neuropsychomotor development was evaluated in two age groups, the first 6 to 24 months and the second 8 to 9 years. The first evaluation was carried out in 2002**, and included evaluation of neurological development of 221 infants from 14 kindergarten programs in Florianópolis, SC. The study employed the Brunet and Lèzine Psychomotor Development Scale for early childhood, and included evaluation of posture, oculomotor skills, language, and social skills. We obtained ages and global development quotients.

A second evaluation was carried out in 2010**, in which 145 of the same children were assessed during the 4th and 5th years of elementary school. The children were distributed among 45 schools in Florianópolis, SC. We used the Motor Development Scale (EDM) for evaluations[8], which evaluates fine motor function, global motor skills, balance, body scheme, spatial organization, temporal organization, and laterality, obtaining ages and motor quotients for these motor domains. Motor quotient values were measured and categorized, and motor functions were characterized through assigning a score that corresponds to one of seven descriptions of motor capability: very high (130 or more), high (120-129), normal high (110-119), normal average (90- 109), normal low (80-89), low (70-79) and very low (69 or less).

The sample selection in the present study was intentional, as we sought to evaluate only those students whose motor development was classified as "very low" in the 2nd assessment** according to the EDM[8]. These children accounted for 12% of the sample (n = 18), or a total of 145 students. We included as exclusion criteria children residing in other cities at the time of the study. The sample size then consisted of 17 students enrolled in the fourth and fifth years of 14 different public elementary schools (12 state and 2 municipal) in Florianópolis, SC. The inclusion criteria in this study were: i) letters of consent were signed by responsible parties; Ii) the child had interest in participating in data collection; III) the child did not have physical problems or general medical conditions preventing (either temporarily or permanently) performance of tasks.

The second evaluation included a biopsychosocial questionnaire in the form of an interview with parents of the subjects. This questionnaire was tested under criteria of clarity (M = 9.0) and validity (M = 9.5), and is used in projects developed by the Human Development Laboratory (LADEHU) of CEFID/UDESC, with data distributed as follows: Identification info; data from parents or guardians; pregnancy complications; complications during childbirth; child development; language and social behaviour; socioeconomic conditions; health issues during childhood. In this study we present only those variables that are biological and environmental risk factors for motor development.

Prior to study implementation we contacted the Secretary of Education, which issued a favourable opinion of conducting the proposed research in the corresponding educational units. We searched for students through the Secretary of Education using the computerized student record systems SERIE and Educacenso. Of the 221 children who participated in the previous survey, 154 were enrolled in Florianópolis elementary schools. We contacted schools where the project would be implemented to verbally explain the study objectives and research protocols. The students then received the 'terms of consent' documents to be signed by parents or guardians to authorize participation in the study. The survey was conducted in 145 schools, however data collection for this study included only the 17 schools that met the previously described inclusion criteria. The Development Scale Motor (EDM)[8] was fully implemented by an evaluative, previously trained professional with a master's degree in Physical Education and Human Movement Sciences from CEFID/UDESC.

Individual evaluations were performed at the school while the child was studying during class time, in a quiet space (classroom or gym court) made available by the school. The average time to apply motor tests was 35 minutes. Parent interviews were held later by the same evaluator in a quiet environment at the school. The average time for each parent interview was 20 minutes.

Analysis of descriptive data was done by calculating average, maximum, and minimum values, as well as standard deviations and percentages. The significance level was set at $p < 0.05$. Data were stored and analysed using SPSS v17.0. This study followed all the rules of Resolution 196/96 of the National Health Council regarding research involving human beings. It was approved by the UDESC Ethics Involving Humans Committee under protocol number 14/2010.

RESULTS

We created biopsychosocial profiles of the students and analysed motor development over the course of eight years. The results are presented in two stages: a) group biopsychosocial profile and b) two-stage motor development analysis.

Group biopsychosocial profile

Average child age was 9.3 years, with 9 females (53%) and 8 males (47%). They were enrolled in the 4th year (77%) or 5th years (23%) of elementary school. During the interview, most parents pointed several biological risk factors during the pre-, peri- and post-natal periods that may have influenced motor development (Table 1).

Reported factors associated with childbirth included high-risk pregnancies, and a considerable number of mothers who smoked cigarettes during pregnancy (Table 1).

Three children were born premature, with gestational ages of 32-37 weeks. There was high prevalence of caesarean delivery in the study group, and two mothers claim to have not breastfed. In terms of developmental benchmarks, we observed delays in walking without support and language acquisition. One child had a stroke at 5 years of age.

Table 1: Biological risk factors for childhood delays in development.

Variable	Risk Category	n	%
Pregnancy	High-risk		22
	Bleeding	1	
Threat of miscarriage		1	
	High blood pressure	1	
	Emotional trauma	1	
Use of toxic substances during pregnancy	Cigarettes	5	29
Medications (contraindicated)		1	6
Gestational age at birth	32-37 weeks	3	18
	> 42 weeks	1	6
Birth type	Cesarian	10	59
Birth weight	< 2.500 g	3	18
Breast feeding period	0 – 3 months	3	18
First spoken words	After 18 months	1	6
Walking unassisted	16 to 21 months	3	18
Complications during infancy	AVC	1	6
	Malnutrition	1	6

The main environmental risk factors were those related to poor socioeconomic conditions, with 56% of families reporting low income (or equal to the minimum wage). Parents in most cases reported a large number of residents living in the household. One child lives in a household that does not belong to his family (the mother lives in the workplace). The highest level of education of most parents was elementary school (1^{st} – 4^{th} grade). (Table 2).

Table 2: Environmental risk factors for childhood delays in development

Variable	Risk Category	n	%
Number of people residing in the home	2	1	6
	5 or more	9	53
Monthly income	1 minimum wage salary	10	56
	1 to 5 minimum wage salaries	7	41
Maternal education level	0-4	8	47
	5-8	5	29
Paternal education level	0-4	8	47
	5-8	7	41
Presenting learning difficulties		16	94
Physical inactivity	No systematic practice of physical activity	15	88
Complications during infancy	Alcoholic father	2	12
	Parents separated	3	18

Motor development in infancy vs. school-aged children

We reported descriptive analysis of chronological age variables (CA), negative age (NA), general motor age (GMA) and general motor quotient (GMQ) for both study stages (infancy vs. school-age). CA values are expressed in months, with a 17.9-month average in the infancy period and 112-month average (9.3 years) in the school-age period, for a total of eight years elapsed between the two evaluation periods. IN values increased from -1 month in the infant stage to -27.7 months in the school stage. The GMQ values confirmed delayed motor development in these children, who went from "average normal" in the infant period (value = 95.48) to "very low" in the school period (value = 75.23) (Figure 1).

Specific motor ratios were compared for children in both life stages. Analysis of individual motor development revealed a significant reduction in patterns of motor development in all cases except for children B and Q, both of which demonstrated motor inferiority from infancy (GMQ < 79 in both stages, (Figure 2).

DISCUSSION

Practically all children had negative test results (decreased motor quotient) after eight years. Of the seventeen subjects analysed whose motor development was considered "at risk", only two (2) had motor repertoire issues from infancy. This suggests severe motor development problems in childhood tend to extend into adulthood, and future research should address this issue.

Other longitudinal studies with design characteristics similar to the current study (i.e., children with motor delays and with a long period of time between assessments) also showed negative effects occurring over the length of the study period. Gilbert, Gilbert and Broth[9] as-

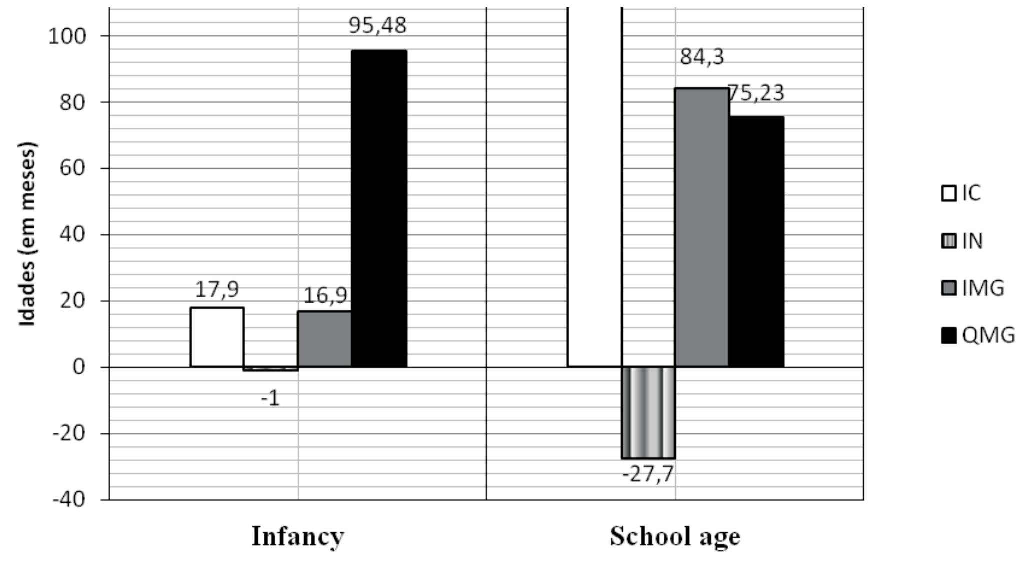

Figure 1: Chronological age (CA), negative age (NI), general motor age (GMA) and general motor quotient (GMQ) during infancy and school age.

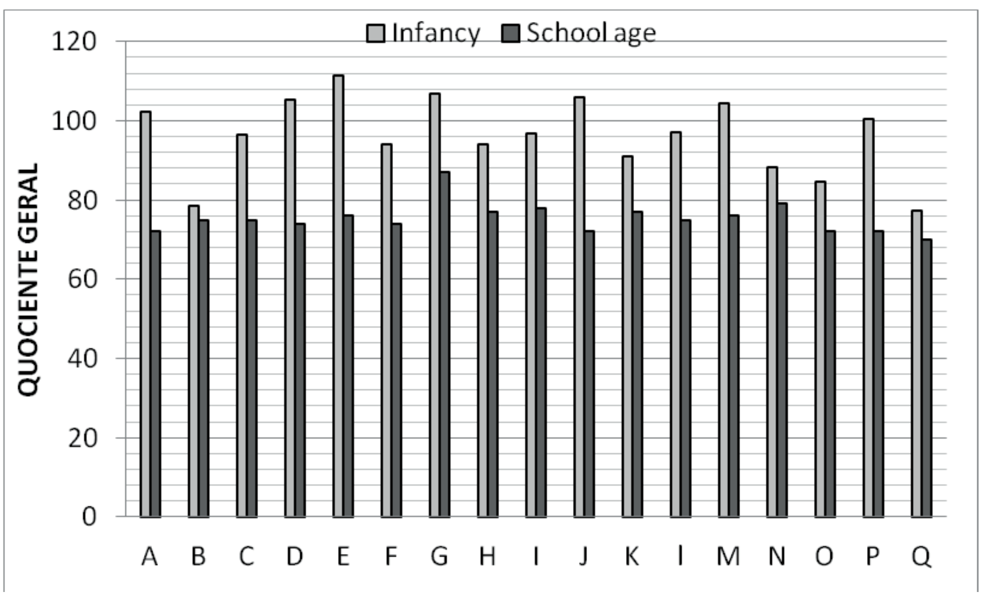

Figure 2: Motor skill development quotient values in infants and school-aged children.

sessed a group of children with deficits in attention, motor control, and perception at seven years of age, and found that more than two-thirds of the children showed decline in perceptual motor difficulties over 13 years. Similarly, other authors[10] have shown that in a group of children diagnosed with motor difficulties at six years old, the majority (87%) continued to have motor difficulties for the next 16 years. In another study[11] of children with coordination disturbances at five years old showed that these children continued to present motor problems 10 years later. When examining the same group of children at age 17, Cantell, Smyth and Ahonen[12] confirmed two prognoses for children with motor difficulties: persistence and recovery.

In addition to studies following the course of motor development among at-risk children, there is also a need for studies of how these problems might affect other aspects of development. Cantell, Smyth and Ahonen[12] also found that children diagnosed with motor skill disorders at age 5 had the lowest scores in the educational domain at ages 15 and 17 when compared to the control group (normal). Similarly, 16 children of the children in the current study were reported by teachers to have learning difficulties, an important factor in the context of this study. This fact deserves attention because these issues may be related to motor deficiencies, as polls show that there is a strong relationship between mobility problems and difficulties learning in school[13,14].

It is known that children with handwriting and group interaction problems typically also have motor difficulties, and these problems have been attributed to neurological and psychological disorders; however some of these children do not present symptoms of any disorder, yet still present motor problems[15]. O'Hare and Khalid[16] suggest that children with Developmental Coordination Disorder (DCD) also have delays in reading and writing, and that the origin of motor skill difficulties are heterogeneous, involving problems with posture, balance, and control of rapid movements. DCD results in a manifested disadvantage regarding daily activities and in school, however diagnosis is a complicated task because there are few diagnostic criteria and no guidelines for categorization specific to motor difficulties[17].

Cantell and Smyth[11] and Cardoso, Magellan and Barbosa[18] claim that in addition to motor problems being associated with school failure, they also are associated with lack of concentration, behavioural problems, low self-esteem, low social competence, and lack of physical activity. As children explore their environments through physical exercise and games involving motor activity, motor limitations may result in physical, motor-perceptual, moral, and emotional changes[19]. However, in this study more than half of the at-risk children did not participate, or never participated, in after school sports or social programs. Brauner*** explains that the experiences provided in a physical activity program cause interaction of individual and the environment characteristics, providing changes that drive development in ways that enable subjects to achieve higher levels of performance.

In general, there is overlap of biological and environmental factors in many situations that results in a high probability of developmental impairment[18,20]. Mancini et al.[3] mention the concept of "double jeopardy", which suggests that the presence of different types of risk factors (i.e., biological and environmental) may change the independent expression of each factor. It is worth mentioning that a Brazilian study by Magalhães et al.[21] found that with double jeopardy, children born at gestational ages of 32-36 weeks had the same developmental difficulties as children born at higher-risk gestational ages (< 32 weeks). In this context, the authors believe that social risk affects childhood development in groups exposed to different biological risk gradients.

Mancini et al.[3] showed that the social risk changes the relationships between biologic risk and childhood development in specific areas of functional performance of three-year olds, and their results suggest that high family socioeconomic status could minimize or neutralize potential losses of motor performance resulting from prematurity, offsetting the effects of biological risk.

Recent studies suggest that other factors may influence motor development. Noble, Coutinho and Valentini[22] suggest that motor proficiency may be affected environmental violence and parental belief system, lack of physical infrastructure and material resources, and most importantly, lack of opportunities for motor practice and poor teacher training. Factors such as nutrition[23] and sedentary behavior[24] may also influence the motor skill development in children.

Using a bioecological model, Noble, Coutinho and Valentini[22] found that high prevalence of childhood motor delays is an intercultural phenomenon acting mainly in children of low socioeconomic status. They then identified changes in the built environment, community, and social environments that foster appropriate motor development in childhood. Considering these results, actions taken by the school and implementation of social projects may serve as alternatives to ensure greater motor development in socioeconomically disadvantaged children. Santos, Pepper and Rose Neto[2] that social risk students in Florianópolis have better motor development patterns when they participate in social and sports programs compared to students who do not participate in extracurricular activities. Fernani et al.[25] also associated motor deficits and learning difficulties, and demonstrated the benefits of motor interventions for improving motor pattern and consequently, academic performance in school children aged 6-11 years.

In short, beyond biological (evolutionary) processes, environmental and social factors may influence motor development[22], a fact that we have demonstrated in the current study. We have revealed that students whose biopsychosocial profile contained biological and environmental risk factors showed significant delay in motor development, and that inferior motor development may be due to these factors. Current ecological research is aimed at understanding a child's environment as an influencing, yet modifiable factor for development of motor skills. As such, further studies assessing the environment (home, natural, social and community factors) are critical for development of methods to ensure adequate or appropriate pattern of childhood motor development. We found few longitudinal studies on motor development, which may have hampered thorough discussion of the results. We feel that this work is relevant in teaching, educational and public health contexts; specifically, we feel that additional studies using longitudinal methods are needed for emergence of related informative data.

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Resumo

Introdução: Condições biopsicossociais podem influenciar a aquisição de habilidades motoras na infância.

Objetivo: analisar o perfil biopsicossocial de escolares com atraso no desenvolvimento motor.

Método: trata-se de uma pesquisa descritiva quantitativa sob análise longitudinal. Foram investigados dezessete escolares que tiveram na segunda avaliação seu desenvolvimento motor classificado como inferior ao esperado. Para análise dos fatores de risco utilizou-se um questionário biopsicossocial em forma de entrevista com os pais das crianças e a Escala de Desenvolvimento Motor (EDM) para avaliação do padrão motor da criança.

Resultados: fatores de risco biológico e ambientais, como dificuldades na aprendizagem escolar e baixo nível socioeconômico podem ter contribuído para o atraso no desenvolvimento motor.

Conclusão: o desenvolvimento motor pode ser influenciado por fatores de risco tanto biológico como ambiental, tais como: tempo de gestação, tipo de parto, condição socioeconômica da família, nível de escolaridade dos pais.

Palavras-chave: habilidades motoras, desenvolvimento infantil, condições sociais.