Universidade de Lisboa
Faculdade de Motricidade Humana

Biosocial Determinants of Motor Competence in Preschool Children

Dissertação elaborada com vista à obtenção do Grau de Doutor em Motricidade Humana na especialidade de Comportamento Motor

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Abstract

This thesis focuses on motor competence of preschool children (3-5 years), and aimed to contribute to a better understanding of the causes for motor variability, based on an ecological framework. A set of empirical studies sought to explore the effects of the biosocial variables related to the child's characteristics, the family and preschool environments. An initial sample of 540 children was used to validate the Portuguese version of the PDMS-2, to evaluate its cultural sensitivity, and to determine the motor profile of Portuguese preschool children. In the following studies, the influence of age, sex and somatic variables, and the biosocial determinants associated with low and high motor competence were evaluated. Multiple linear and logistic regression analysis were conducted in the different studies. The results showed a sexual differentiation in motor competence. The effect of age and sex on motor performance varied with age group and motor specificity. The motor variability of preschool children was mainly explained by social/environmental factors. The motor competence of boys and girls was explained by different biosocial factors that may suggest different practice opportunities. The existence of a non-linear effect of biosocial variables along the spectrum of motor competence is suggested.

Keywords: motor competence; biosocial factors; preschool children; family environment; school environment; peers; ecological approach; validation; motor assessment; PDMS-2.

Resumo

A presente tese aborda a competência motora das crianças pré-escolares (3-5 anos), visando contribuir para um melhor conhecimento das causas da variabilidade motora, baseada numa abordagem ecológica. Foi realizado um conjunto de estudos empíricos com o objetivo de avaliar os efeitos das variáveis biossociais relacionadas com as características da criança, e dos ambientes escolar e familiar. Foi inicialmente utilizada uma amostra de 540 crianças para validar a versão portuguesa das PDMS-2, avaliar a sua adaptação cultural, e determinar o perfil motor das crianças pré-escolares portuguesas. Nos estudos seguintes, foi analisada a influência da idade, do sexo e de variáveis somáticas, assim como as variáveis biossociais associadas à baixa e alta competência motora. Regressões lineares e logísticas foram utilizadas nos vários estudos. Os resultados revelaram uma diferenciação sexual nos níveis de competência motora. O efeito da idade e do sexo variaram com o grupo etário e a especificidade motora. A variabilidade motora foi principalmente explicada por fatores sociais e do contexto. A competência motora entre rapazes e raparigas foi explicada por diferentes fatores biossociais, o que reflete em parte as diferentes oportunidades de prática que lhes são facultadas. É sugerida a existência de um efeito não linear das variáveis biossociais ao longo do espetro de competência motora.

Palavras-chave: competência motora; fatores biossociais; crianças pré-escolares; contexto familiar; contexto pré-escolar; pares; abordagem ecológica; validação; avaliação motora; PDMS-2.

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Saraiva, L., Rodrigues, L. P., & Barreiros, J. (2011). Adaptação e validação da versão portuguesa Peabody Developmental Motor Scales-2: um estudo com crianças pré-escolares. [Adaptation and Validation of the Portuguese Peabody Developmental Motor Scales-2 version: A study with Portuguese Preschoolers]. *The Journal of Physical Education/UEM*, 22 (4), 511-521.

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Book chapters

Saraiva, L., Rodrigues, L. P., Barreiros, J. (2011). Determinantes biológicas do desenvolvimento motor da criança em idade pré-escolar. [Biological determinants of children´s motor performance in preschool age]. In Pedro Morouço, Olga Vasconcelos, João Barreiros, & Rui Matos (Eds.). *Estudos em Desenvolvimento Motor da Criança IV* (pp. 166-176). Leiria: ESECS/CIMH- Instituto Politécnico de Leiria.

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Poster Communications

Saraiva, L., Rodrigues, L. P, Barreiros, J. (2009). Cross cultural comparison of motor development between Portuguese and US children. North American Society for the Psychology of Sport and Physical Activity (NASPSPA) Conference. Austin, USA.

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List of Abbreviations

AHEMD	Affordances in the Home Environment for Motor Development
AIMS	Alberta Infant Motor Scale
BOT	Bruininks-Oseretsky Test of Motor Proficiency
BMI	Body Mass Index
BSID (PDI)	Bayley Scales of Infant Development (Psychomotor Developmental Index)
CFA	Confirmatory Factor analysis
CFI	Comparative Fit Index
DCD	Developmental Coordination Disorder
DDST	Denver Developmental Screening Test
ENE	The Evolutionary Neurological Examination
FMQ	Fine Motor Quotient
HAZ	Height-for-age z-score
HOME	Home Observation for Measurement of the Environment
GMQ	Gross Motor Quotient
MABC	Movement Assessment Battery for Children
MC	Motor Competence
NASPE	National Association for Sport and Physical Education
NFI	Normed Fit Index
NNFI	Non-Normed Fit Index
PDMS-2	Peabody Developmental Motor Scales - 2
RML	Robust Maximum Likelihood
RMSEA	Root Mean Square of Error Approximation
SES	Socioeconomic Status
TGMD-2	Test of Gross Motor Development-2
TMQ	Total Motor Quotient
VABS	Vineland Adaptive Behavior Scales
WAZ	Weight-for-age z-score
WHO	World Health Organization
WHZ	Weight-for-height z-score

Chapter 1. Prolegomenon

1.1. Introduction

All healthy children have a potential for developing and learning fine and gross motor skills during early childhood. Nevertheless, research shows that children may have different developmental pathways to achieve their own level of motor competence (Adolph, Karasik & Tamis-Lemonda, 2010). The understanding and explanation of this inter-individual variability is still a challenging topic in contemporary research.

Historically, the theoretical and empirical approach of this topic has been portrayed by the “nature versus nurture” dichotomy. Currently, researchers abandoned this approach and recognized that development of motor competence during early childhood is determined by the complex interaction between biological factors and environmental conditions in which child lives and grows (Gabbard, 2011; Malina, 2004).

Based on this conceptual advance, the late twentieth century witnessed a gradual increase in the complexity of explanatory models of human development in an attempt to explain the processes of mutual regulation between the individual and the environment. Among various contemporary theories of human development, Bronfenbrenner’s Bioecological Theory (Bronfenbrenner, 2005) provides a useful theoretical and conceptual framework for understanding children’s motor development (Gabbard, 2011; Krebs, 2009). This ecological and systemic approach equates child development as a dynamic and interactive process between the child’s characteristics and his/her multiple contexts over time. In addition, Bronfenbrenner emphasizes that the child’s development is not only affected by the most immediate contexts in which children interact (family, peers, school and neighbourhood), but it is also influenced by the relationship between those systems and broader contexts (community, workplace of parents, etc.). In short, children are affected by their interpersonal relationships, the social institutions that touch their lives, their culture, and the historical period in which they are developing (Bronfenbrenner & Morris, 2006).

Despite these theoretical assumptions, the literature does not provide many empirical studies based on this framework. Ecological studies that have considered the bidirectional relation child-context and the multidimensionality of the context are scarce. Furthermore, in most of these studies, only the influence of family environment (physical and social factors) was explored without controlling other context effects, such as school, peers, or neighbourhood.

It is noteworthy to mention that these studies involved particularly infants from disadvantaged settings (Andraca, Pino, Parra, & Marcela, 1998; Chowdhury, Wrotniak, & Ghosh, 2010; Lima et al., 2004; Raikes, 2005) or children with biological risks factors, such as preterm birth or low birth weight (Janssen, der Sanden, Akkermans, Oostendorp, & Kollée, 2008). Studies that address the influence of biosocial factors on healthy preschoolers' motor development are scarce (Abreu-Lima, 2005; Barnnet, Hinkley, Okely, & Salmon, 2013; Lopes, 1998).

As noted, the causes of motor variability are not yet sufficiently clarified in the literature, particularly under a multidimensional understanding of motor development. On this research field some questions remain, for instance: What is the effect on motor competence of the reciprocal interaction between children’s characteristics and their main contexts of development, including the family, school and peers? How does this effect vary according to age, sex, and motor specificity? What are the biosocial determinants associated with low and high motor competence? Are these determinants the same but in an inverse relation?

A more specific advance in this matter may be given by formulating more complex research designs that seek to understand the adaptation mechanisms and the joint effects of biological and environmental factors on child’s motor competence. Such designs should also include the multidimensionality of the child’s context.

This thesis focuses on motor competence of preschool children (3-5 years), and aims to contribute to a better understanding of the causes for motor variability. Particularly in preschool age, children tend to broaden their social interaction environment (Shaffer, 2009). Other than family, the preschool and peers may also play an important role on preschooler's motor development. Therefore, it is imperative to know the joint effects of all these immediate contexts in order to have a more accurate understanding of the causes of motor variability.

A better understanding of the influence of biosocial factors on children's motor competence will help to design suitable educational interventions, policies and guidelines to promote an optimal motor development of children.

1.2. Objectives and outline of this thesis

Based on the main theoretical assumptions of the Bioecological theory, the present thesis aims to investigate the causes for motor variability on preschool children, analysing the effects of the interaction between preschool children (biological factors) and their main developmental contexts, including family, school and peers (social and environmental factors). This research seeks to clarify several key issues such as determining what is the combinatorial of variables with the best predictive value on high and low motor competence, the gender differentiation, and the age and sex effect on the different dimensions of the child's motor development.

To accomplish these aims, the dissertation comprises a sequence of studies that are presented as chapters.

This work starts with one review study (Chapter 2 - Biosocial determinants of children's motor development: an overview) that aimed to systematize the current knowledge concerning the influence of biosocial factors on child's motor development, highlighting the key gaps of the research.

The empirical part of this thesis begins by selecting the most appropriate tool to assess preschooler's motor competence. This part corresponds to the second study which is presented in Chapter 3 (Adaptation and Validation of the Portuguese Peabody Developmental Motor Scales-2 version: A study with Portuguese Preschoolers). Its aim was to test the psychometric properties of the PDMS-2, using a Portuguese preschooler's sample. It is important to note that PDMS-2 is widely used in international research, and allows a multidimensional interpretation of children motor development.

This first empirical study was followed by two exploratory studies in order to characterize the motor profile of preschool children (Chapter 4 - Motor Profile of preschool Portuguese children on the Peabody Developmental Motor Scales-2: a cross-cultural study), and to examine the effects of age, sex and selected biological factors on the different dimensions of children's motor development throughout the preschool period (Chapter 5 - Influence of age, sex and somatic variables on the motor performance of preschool children).

The last empirical study presented aims to identify the biosocial determinants associated with low and high gross motor competence (Chapter 6 - Biosocial determinants associated with low and high gross motor competence in preschool children).

Finally, in Chapter 7 (General Discussion), the main findings from the empirical studies are outlined and discussed within a bioecological approach. In addition, methodological implications from this thesis are drawn and some notes for future research are presented. This chapter ends addressing a number of potential practical implications derived from this work.

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Chapter 2. Biosocial determinants of children's motor development: an overview[1]

2.1. Abstract

The contemporary researchers recognized that development of motor competence during early childhood is determined by the complex interaction between biological factors and environmental conditions in which child lives and grows. Based on this assumption, the present study aims to analyze the current state of knowledge on the biosocial determinants of children's motor development. In summary, the influence of biosocial factors in child's motor development is not yet clearly understood, especially if we seek a more comprehensive explanation of the dynamical interaction between the child and its environment. In the future, it is needed to formulate more complex research with prospective designs that seek to understand the adaptation mechanisms and the joint effects of biological and environmental factors in the child's developmental pathway.

Keywords: child motor development; ecological approach; biosocial factors.

2.2. Introduction

During the twentieth century, researchers interested in the causes of variability and plasticity of human development often oscillated between extreme positions, defining the development as either the product of internal forces and innate ("Nature"), or as the product of external forces and environmental ("Nurture"). Currently, it is well recognized that development is not determined by a single cause, either biological or environmental, but by a multiplicity of biosocial factors, among

[1] Part of this chapter has been published in: Saraiva, L. & Barreiros, J. (2008). Determinantes biossociais do desenvolvimento motor infantil numa perspectiva ecológica [Biosocial determinants of children's motor performance based on an ecological approach]. In D. Catela & J. Barreiros (Eds) *Estudos em Desenvolvimento Motor da Criança* (pp. 141-150). Rio Maior: ESDRM Edições

which there are dynamic relationships (Bronfenbrenner, 1999; Lerner, 1998). Based on this conceptual advance, contemporary approaches of human development have been evolving in order to provide a more comprehensive explanation of the dynamic interaction between the organism and its environment. Among various contemporary approaches, the Bronfenbrenner's Bioecological Theory (Bronfenbrenner, 2005) provides a useful theoretical and conceptual framework for better understanding the biosocial influences on children's motor development (Gabbard, 2011; Krebs, 2009).

2.3. Overview of Bronfenbrenner's bioecological theory

Briefly, this theory conceptualized child development as a dynamic and interactive process between child characteristics and their multiple contexts over time. According to Bronfenbrenner (2005), the child development should be studied through four components and the dynamic relationship among them: Process, Person, Context and Time (PPCT model). The Process is considered the primary mechanism of human development and includes specific forms of interaction between child and environment that operate over time, which are designed as *proximal processes*. However, the form, power, and direction of such processes varies as a function of the characteristics of the developing Person, of the immediate and more remote environmental Context, and of the Time periods in which the proximal processes take place (Bronfenbrenner & Morris, 1998, p. 994).

As to Context, this theory stated that the child's development is not only affected by the most immediate contexts in which children interact (family, peers, school and neighbourhood), but is also influenced by the relationship between those systems and broader contexts (e.g., community, workplace of parents). Four interrelated environmental systems are identified in bioecological model: the *microsystem, mesosystem, exosystem, macrosystem* (fig. 2.1).

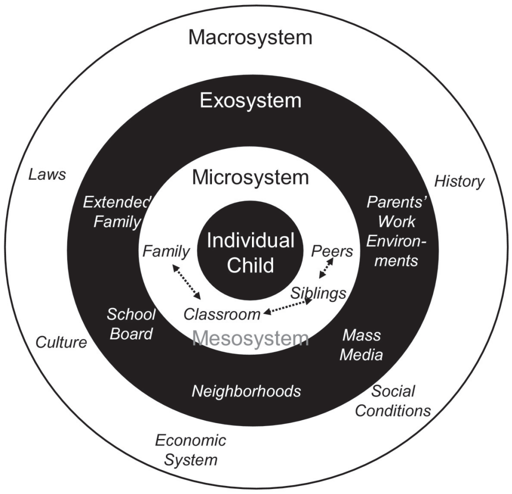

Figure 2.1. Bronfenbrenner's bioecological theory of development (adapted Eisenmann et al., 2008)

The microsystem is the setting in which developing child spends a good deal of time engaging in activities and social interactions. For example, family and child care settings are the primary developmental contexts of preschool children. The mesosystem comprises the interrelations among two or more settings within the microsystem, for example, the relation between family and child care. The exosystem refers to settings in which the child does not actively participate but that can indirectly influence the child, for instance parental workplace. The macrosystem involves the influences of broader social contexts such as the cultural, political systems and social values.

Lastly, it is important to note that in the bioecological model, the characteristics of the person are both a producer and product of development and "…within the limits and opportunities afforded by historical, cultural, and socioeconomics in which they live, human beings themselves influence their own development - for better or for worse - through their own choices and acts" (Bronfenbrenner, 1999, p. 22).

Based on this theoretical approach, the study of biosocial effects on child's motor development demands a multidimensional framework that considers the interaction between the child's characteristics and his/her multiple developmental contexts over time. Under this assumption, the present study aims to analyze current state of knowledge on the biosocial determinants of children's motor development through a critical analysis of ecological studies found in the literature.

2.4. Methods

2.4.1. Data sources

Four databases were searched to identify relevant studies for this review, including: PUBMED, SportDiscus, Scielo and RCAAP. Search terms included a combination of the following terms: Child development, motor development, psychomotor development, motor skills, motor performance, fundamental motor skills, motor competence, gross motor, fine motor, risk factors, biological factors, somatic factors, environment, biosocial factors, home environment, family, siblings, child rearing, peers, neighbourhood, and socio-economic status. Moreover, as information about influence of biosocial factors on children's motor development are usually provided in cross-cultural studies, the words "cross-cultural", "validation", "motor test", "standardization", were included as a keywords too.

2.4.2. Inclusion and exclusion criteria

Only articles meeting the following criteria were selected for this review: i) study was conducted after 1990 and was published in a peer review journal or in an edited book; ii) subjects included children aged ≤ 6 years; iii) only multivariate studies that examined the joint effects of biological and social/environmental factors on children's motor development. Studies that focused on children with disability or clinical disorders were excluded of this review.

2.5. Results

The search conducted shows that there are many studies that seek to examine the effect of biosocial factors on children's motor development. However, most of these studies have univariate designs, i.e., the biological and social/environmental effects on children's motor development were explored separately. Only seventeen studies with a multivariate approach were identified in the literature. Most of these studies were published in the last decade.

2.5.1. General characteristics of the studies reviewed

The main methodological characteristics and findings of these 17 studies are briefly presented in table 2.1.

Table 2.1. Summary of multivariate studies conducted to determinate the biosocial effects on children motor performance.

Study	Objective	Sample, Design and Analyses	Measures motor outcomes	Hypothetical factors	Findings
Andraca, Pino, Parra, & Marcela (1998)	To evaluate the effect of risk factors on infant development, among low socioeconomic children born under optimal biological conditions, and who are exposed to adverse social circumstances.	788 Infants (6 -12 months) Prospective study Multiple regression (stepwise)	BSID-II (PDI)	**Biological factors:** sex; temperament; birth weight; breastfeeding and height at 12 months; **Social and environmental factors**: SES, number of children; parental education; father's presence, and home stimulation; maternal intelligence; maternal depression; family stress; alcohol ingestion;	Breastfeeding, child temperament, maternal intelligence and home stimulation are consistently associated with PDI. After adjustment for covariables, home stimulation persisted as a significant factor for explaining the variation PDI and child sex (female) also appears as a risk factor for motor skills development. The accumulated effect of 7 or more risk factors is associated with a significant decrease of development scores.
Lopes (1998)	To assess the influence of selected biological and environment factors on motor performance of children.	181 children (5-6 years) Cross-sectional study Multiple regression (stepwise) and ANCOVA	Standing long jump; distance throw of a tennis ball; 20 metre dash; and static balance.	**Biological factors**: height, weight, biacromial and bicristal diameters, upper limb length, the brachial and calf perimeters and five skinfolds: triceps, subscapular, abdominal, suprailiac and calf. **Social and environmental factors**: parental education; parental occupation, household income; house type, number of people per room, space for playing outside the house, number of siblings, birth order, presence of older siblings, regular parental presence at home, geographical limit for child's play space, interaction with other children outside school, peers' age and sex; and types of toys more used by the child.	The relationship between motor performance and biosocial factors varied with the specificity of the motor test. However, the environmental factors had the most influence on performance for the majority motor tests. The differences between girls and boys were particularly explained by biological variables.
Halpern, Guibliani, Victora, Barros, & Horta (2002)	To investigate the risk factors and the prevalence of suspected cases of developmental delay in a cohort of children born in Pelotas, Brazil.	1363 infants (12 months) Cross-sectional study Logistic regression	DDTS-II	**Biological factors**: birthweight, cephalic perimeter, gestational age, intrauterine growth delay, body proportionality, neonatal morbidity, breastfeeding; vaccination, nutritional status at age 6 months, hospitalization in the 1st year of life, weight/age, height/age, weight/height indexes. **Social and environmental factors**: family income, parents' schooling, maternal age, interdelivery interval, dwelling, sanitation, density, parity, prenatal care; marital status; mother's color; smoking during pregnancy, support during pregnancy, paternal care, home pediatric care, day care attendance, working mother, current pregnancy.	After adjustment for confounders, low motor competence was associated with lower family income (OR= 1.5), very low birth weight (OR= 4.0), gestational age of less than 37 weeks (OR= 1.6), more than three siblings (OR= 1.9), less than 3 months of breastfeeding (OR=1.6), or no breastfeeding (OR= 1.9). The risk for failing the Denver II test was 10 times higher in children who presented a weight/age index lower than or equal to -2 z-score of the reference population at the 6th month of life.

Note: BSID-I (PDI): Bayley Scales of Infant Development- I (Psychomotor Development Index); DDTS-II: Denver Developmental Screening Test;

Table 2.1. continued

Study	Objective	Sample, Design and Analyses	Measures motor outcomes	Hypothetical factors	Findings
Lejarraga, et al. (2002)	To evaluate the association between environmental variables and the attainment of developmental milestones	3573 healthy infants and children (0-5 years) Cross-sectional study Logistic regression	12 development milestones (fine and gross motor)	**Biological factors**: sex; birth weight. **Social and environmental factors**: type of pregnancy care, maternal age, mother's education, father's occupation, family size, birth order, father's presence at home, and day care attendance.	Social class, maternal education and sex (female) were associated with earlier attainment of selected developmental items, achieved at ages later than 1 year. Selected items achieved before the first year of life were not affected by any of the independent environmental variables studied.
Kolobe (2004)	To examine the relationship between maternal childrearing practices and behaviors and the developmental status of Mexican- American infants.	62 Infants (9-12 months) Cross-sectional study Logistic regression	BSID-I(PDI)	**Biological factors**: gestational age at birth. **Social and environmental factors**: SES, maternal age, years of education, Parent behaviors (PBC), and Childrearing practices (HOME and NCATS).	The maternal SES and age, infants' GA, and NCATS scores accounted for 32% of the motor scores on the BSID-II. For motor developmental status, the association appeared stronger with the infants' characteristics than with maternal childrearing practices and behaviours tested in this study.
Lima, et al. (2004)	To identify biological and environmental factors associated with poorer mental and motor development at age 12 mo in urban communities in northeast Brazil	A cohort of 245 infants Longitudinal study (followed twice weekly from birth until 12 months). Multiple linear regression	BSID-I(PDI)	**Biological factors**: sex, gestational age, birth anthropometry and nutritional status at 12 months (length for age, weight-for age, weight-for-length). Information on morbidity and feeding practices (from 0-12 months), Haemoglobin concentration (at 12 months). **Social and environmental factors**: parental education, cohabitation and occupation, maternal age, household income, family size, parity, smoking during pregnancy, crowding, household conditions, and home stimulation (HOME).	Environmental factors explained about 19% of the variance in motor development. Of these, the most important were poverty-related. Significant biological factors associated with motor development were: weight-for-age and haemoglobin concentration. Biological factors explained only 5% of the variance in motor development. Of the variables examined, environmental factors had a greater detrimental effect on child development than biological factors in this population.
Abreu-Lima (2005)	To assess the relationship between HOME and child's developmental status	215 children (4-5 years) Cross-sectional study Multiple linear regression	VABS-II	**Biological factors**: sex, age, temperament. **Social and environmental factors**: SES, home stimulation (HOME), and day care attendance.	The results of the multiple regression indicated that the age and day care attendance explained 35.8% of the variance.
Raikes (2005)	To examine the impact of child's characteristics and family environments on different domains of development (such as language and motor) of young children living in a highly-impoverished environment in Nicaragua	95 children (2-5years) Cross-sectional study Multiple linear regression	DDTS-II: fine and gross motor subscales	**Biological factors**: sex, age, weight status. **Social and environmental factors**: child's health history (frequency and severity of illness), household density (persons per room), the number of other children under age five, parity food availability (taken as a proxy for the child's nutritional status).	Variance in developmental outcomes was explained by child's characteristics (weight status and age), and family and home characteristics (number of children under age five in the home, household density, and reported food shortages), but fine motor development was more sensitive to these factors than gross motor development.

Note: BSID-I (PDI): Bayley Scales of Infant Development- I (Psychomotor Development Index); DDTS-II: Denver Developmental Screening Test; HOME: Home Observation Measurement of Environment; NCATS: Nursing child assessment teaching scale; PBC: Parent Behavior checklist; VABS-II: Vineland Adaptive Behaviour Scales-II;

Table 2.1. continued

Study	Objective	Sample, Design and Analyses	Measures motor outcomes	Hypothetical factors	Findings
Bobbio, Morcillo, Filho, & Gonçalves (2007)	To identify factors associated with inadequate fine motor skills in Brazilian students of different socioeconomic status	238 schoolchildren (6-7 yrs) Cross-sectional study Multivariate logistic regression	ENE	**Biological factors**: birth weight. **Social and environmental factors**: household income, father's education, occupation and age, mother's education, occupation and age, marital status, type of residence and with whom the child lives, use of PC at home, extracurricular activity participation, age at time of starting school.	The findings indicate that socioeconomic status and the age at which a child starts school are related to fine motor skills. Children attending public school had a 5.5-fold greater risk of having inadequate fine motor skills for their age compared to children attending private school. While children who started school after four years of age had a 2.8-fold greater risk of having inadequate motor coordination compared to children who began school earlier.
Pilz & Schermann (2007)	To determine the prevalence of potential delays in neuro-psychomotor development and their possible association with, environmental and biological factors, and maternal competence, in a sample of children up to six years old living in Canoas, Rio Grande do Sul state.	197 children (up to 6 yrs) Cross-sectional study Multivariate logistic regression (hierarchical model)	DDTS- II	**Biological factors**: birth weight; birth age; conditions at birth; pathologies; breastfeeding. **Social and environmental factors**: household income; mother's education, age and health; family structure; father presence at home; number of siblings; intervals between pregnancies; day care attendance and elements of maternal competence.	The factors associated with potential development delays were: low income (OR=9.3); mothers with less than 18-month intervals between pregnancies (OR= 3.9); and lack of support from child's father (OR=7.0).
Janssen, der Sanden, Akkermans, Oostendor, & Kollée (2008)	To determine the influence of risk factors for delayed motor performance in Dutch preterm infants.	437 preterm infants (*M*=29 months; *SD*=3.3) Cross-sectional study Binary logistic regression	BSID-II	**Biological variables:** twenty neonatal risk factors, sex, gestational age, birth weight, Apgar score, congenital malformation; endotracheal intubation after birth. **Social and environmental factors**: maternal education level, multiple births.	Risk factors for delayed motor performance were: neonatal convulsions (OR=4.5), low maternal educational level (OR=3.3), male sex (OR=2.8), and chronic lung disease (OR=2.1).
Wu et al., 2008	To explore the factors that relate to mental and motor development in Taiwanese infants aged between 6-24 months.	570 full-term infants Prospective study (at 6, 12, 18, and 24 months of age) Multivariate generalized estimating equations	BSID-II	**Biological variables:** gestational age, birth weight, intrauterine growth status, birth set, mode of delivery, gender. **Social and environmental factors**: birth order, residence, parental age at delivery, parental education and occupation.	Intrauterine growth status, birth order and paternal occupation had longitudinal associations with motor scores. Large for gestational age and first birth order had a positive relation with the motor scores, whereas paternal occupation as technician had a negative relation with the motor development.

Note: BSID-I (PDI): Bayley Scales of Infant Development- I (Psychomotor Development Index); DDTS-II: Denver Developmental Screening Test; ENE: The Evolutionary Neurological Examination; PDMS-II: Peabody Developmental Motor Scales-II;

Table 2.1. continued

Study	Objective	Sample, Design and Analyses	Measures motor outcomes	Hypothetical factors	Findings
Santos, et al. (2009)	To analyze gross motor performance and its association with neonatal and familial factors and day care exposure among Brazilian children up to three years of age attending public day care.	145 children (58 aged 6-11 months, 54 aged 12-23 months and 33 aged 24-38 months) Cross-sectional study Logistic regression analyses	PDMS-II: Gross motor scale and Locomotion subtest	**Biological variables**: Gestational age; Birth weight; Apgar score. **Environmental factors:** Parental age, educational level and cohabitation, household density, monthly family income, day care attendance.	There were associations of risk between suspected delays in gross motor performance and family income, and between suspected delays in locomotion skills and parental educational level. Children whose families had a monthly income of up to 700 reais were 2.8 times more likely to present delays in gross motor performance. Children whose parents had up to eight years of education were 4.6 times more likely to present delays in locomotion skills.
Chowdhur, Wrotniak, & Ghosh (2010)	To examine the effect of socioeconomic and nutritional status on motor development of 5-12 year-old Santal children of India.	841 children (5-12 years old) Cross-sectional study Linear regression model	BOT-II	**Biological variables**: Age, sex, BMI and nutritional status: height-for-age z-score. **Environmental factors:** Socioeconomic status.	Stepwise regression analyses showed that, except for BMI, all other predictor variables such as nutritional status, socioeconomic status, age, sex and height have a significant impact on total BOT-2 score.
Koutra, et al. (2012)	To describe the socio-demographic characteristics associated with neurodevelopment in 18 months Greek infants.	605 infants (18 months) Cross-sectional study Multivariate linear regression	BSID-III (fine and gross motor subscales)	**Biological variables**: Gender, Gestational age; type of delivery. **Environmental factors**: parental age, education and employment status, parental origin, marital status, siblings, parity, hours per day that parents spend with his child.	Factors found to positively affect infants' fine motor development were being a girl; Greek paternal origin, and maternal education. Infants with older siblings scored lower in the gross motor scale and infants of working mothers scored higher.
Barnett, Hinkely, Okely & Salmon (2013)	To identify factors associated with children's motor skills.	76 children Mean age=4.1 (0.68) Cross-sectional study Multivariate linear regression	TGMD-II (locomotion and object control subtests)	**Biological variables**: age, sex. **Social and environmental factors**: parent perception of child's skill, participation in unstructured and structured activity, support to child's activity, parent–child physical activity interaction, parent physical activity and perceived environmental factors (play space visits, equipment at home), moderate to vigorous physical activity (MVPA).	Child age, swimming lessons, and home equipment were positively associated explaining 20% of locomotor skill variance, but only age was significant (β=0.36, *p*=0.002). Child age and sex, unstructured activity participation, MVPA%, parent confidence, home equipment (all positively associated), and dance participation (inversely associated) explained 32% object control variance. But only age (β=0.67, *p* <0.0001), MVPA% (β=0.37, *p*=0.038) and no dance (β=−0.34, *p*=0.028) were significant.
Saccani, Valentini, Pereira, Muller, & Gabbard (2013)	To determine the associations of biological factors and affordances in the home with motor development.	571 infants (aged newborn to 18 months) Cross-sectional study Backward regression	AIMS	**Biological variables**: gestational age, Apgar score, birthweight, birth length, cephalic perimeter, and duration of infant stay in a pediatric intensive care unit. **Social and environmental factors**: Affordances in the home environment for motor development (AHEMD), household income, mother's education, choice of toy/physical activities, parents' engagement.	The variables positively associated with infant motor development outcome were: physical space inside the house; parents' engagement in games about body parts; and household income (together those variables explained 27% of the variance of motor development).

Note: AHEMD: Affordances in the home environment for motor development; AIMS: Alberta Infant Motor Scale; BSID-III (PDI): Bayley Scales of Infant Development- III (Psychomotor Development Index); BOT-II: Bruininks-Oseretsky Test of Motor Proficiency-II; TGMD-II: Test Gross Motor Development -2; VABS-II: Vineland Adaptive Behaviour Scales-II;

Methodologically, most of these studies presented large samples and used cross-sectional designs. Only three prospective studies were found in literature (Andraca, Pino, Parra & Marcela, 1998; Lima et al., 2004; Wu et al., 2008).

The biosocial effects were particularly studied on infant's motor development. Only five of the seventeen studies reviewed involved preschool children and only three of those have focused exclusively on preschoolers (Barnett, Hinkely, Okely & Salmon, 2013; Abreu-Lima, 2005; Lopes, 1998). Some studies were conducted particularly with children from disadvantaged settings (Andraca et al., 1998; Chowdhury, Wrotniak, & Ghosh, 2010; Lima et al., 2004; Raikes, 2005) or children with biological risks factors, such as, preterm birth or low birth weight (Janssen, der Sanden, Akkermans, Oostendorp, & Kollée, 2008).

Regarding the choice of motor assessment instrument, various standardized tools were used, such as PDMS-2, TGMD-2, BOT-2, BSID-2 or 3, MABC, VABS-2, DDST and ENE. Some researchers opted to use the global indexes of these tools (e.g. Andraca et al., 1998; Pilz & Schermann, 2007), while others used motor subscales (e.g. fine and gross motor; locomotion and object manipulation) or selected motor tasks (e.g., standing long jump; distance throw of a tennis ball; static balance). The last studies enabled to explore the biosocial effects according to the specificity of the motor test (e.g., Barnett et al., 2013; Lejarraga et al., 2002; Lopes, 1998; Raikes, 2005; Santos et al., 2009).

Several biosocial factors were explored as hypothetical predictors of motor development. The researchers differentiate two types of biological factors: 1) distal factors, such as, neonatal risk factors, intrauterine growth status, gestational age, birthweight, birth length, Apgar score, sex, delivery type, and breastfeeding; and 2) proximal factors, such as, height, weight, weight/height, BMI, age, nutritional status, temperament, and various anthropometric measures.

Regarding the environmental effects, most studies only focused on family environment. Seven studies explored the joint effect of family and day care (e.g., Abreu-Lima, 2005; Bobbio, Morcillo, Filho, & Gonçalves, 2007; Halpern et al., 2002); however it is important to note that only the day care attendance was considered as a hypothetical predictor. Specific characteristics of the day care, such as its dimension, space available for play, characteristics of the school playground were not considered in any study.

While various factors were considered in family environment, they can be grouped in five main sets: 1) socio-economic characteristics, such as parental education, occupation, and household income; 2) family structure characteristics, such as, family size, marital status, number of siblings, birth order, parental age, siblings' age; 3) home characteristics (physical factors), for example, house type, number of people per room, outdoor space of home for child play and toy types; 4) social factors, such as, parental care, father presence at home, hours per day that parents spend with child, parent-child physical activity interaction, child's participation in unstructured and structured physical activity, i.e., quantity of stimulation provide by family; 5) some studies included variables related with mother's characteristics and behaviour, for instance, maternal intelligence, maternal stress, alcohol ingestion, smoking during pregnancy, support during pregnancy and interdelivery interval.

Only one study considered peers' influence on children motor competence including the age and sex of the peers as hypothetical predictors (Lopes, 1998).

The findings of the studies reviewed show that variability of motor performance may be explained by several biosocial factors, such as: age (Abreu-Lima, 2005; Barnett et al., 2013; Chowdhury et al., 2010; Kolobe, 2004); sex (Andraca et al., 1998, Barnett et al., 2013; Chowdhury et al., 2010; Lejarraga et al., 2002; Koutra et al., 2012; Wu et al., 2008); birthweight (Halpern et al., 2002); gestational age (Halpern et al., 2002); neonatal factors (Jannssen et al., 2008); weight (Halpern et al., 2002, Lima et al., 2004; Raikes, 2005), height (Chowdhury et al., 2010); breastfeeding (Andraca et al., 1998; Halpern et al., 2002); nutritional status (Chowdhury et al., 2010); family income (Bobbio et al., 2007; Halpern, Guibliani, Victora, Barros, & Horta 2002; Kolobe, 2004; Pilz & Schermann, 2007; Santos et al. 2009; Saccani, Valentini, Pereira, Muller, & Gabbard, 2013); mother education (Jannssen et al., 2008; Lejarraga et al., 2002; Santos et al. 2009; Wu et al., 2008); paternal occupation (Wu et al., 2008); support of child's father (Pilz & Schermann, 2007); home characteristics (Barnett et al., 2013; Raikes, 2005; Saccani et al., 2013); home stimulation (Andraca et al., 1998, Barnett et al., 2013); childrearing practices

(Kolobe, 2004); number of children at home (Halpern et al., 2002, Kolobe, 2004); siblings (Koutra et al., 2012); birth order (Wu et al., 2008); mother intelligent (Andraca et. al, 1998); interval between pregnancies (Pilz & Schermann, 2007), structured physical activity (Barnett et al., 2013), unstructured physical activity (Barnett et al., 2013); and day care attendance (Abreu-Lima, 2005; Bobbio et al., 2007).

2.6. Critical analysis of the studies reviewed

Most of the studies summarized in table 2.1 sought to answer key questions, such as: what is the combination of biosocial variables with higher predictive power of motor development? What is a set of biosocial variables or risk factors associated low motor development?

Overall, the findings of these studies support the assumption that motor development during early childhood cannot be explained by a singular cause, either biological or environmental, but by a multiplicity of biosocial factors, among which there are dynamic relationships. More than the effects of the variables, we should consider the effect of a group of variables that dynamically evolves with time according to the circumstances. Hence, it is extremely difficult to replicate the effects of this group of variables in another spatial or temporal context.

Unfortunately, the literature review does not provide enough findings to explain how the magnitude of biosocial effects varies throughout developmental process. The hierarchy of variables and their explanatory power are still far from being understood. For example, the identification of a collective variable which integrates the expression of a multiplicity of variables in a single quantitative expression has not been fully explored.

In this matter, some cross-sectional studies suggest that the biosocial effects vary according to age, sex and motor specificity (Barnett, 2013; Lopes, 2008; Raikes, 2005; Lejarraga et al., 2002). For instance, the study conducted by Lejarraga et al. (2002) with children up to three years of age, indicates that certain variables are only found to be predictive after the first or second year of life, such as social class, mother's educational level and sex. This finding suggests that the social and environmental factors appear to play a larger role among older children. In fact, the variation of the predictive power of the biosocial variables throughout development is of major importance. This issue will allow theorizing about a quantitative approach more than highlighting generic networks of variable effects. In addition to knowing which variables are determinants, it is important to know the dynamics of their effects.

Lopes (1998) investigated the influence of biosocial factors on the motor performance of 181 children between 5 and 6 years of age, and concluded that the magnitude of biosocial effects varies according to sex and motor specificity (e.g., standing long jump, distance throwing of tennis ball, 20 meter dash, and static balance). The social/environmental factors that most often entered in the predictive models were: father's occupation and educational level, the geographic limits set for children's play and birth order. The biological factors that most often entered in the predictive models were: the sum of skinfold measures and the calf's perimeter. In this study the motor variability among preschool children was particularly explained by social/environmental factors. On the other hand, the sex differences found in standing long jump and distance throw of the tennis ball were mainly explained by biological factors.

In other study with a sample of 95 impoverished Nicaraguan children, aged two months to five years, Raikes (2005) concluded that motor variability was explained by the child's characteristics (weight status and age), and family and home characteristics (number of children under age five at home, household density, and reported food shortages). However, the fine motor development was more sensitive to these factors than gross motor development. Once again, the problem of the heterogeneity of the dependent variable is underlined, raising serious reservations regarding a global explanation of motor development trends.

In most of these reviewed studies, only the influence of family environment (physical and social factors) was explored. In fact, there are few ecological studies that have considered the multidimensionality of the context (Abreu-Lima, 2005; Bobbio et al., 2007). On this issue, Abreu-Lima (2005) conducted a study to examine the relationship between the quality of family environment and the developmental status of the 215 children between 4 and 5 years. The quality of the family environment was assessed by HOME inventory (Home Observation for Measurement of the Environment) and the developmental status was assessed by VABS-II (Vineland Adaptive Behavior Scales). This study reported that the effects of family environment on the child's motor development were insignificant when adjusted for child's age and other environmental variables, for example, the day care center attendance. The age and the frequency in day care center explained 13% of the variance in motor development. This finding reinforces the need for a better clarification of the role of different developmental contexts in the child's motor development, such as school, peers, or neighbourhood.

Clearly, research provides evidence that the absence of adequate stimulation and/or the presence of certain biological and environmental risk factors (e.g., low gestational age, low maternal education, low income household, low home stimulation) may constrain children's motor repertoire. On the other hand, the explanation for high motor competence has not deserved much attention from the literature. The question whether the explanatory variables for low and high motor competence are different or are the same but in an inverse relationship requires further attention.

2.7. Conclusions

In short, it is impossible to make a general statement about the relative importance of biological and environmental factors because the answer depends entirely on the biosocial variables under question, the motor specificity and the nature of the sample. The understanding of biosocial effects on children's motor development is not yet sufficiently clarified in literature, particularly under a multidimensional approach. On this field of research some questions remain, for instance: What is the effect of the reciprocal interaction between children's characteristics and their main contexts of development, including the family, school and peers on motor competence? How does this effect varies according to age, sex, and motor specificity? What are the biosocial determinants associated with low and high motor competence?

In the future, it is necessary to formulate more complex studies with prospective designs that seek to understand the adaptation mechanisms and the joint effects of biological and environmental factors in child's developmental pathways. Such designs must not only include the multidimensionality of the child's context (school, family, peers, urban context), but also the different dimensions of motor behavior, to be able to attain more serious, reasoned and applied levels of explanation.

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Chapter 3. Adaptation and Validation of the Portuguese Peabody Developmental Motor Scales-2 version: A study with Portuguese Preschoolers [2]

3.1. Abstract

The purpose of this study was to examine the psychometric proprieties of the Peabody Developmental Motor Scales II (PDMS-2) (Folio & Fewell, 2000), using a Portuguese sample group. The Portuguese PDMS-2 version was applied according to the manual, to 540 children, from fifteen preschools, aged 36 to 71 months. The results of the confirmatory factor analysis (S-Bχ2=3.3, *p*=.349; CFI =1.0, NFI =.99, NNFI=.99, RMSEA =.013) support that the Portuguese version presents a model of two factors (Fine and Gross Motor) as does the original version. Most of the subtests showed good internal consistency (α = .76 to .95) and good test-retest reliability (ICC = .85 to .95). These findings indicate that the Portuguese PDMS-2 version is an accurate and valid tool to assess the gross and fine motor skills of Portuguese preschoolers.

Keywords: child development; motor skills; validation.

[2] Saraiva, L., Rodrigues, L. P., Barreiros, J. (2011). Adaptação e Validação da versão portuguesa Peabody Developmental Motor Scales-2: um estudo com crianças pré-escolares [Adaptation and Validation of the Portuguese Peabody Developmental Motor Scales-2 version: A study with Portuguese Preschoolers]. *Revista da Educação Física/UEM*, 22 (4), 511 - 521.

3.2. Introduction

Among several motor assessment tools described in literature, Peabody Developmental Motor Scales - second edition (PDMS-2) (Folio & Fewell, 2000) is one of the most widely used instruments in clinical and research settings (Saraiva & Rodrigues, 2007). This standardized and norm-referenced tool has been applied to assess the fine and gross motor skills of children from birth through 71 months of age and its normative sample was based on 2003 children residing in forty-six states of the United States and one Canadian province.

In its first edition (Folio & Fewell, 1983), the PDMS tool was specially designed for early detection of developmental delays or disorders. The current revised version (Folio & Fewell, 2000) presents other advantages that specifically allow: to estimate a child’s motor competence relative to his or her peers; to identify motor skill deficits and disparities within the fine and gross motor abilities; to establish individual goals and objectives for clinical or educational intervention; and to evaluate the child’s individual progress. Folio and Fewell (2000) also highlight the PDMS-2 utility as a research instrument.

PDMS-2 usefulness as a measurement tool is evident in several studies that sought to characterize the motor profile of special or clinical populations, such as: cerebral palsy, autistic, Down Syndrome and Hurler Syndrome (Dusing, Thorpe, & Rosenberg, 2006; Maring & Courcelle-Carter, 2004; Mitchel et al., 2005; Rao et al., 2004; Provost, Lopez, & Heimerl, 2007; Smith, Danoff, & Parks, 2002). In another line of research, PDMS-2 has been widely used to examine the effects of biological and environmental risks factors on children’s development (Angelsen, Jacobsen & Bakketeig, 2001; Arendt et al., 1999; Evensen et al., 2009; Fetters & Tronick, 1996, 2000; Majnemer, Barr, & 2006; Miller-Loncar et al., 2005; Goyen & Lui, 2002; Nelson et al., 2004; Trasti et al., 1999; Sommerfelt et al., 2002; Rodrigues, 2005; Santos, 2009). Some studies have examined the effectiveness of intervention programmes in educational or clinics settings (Wang, 2004; Willis et al., 2002)

The acceptability of the PDMS-2 among the scientific community is in part due to its composite structure that allows a multidimensional interpretation of motor development. The scales enable to calculate three global indexes of motor performance, namely: the Fine Motor Quotient (FMQ), the Gross Motor Quotient (GMQ) and Total Motor Quotient (TMQ), which is a result of the two previously mentioned quotients. The segmentation of the TMQ holds special interest for differentiating the individual characteristics and, particularly for monitoring the intervention program's effects.

The second edition of PDMS shows several improvements from the original version with respect to the normative sample and their psychometric proprieties. Concerning the instrument's reliability, the PDMS-2 examiner's manual reports a good internal consistency for each subtest (α = .89 to .95) and for each motor quotient (α = 0.96 a 0.97); acceptable test-retest reliability (r=0.73 to 0.96 depending on the age group); and a high inter-rater reliability which varies between 0.97 and 0.99 for each subtest and between 0.96 and 0.98 for the motor quotients.

Regarding its construct validity, Folio and Fewell (2000) examined two confirmatory factor analysis on two sub-samples of the North American normative data (children from birth to 11 months and 12 to 72 months) and established two-factor model of the PDMS-2: Fine and Gross Motor abilities, defined respectively by two fine motor subtests (Visual-Motor Integration, Grasping) and three gross motor subtests (Stationary, Locomotion and Object Manipulation, or Reflexes - for children birth through 11 months). In another study with Taiwanese children, Chien and Bond (2009) investigating the measurement properties of the fine motor scale of PDMS-2 using the Rasch analysis, concluded that unidimensionality of the Grasping and Visual-Motor Integration subtests could be achieved after removal of specific misfitting items. These results suggest that North American PDMS-2 model may not be adequate or identical for other sample populations. Therefore, its transcultural adaptation and validation is prudent before its application.

As far as criterion validity, the PDMS-2 authors supported a high correlation with their original version (*r*=0.84 and 0.91 respectively for GMQ and FMQ) and with the Mullen Scales of Early Learning (*r*=0.86 e 0.80 respectively for GMQ and FMQ). Bean et al. (2004) registered high correlations (*r*=0.90 to 0.97) between three PDMS-

2 GMQ subtests (reflexes, Locomotion and Stationary) and the Alberta Infant Motor Scale Total Motor Quotient in children (aged 2 through 15 months) at risk of developmental delays. In turn, Connolly and colleagues (2006) examined the concurrent validity of the PDMS-2 and the Bayley Scales of Infant Development II (BSID-II) in 12-month-old infants. The results indicate a low correlation between the Psychomotor Developmental Index (PDI) of the BSID-II and the PDMS-2 FMQ (r=0.30), GMQ (r=0.22), TMQ (r= 0.32) and a lack of agreement between age equivalent scores of the BSID-II Motor scales and the PDMS-2 subtests, except for Locomotion(r=.71, p<0.05). Based on these results, the authors recommended the use of multiple source of information when deciding upon eligibility for services rather than the use of the standard scores on only one test.

The sensitivity of the PDMS-2 was also confirmed in different groups of individuals (males, females, European Americans, African Americans, Hispanic Americans, children with mental retardation, children with physical disorders). Wang and colleagues (2006) confirmed its responsiveness, namely the ability to detect changes within six months in a sample group of 2 to 5-year old children with cerebral palsy. It appears to be a significant improvement to the revised version, considering that Palisano, Kolobe and Haley (1995) concluded that the Gross Motor Scale of the original PDMS version was not able to detect changes in motor development in children with cerebral palsy an interval of six months.

Despite these psychometric proprieties, some authors (Crowe, Mcclain & Provost, 1999; Provost et al., 2004; Tripathi, Joshua, Kotian, & Tedla, 2008; Van Hartingsveldt, Cup & Oostendorp, 2005) warn that the application of the PDMS-2 and particularly the interpretation of standard scores with children from a different cultural background of the normative sample should be performed with caution. It is possible that the North American norms are reasonably different for populations that are culturally and geographically distinct. Hence, the use of the PDMS-2 scale outside the U.S. demands checking for cross-cultural and regional relevance. The present study was designed to test the psychometric properties of the PDMS-2, using a Portuguese preschooler's sample. The validity and reliability of this tool for the Portuguese population is an important condition for its usefulness in clinical, educational, and research contexts.

3.3. Methods

The translation and cultural adaptation of the PDMS-2 for the Portuguese population was approved by PRO-ED in Austin, Texas. The International Test Commission guidelines for translating and adapting tests (Hambleton, Merenda, & Spielberger, 2005; AERA, APA, & NCME, 1999) were followed. All the procedures aimed to guarantee the linguistic, conceptual, operational, and metric equivalence, between the Portuguese and original version. This process comprised two distinct steps: 1st) PDMS-2 Translation and Adaptation for the Portuguese language; 2nd) Analysis of the psychometric properties of Portuguese version PDMS-2.

In the first step, the forward-translation design was applied (Hambleton & Patsula, 1999; Peña, 2007). Two authors of this study translated the PDMS-2 Examiner's Manual chapter regarding test structure, administration and scoring, as well as the Examiner Record Booklet. These authors were fluent in both the languages, familiar with both cultures under study, and knowledgeable in the construction of measuring tools. The comparison of the two translated versions resulted in the first Portuguese PDMS-2 version, which was submitted for evaluation by a panel of Child Motor Development, and Educational specialists (5 university professors, 3 therapists, and 2 preschool educators) for an expert review. The preschool educators were included in the expert review panel in order to assess the child's approach to the instructions (clarity and adequateness of the directives). The alterations proposed by the expert review panel were incorporated into the first Portuguese PDMS-2 version. Some pilot studies (Saraiva & Rodrigues, 2005, 2008) were conducted to test various aspects of the PDMS-2 administration and scoring, and simultaneously assess the understanding and feasibility for the targeted population. The final Portuguese version displays an identical structure and number of items as the original PDMS-2 version.

In the second step of this study, the Portuguese PDMS-2 version was applied to a sample of 540 preschoolers in order to test its reliability (internal consistency and test-retest reliability) and construct validity.

3.3.1. Instrument

This instrument is composed of six subtests: Reflexes (ability to automatically react to environmental events in children from birth to 11 months - 8 items), Stationary (ability to sustain control of the body within its centre of gravity- 30 items), Locomotion (ability to move from one place to another - 89 items), Object manipulation (ability to manipulate balls by children with 12 months of age or older - 24 items), Grasping (ability to use hands - 24 items), and Visual-motor integration (ability to use visual perceptual skills to perform complex eye-hand coordination tasks - 72 items). Each motor subtest item is scored using a three-point rating scale (0, 1, or 2). The sum of the individual items within each subtest (raw score) can be converted to age equivalent, percentile and standard scores. Standard scores of each subtest can then be summed and converted into three global indexes of motor performance (composites): Fine, Gross and Total Motor Quotients. The FMQ is calculated by adding 2 subtests: grasping and Visual-Motor Integration, while the GMQ results from three other subtests: Stationary, Locomotion and Object manipulation (the latter is substituted by the reflexes subtest for children from birth to 11 months). The TMQ is determined by a combination of the gross and fine motor subtests results. The PDMS-2 has established the mean value of 10 points (± 3) for each subtest and the mean value of 100 points (± 15) for each motor quotient. The standardized values can also be converted into qualitative classification of seven categories (between "Very Superior" and "Very Poor").

3.3.2. Sample

A total of 540 children (255 males and 285 females) were recruited from 15 public preschools located in urban, rural and suburban areas of Viana do Castelo, Portugal. Children who met the following criteria were included in the study: i) children aged between 36 and 71 months; ii) Portuguese nationality; and iii) absence of any known intellectual, physical or emotional disabilities, as well as without special educational needs as proven by an evaluation from special education professionals. Socio-demographic characteristics of the sample by age group are summarised in Table 3.1.

Table 3. 1. Socio-demographic characteristics of 540 Portuguese children.

	Total (*N*=540)	36-47 months (*n*=162)	48-59 months (*n*=189)	60-71 months (*n*=189)
Age (*M* ± *SD*)	53.5±10.7	41.95±3.4	53.41±3.5	64.7±3.3
Sex, *N* (%)				
Male	255 (47.2)	84 (51.9)	84 (44.4)	87 (46.0)
Female	285 (52.8)	78 (48.1)	105 (55.6)	102 (54.0)
Residence, *N* (%)				
Urban	297 (55.0)	76 (46.9)	101 (53.4)	120 (63.5)
Suburban	146 (27.0)	55 (34.0)	54 (28.6)	37 (19.6)
Rural	97 (18.0)	31 (19.1)	34 (18.0)	32 (16.9)

3.3.3. Data collection procedures

Prior to data collection, informed consent was obtained from the school administration and classroom educators. The parents or legal guardians of the preschool children were informed about testing procedures, and corresponding written consent was obtained. The PDMS-2 was administered according to manual guidelines (Folio & Fewell, 2000) by two researchers, who were specially trained and achieved an inter-rater agreement for the item scores of 90% before data collection.

The assessment took place in a quiet area of the school (kindergarten room) with very little intrusions. Depending on the children's age, the individual assessment duration ranged from 30 to 45 minutes. The data collection was videotaped for latter observation. The raw scores obtained in subtests were converted into standard scores and gross, fine and total motor quotients were calculated, based on the values referenced in the manual. In order to examine the test-retest reliability, 22 children were assessed twice within five days by same rater.

The procedures employed were in accordance with Helsinki's Declaration of Human Ethical guidelines (1975). The study protocol was approved by the Faculty of Human Kinetics (Technical University of Lisbon, Portugal) Ethics Committee.

3.3.4. Data Analysis

Descriptive statistical for PDMS-2 subtests (mean, standard deviation, maximum and range) by age group was used. Test-retest reliability of the subtests was assessed using intra-class correlation coefficient (ICCs, model one way random, single measure). An ICC of 0.75 or more was considered acceptable reliability (Portney & Watkin, 2000). The internal consistency of each subtest was estimated using the Cronbach's Alpha coefficient (α), values of 0.70 or more were considered acceptable (Nunnally, 1978). The construct validity of PDMS-2 was tested using Confirmatory Factor analysis (CFA). Robust maximum likelihood (RML) (Satorra & Bentler, 2001) was used to estimate model parameters, because the data exhibited a multivariate non-normal distribution (coefficient of Mardia = 9.78). To measure overall fit, we used Santorra-Bentler Scaled Chi-Square (S-B $\chi2$]), Root Mean Square of Error Approximation (RMSEA), Comparative Fit Index (CFI), Normed Fit Index (NFI), and Non-Normed Fit Index (NNFI). The S-B $\chi2$ assess the discrepancy between the sample and fitted covariance matrix, with an non-significant test indicating a good fit (*p*-values above 0.05). The RMSEA measures the degree of misspecification per model degree of freedom, adjusted to the number of estimated parameters in the model (i.e., the complexity of the model). Values below 0.06 indicate an adequacy of model (Hu & Bentler, 1999). The CFI indicates the degree of fit between the hypothesized and null measurement, adjusted to the sample size. The NFI reflects the proportion of the joint amount of data variance and covariance that can be explained by the measurement model being tested. The NNFI is a relative fit index that compares the model being tested to a baseline model (null model), accounting for the degrees of freedom. CFI, NFI and NNFI values above 0.95 are considered indicative of a good model fit (Hu & Bentler, 1999). Statistical programs used were SPSS 16.0 and EQS 6.1.

3.4. Results

3.4.1. Age-differentiation study

Age differentiation of PDMS-2 was inspected through the raw score obtained in the different age groups. Table 3.2 presents the descriptive results of each subtest by age group.

Table 3.2. Means, standard deviations (*SD*), minimum-maximum values and range of PDMS2 subtests by age group

Subtests		36-47 months (*n*=162)	48-59 months (*n*=189)	60-71 months (*n*=189)
Grasping	*M* (*SD*)	48.7 (2.6)	50.9 (1.4)	51.4 (1.0)
	Min – Max*	40-52	44-52	45-52
	range	12	8	7
Visual-motor Integration	*M* (*SD*)	123.6 (7.0)	136.2 (5.5)	140.5 (3.5)
	Min – Max*	109-140	113-144	113-144
	range	31	31	31
Stationary	*M* (*SD*)	48.1 (4.2)	53.9 (3.4)	57.2 (2.8)
	Min – Max*	38-59	44-60	46-60
	range	21	16	14
Locomotion	*M* (*SD*)	144.5 (9.9)	160.1 (8.3)	170.1 (5.8)
	Min – Max*	118-169	133-177	145-178
	range	51	44	33
Object manipulation	*M* (*SD*)	29.2 (5.6)	34.6 (6.0)	39.7 (5.1)
	Min – Max*	18-45	20-48	27-48
	range	27	28	21

* Maximum possible score: Grasping = 52; Visual-Motor Integration = 144; Stationary = 60; Locomotion = 178; Object manipulation = 48*

A brief data analysis confirmed that the mean values for each motor subtest increased throughout the age group. These results support that PDMS-2 is able to differentiate amongst the motor development level of children between three and five years of age. As expected, variability of the results can be seen in all subtests, except in the grasping subtest which had a standard deviation of 1.4 and 1.0 in age groups of 4 and 5-year-olds, respectively. Furthermore, it is noticeable in this subtest a clear ceiling effect, taking into account that most 5-year-old children (117 children, 61.9%) reached the maximum possible score of 52 points.

3.4.2. Reliability Study

In this study, two types of error variance were analyzed: internal consistency of the items on all the PDMS-2 subtests and test-retest reliability tested with 22 children in a five days time interval. Table 3.3 presents the results for these reliability parameters.

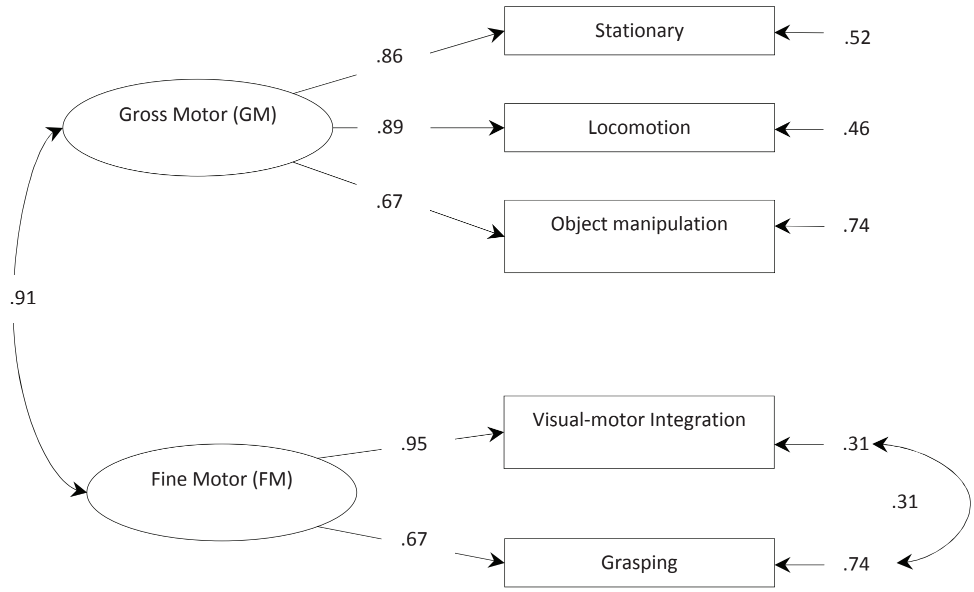
Table 3.3. Internal consistency and test-retest reliability of PDMS-2 subtests.

Subtests	Internal consistency (*α Cronbach*) *n*=540	Test-retest reliability (ICC) *n*=22
Grasping	.76	.87
Visual-Motor Integration	.91	.95
Stationary	.89	.87
Locomotion	.95	.85
Object Manipulation	.87	.94

According to the Table 3.3, it can be noted that the majority of subtests showed a good internal consistency, with the Cronbach's alpha values ranging from 0.76 to 0.95. The Visual-Motor Integration and Locomotion subtests presented high values of internal consistency (α = 0.91 and α = 0.95, respectively), whereas the grasping subtest only reached an acceptable reliability (α =0.76). Concerning the test-retest reliability, ICC values ranged from 0.85 for the Locomotion subtest and 0.95 for Visual-Motor Integration subtest. These values indicate that the subsample of 22 Portuguese children presented good test-retest stability in all subtests.

3.4.3. Construct validity Study

The PDMS-2 model construct tested for Portuguese sample was similar to the originally proposed by Folio and Fewell (2000) (Figure 3.1.). Two factor model (Gross and Fine quotients), defined respectively by three (Stationary, Locomotion and Object Manipulation) and two (Grasping and Visual-Motor Integration) items were tested using a confirmatory factor analysis (CFA). The results of the Langrange Multiplier Test suggested the presence of measurement errors correlated between Visual-Motor Integration and Grasping items, therefore the model was tested again with the necessary adaptations. The obtained model fit indices based on the robust estimation for the Portuguese PDMS-2 model are shown in Figure 3.1.



S-Bχ2=3.3, *df*= 3, *p*=.349; CFI=1.0; NFI=.99; NNFI=.99 and RMSEA (90% CI) =.013 (0.00-0.07)

Figure 3.1. Path diagram of the CFA: two factor model for Portuguese sample, ages from 36 to 71 months. Note: the standardized values of item-factor and factor-factor and residual error of each item (on the right side of rectangle) are presented in diagram; S-B χ2 (Santorra-Bentler Scaled Chi-Square); CFI (Comparative Fit Index); NFI (Normed Fit Index); NNFI (Non-Normed Fit Index); RMSEA (90% CI) (Root Mean Square of Error Approximation, 90% Confidence Interval).

Overall, the results of CFA suggest that model fits the data well. The S-B χ2 test yields a statistic of 3.3 (*df*=3), which has a corresponding *p*-value of *p*=0.349. This *p*-value is too high to reject the null hypothesis of a good fit. The values of goodness of fit indices obtained of CFI (1.0), NFI (.99), NNFI (.99) and RMSEA (.013) also suggest a good fit. In addition, the standardized factor loadings varied in a range from .67 to .95 and a high correlation (.91) between the two latent factors was also identified.

3.5. Discussion

Overall, the results of this study suggest that the Portuguese PDMS-2 version shows similar psychometric characteristics to the original version. The Visual-Motor Integration, Stationary, Locomotion and Object Manipulation subtests are able to discriminate the motor development of children between three and five years of age. The average increase of these motor subtests throughout the age group and its respective standard deviations (exceeding 2.6) confirmed the variability of results found in the Portuguese sample. The same cannot be said for the grasping subtest, which only showed a variability of 1.4 and 1.0, at 4 and 5 year-olds, respectively. Furthermore, this subtest has a clear ceiling effect, given that most 5-year-old children (117 children, 61.9%) reach the maximum possible score of 52 points. This seems to be a limitation of the instrument, regardless of the population concerned. This ceiling effect was also reported in other studies with Taiwanese (Chien & Bond, 2009) and Flemish (Vanvuchelen, Mulders, & Smeyers, 2003) pre-school aged children. In another study with Dutch children at 4 and 5 year-olds, Van Hartingsveldt and his colleagues (2005) concluded that PDMS-2 Fine Motor scale is less sensitive to discriminate children with mild fine motor problems compared to the Movement Assessment Battery for children.

Concerning to the reliability, the Portuguese PDMS-2 version revealed very satisfactory internal consistency and comparable to the original version. All subtests reached a Cronbach's alpha value substantially above the cut-off point 0.70 proposed by Nunnally (1978). The test-retest reliability of PDMS-2 was also confirmed by the high values of ICC (≥. 85) achieved in all subtests. These results are consistent with the findings of previous studies which support reliability of PDMS-2 (Kolobe, Bulanda, & Susman, 2004; Provost et al., 2004; Li-Tsang, Lee, & Hung, 2006; Van Hartingsveldt, Cup, & Oostendorp, 2005; Wang, Liao, & Hsieh, 2006).

As for the construct validity, the results of confirmatory factor analysis of the Portuguese PDMS-2 version supports the two-factor structure of original version proposed by Folio and Fewell (2000). The Portuguese goodness of fit indices (S-B $\chi 2$ = 3.3, p = .349; CFI = 1.0; NFI = .99; NNFI =. 99; RMSEA = .013) were generally more satisfactory than the American version (TLI =. 96; RMSEA = .08). It is important to clarify that the authors of PDMS-2 did not chose CFI, NFI and NNFI fit indices, but the Tucker-Lewis (TLI) index which is comparable to NNFI. Finally, it should be highlighted that the Portuguese model showed greater saturation values item-factor (λ = .67 to .95) compared to the American model (λ =. 54 to 89), demonstrating greater relevance of the values of the items (subtests) in the determination of their latent factors (Gross and Fine Motor).

3.6. Conclusion

The Portuguese PDMS-2 version is a reliable and valid instrument to assess the fine and gross motor skills of Portuguese preschoolers. The different empirical analyses conducted in this study support that the Portuguese version has psychometric characteristics similar to the original version in terms of its sensitivity, reliability and construct validity, which allows its use in the national context. PDMS-2 scales are an instrument particularly promising for understanding the different dimensions of child's motor behaviour. In the future, and to harness the full potential of PDMS-2, it will be important to consolidate its validation process for the Portuguese population. This study should be replicated with other Portuguese samples and particularly with ages not explored in this study (from 0 to 3 years).

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Chapter 4. Motor Profile of preschool Portuguese children on the Peabody Developmental Motor Scales-2: a cross-cultural study [3]

4.1. Abstract

This study was designed to examine the cultural sensitivity of the PDMS-2 for Portuguese preschool children aged 36 to 71 months. A total of 540 children (255 males and 285 females) from 15 public preschools of Viana do Castelo, Portugal, were assessed. Age and gender effects in motor performance were examined. Results indicated that PDMS-2 is valid instrument to differentiate Portuguese age groups. Girls presented higher scores than boys in the Grasping and Visuo-motor integration subtests and lower scores in the Object Manipulation subtest. Portuguese preschoolers performed above U.S. norms on Grasping, Visual-motor integration, and Stationary subtests, and bellow on Locomotion and Object Manipulation subtests. Overall, Portuguese children showed better results on the Fine Motor Quotient comparing to the Gross Motor Quotient. These results underline different motor development profiles between Portuguese and American children.

Keywords: motor assessment; motor performance; PDMS-2; preschool children; cross-cultural.

[3] Saraiva, L., Rodrigues, L., Cordovil, R. & Barreiros, J. (2013). Motor Profile of Portuguese preschool children on the Peabody Developmental Motor Scales-2: a cross-cultural study. *Research in Developmental Disabilities*, 34 (6), 1966–1973.

4.2. Introduction

It is well recognized that development and learning of fine and gross motor skills during early childhood is of paramount relevance for child's overall development (Piek, Hands, & Licari, 2012). Mastery of these motor skills represents an important prerequisite for activities of daily living (e.g., dressing, writing, cutting, playing) (Liberman, Ratzon, & Bart, 2013; Summers, Larkin, Dewey, 2008), as well as for participation in many types of physical activity during the school-age and throughout the lifespan (Barnett, Beurden, Morgan, Brooks, & Beard, 2009; Cairney, Kwan, Hay, & Faught, 2012; Magalhães, Cardoso, & Missiuna, 2011; Okely, Booth, & Patterson, 2001).

On this issue, recent systematic reviews show that motor competence is linked with physical activity and fitness outcomes (Lubans, Morgan, Cliff, Barnett, & Okely, 2010; Rivilis et al., 2011). Children with low motor competence are generally less physically active and have an increased risk for obesity and cardiorespiratory disease. Although the impact of low motor competence on health may not be detected during early childhood, there are strong reasons to predict that children with low competence in early years tend to keep this trend in later stages of development (Gabbard, 2008). Other studies report that these children have additional difficulties in academic performance (e.g., Alloway, 2007; Lingam et al., 2010; Tseng, Howe, Chuang, & Hsieh, 2007), attention (e.g., Lingam et al., 2010; Tseng et al., 2007), emotional aspects (e.g., Emck, Bosscher, Beek, & Doreleijers, 2009; Piek, Baynam, & Barrett, 2006; Rigoli, Piek, & Kane, 2012) and social skills (e.g., Lingam et al., 2010; Skinner & Piek, 2001), which can persist into adolescence and adulthood (e.g., Piek, Barrett, Smith, Rigoli, & Gasson, 2010; Piek, Dawson, Smith, & Gasson, 2008). It is clear that prevention or reduction of these negative effects is dependent on the early identification of motor impairment, and timely intervention. However, effectiveness of this process requires reliable and valid assessment tools specifically designed to able to identify motor problems, even in minor disorders such Developmental Coordination Disorder (DCD).

Among several motor assessment tools available in literature, the Peabody Developmental Motor Scales - second edition (PDMS-2) (Folio & Fewell, 2000) is one of the most widely used instruments in clinical and research settings (Cools, De Martelaer, Samaey, & Andries, 2009; Piek et al., 2012; Slater, Hillier, & Civetta, 2010; Tieman, Palasino, & Sutlive, 2005).

The PDMS-2 is a norm-referenced tool and was designed to assess the fine and gross motor skills of children from birth through 71 months of age. Its normative sample was based on 2003 children residing in forty-six states of the United States and one Canadian province.

According to Folio and Fewell (2000), the second edition of PDMS provides five principal uses: to estimate a child's motor competence in comparison to peers; to identify relative differences within gross and fine motor development; to establish individual goals and objectives for therapy or educational intervention; to monitor the child's individual progress; and to be used as a research tool.

In fact, over last decade the PDMS-2 has been used in several studies to evaluate motor profile of children with typical development (e.g., Darrah, Magill-Evans, Volden, Hodge, & Kembhavi, 2007; Eldred & Darrah, 2010), as well as children with different developmental condition such as developmental coordination disorders (DCD) (Liberman et al., 2013), cerebral palsy (Wang, Liao, Hsieh, 2006), autism spectrum disorders (ASD) (Provost, Heimerl &, Lopez 2007), and intellectual disabilities (Dusing, Thorpe, Rosenberg, Mercer, & Escolar, 2006; Maring & Courcelle-Carter, 2004). Other studies have applied the PDMS-2 to determinate biological and environmental effects on children's motor development, such as prematurity degree (e.g., Lee, Chow, Ma, Ho, & Shek, 2004; Snider, Majnemer, Mazer, Campbell, & Bos, 2009; Wang, Howe, Hinojosa, & Weinberg, 2011), obesity (Nervik, Martin, Runquist & Cleland, 2011), family environment (Osorio, Torres-Sánchez, Hernández, López-Carrillo, & Schnaas, 2010; Santos et al, 2009) and the effectiveness of intervention programmes (e.g., Chew et al., 2007; Cope, Forst, Bibis, & Liu, 2008; Lin et al., 2011; Wang, 2004).

The test's acceptability amongst the scientific community is in part due to its composite structure that allows a multidimensional interpretation of motor development. The test is composed of six motor subtests: reflexes, stationary, locomotion, object manipulation, grasping, and visual-motor integration. These subtests allow estimating three global indexes of motor performance called composites: Fine Motor Quotient (FMQ), Gross Motor Quotient (GMQ) and Total Motor Quotient (TMQ). Empirical evidence of its validity (content, criterion, construct) and reliability (content sampling, time sampling and interscorer differences) are detailed in PDMS-2 test manual (Folio & Fewell, 2000). Briefly, the test's authors report a good internal consistency for each subtest (α =.89 to .95) and for each motor quotient (α = .96 to .97); acceptable test-retest reliability (r =.73 to .96 depending on the age group); and a high inter-rater reliability varying between .97 and .99 for each subtest and between .96 and .98 for the motor quotients. In what respects the criterion validity, the PDMS-2 has a high correlation with the original version (r = .84 and .91 respectively for GMQ and FMQ) and with the Mullen Scales of Early Learning (r = .86 and .80 respectively for GMQ and FMQ). Lastly, Folio and Fewell (2000) report that the test's construct validity was established by confirmatory factor analysis. The validity of PDMS-2 in different groups of individuals (males, females, European Americans, African Americans, Hispanic Americans, as well as children with physical handicap and children with mental retardation) was also confirmed.

Despite these evidences, one question remains: is PDMS-2 tool considered a valid and reliable discriminative measure to evaluate children's motor performance from a different cultural background of the normative sample? Previous cross-cultural studies (Cohen et al., 1999; Crowe, Mcclain & Provost, 1999; Tripathi, Joshua, Kotian, & Tedla, 2008) warn that the interpretation of test results should be performed with caution when assessing children of different cultural background. For instance, Crowe and collaborators (1999) found that Native American children scored significantly lower than the normative sample in the Peabody Fine Motor Developmental, and when gender was taken into consideration, older girls (30 to 35 months) had significantly lower scores. In other study, Tripathi and colleagues (2008) concluded that Indian children scored better on gross motor scale than on fine motor. Depending on the motor subtest and age group, significant differences were also found between Indian children and the PDMS-2 normative sample. These results reinforce that the cultural and regional relevance of the PDMS-2 must be examined before its use.

To our knowledge and to date, there is no evidence concerning suitability (regional relevance) of PDMS-2 for Portuguese children. Therefore, the purposes of this study were: 1) to examine the cultural sensitivity (regional relevance) of the scales for a sample of Portuguese children aged 36 to 71 months; 2) to analyze the age and sex effects on children's motor performance; 3) to characterize and compare the motor performance of Portuguese preschoolers with the U.S. norms.

4.3. Methods

4.3.1. Participants

A convenience sample of 540 typically developing children (255 males and 285 females), aged between three to five years (mean age 53.5 ±10.7) was recruited from fifteen public preschools located in district of Viana do Castelo, Northwest Portugal. The parents or legal guardians of the preschool children were informed about testing procedures, and corresponding written consent was obtained. Children included in the study met the following criteria: age between 36 and 71 months, absence of any known intellectual, physical or emotional disabilities, as well as without special educational needs as proven by records of special education teams. The identification of children with special needs is a standard procedure in the Portuguese educational system.

The sample was divided in three age groups according to the PDMS-2 age categories: three-year-olds (36 to 47 months, n=162), four-year-olds (48 to 59 months, n=189) and five-year-olds (60 to 71 months, n=189). Child's birth related information and socio-demographic data was based on school records. Overall, the sample exhibited a balanced ratio of the participants according to sex (47% boys and 53% girls) and age (3 yrs: 30%; 4 yrs: 35%; 5 yrs: 35%). The children's parents had different education levels: middle school (35%), high school (33%), and college (32%).

4.3.2. Peabody Developmental Motor scales-2 (PDMS-2)

Prior to this study, the original PDMS-2 was translated to Portuguese, and its construct validity and reliability was confirmed for Portuguese preschoolers (Saraiva, Rodrigues, & Barreiros, 2011). All PDMS-2 subtests showed good internal consistency (Cronbach's alpha = .76 to .95) and good test-retest reliability (intraclass correlation coefficient = .85 to .95). The results of the confirmatory factor analysis (Satorra-Bentler χ^2 = 3.3, p = .349; CFI = 1.0, NFI = .99, NNFI = .99, RMSEA = .013) support that the Portuguese version displays the same construct and number of items as the original PDMS-2 (Folio & Fewell, 2000).

This assessment tool is composed of six motor subtests: Reflexes (for children from birth to 11 months, 8 items), Stationary (ability to sustain control of the body within its center of gravity, 30 items), Locomotion (ability to move from one place to another, 89 items), Object manipulation (ability to manipulate balls by children with 12 months of age or older, 24 items), Grasping (ability to use hands, 24 items), and Visual-motor integration (ability to use visual perceptual skills to perform complex eye-hand coordination tasks, 72 items). Each motor subtest item is scored using a three-point rating scale (0, 1, or 2). The sum of the individual items within each subtest (raw score) can be converted to age equivalent, percentiles and standard scores. Standard scores of each subtest can then be summed and converted into three global indexes of motor performance (composites): Fine, Gross and Total Motor Quotients. The FMQ is calculated by adding 2 subtests: Grasping and Visual-Motor Integration, while the GMQ results from three other subtests: Stationary, Locomotion and Object Manipulation (the latter is substituted by the reflexes subtest for children from birth to 11 months). The Total Motor Quotient (TMQ) is determined by a combination of the gross and fine motor subtests results.

4.3.3. Procedures

Prior to data collection, informed consent was obtained from the school administration, classroom educators and parents or legal guardians of the children.

The PDMS-2 was administered according to manual guidelines (Folio & Fewell, 2000) by two researchers, who were specifically trained, and achieved an inter-rater agreement for the item scores of 90% before data collection. Each child was individually tested in a quiet area of the school. Depending on the child's age, the assessment duration ranged from 30 to 45 minutes. Taking account that young children's concentration is very short, each motor subtest of the scales were administered at different times within a 5-day period. The data collection was videotaped for later observation and scoring. For this study, the raw scores of Grasping, Visual-Motor Integration, Stationary, Locomotion and Object manipulation subtests were converted to standard scores. Then, z-scores for all motor subtests and Fine, Gross and Total quotients were calculated, according to the normative data provided in PDMS-2 manual.

The study protocol was approved by the Faculty of Human Kinetics (Technical University of Lisbon, Portugal) Ethics Committee.

4.3.4. Data Analysis

Descriptive statistics (frequencies, means and standard deviations) were calculated to characterize the motor performance of the Portuguese sample on all PDMS-2 motor subtests by age and sex groups. The Welch's ANOVA followed by Dunnett´s C post-hoc test was used to examine the differences on motor performance among age groups because the homogeneity of variance assumption was violated. The Student's *t*-test was calculated to examine the differences on motor performance between Portuguese boys and girls at each age group. For cross-cultural comparison between Portuguese and U.S. children, the mean z-score and respective standard deviations of all motor subtests and quotients for each age group were calculated. Further, a comparison of z-score mean with the zero mean reference value was carried out using the Student's *t*-test. The level of significance was set at .05 for all statistical tests. In addition, Cohen's *d* measure of effect size was calculated. Effect sizes of < 0.5, 0.5-0.8, and > 0.8 were interpreted as small, moderate, and large, respectively (Cohen, 1988). Statistical analyses were performed using the SPSS 19.0 and GraphPad software.

4.4. Results

4.4.1. Motor performance of a Portuguese sample on PDMS-2 subtests

Table 4.1 presents the means and standard deviations of the raw scores on each PDMS-2 subtest by age group.

Table 4.1. Mean raw scores and standard deviations (*M*±*SD*) for each PDMS-2 subtest by age group.

Subtests [a)]	3 years (*n* = 162)	4 years (*n* = 189)	5 years (*n* = 189)	*Welch´s F*	*Post hoc*
Grasping	48.8 ± 2.6	50.9 ± 1.4	51.4 ± 1.0	*74.1****	*3 yrs < 4 yrs < 5 yrs*
Visual-motor integration	123.6 ± 7.0	136.1 ± 5.5	140.5 ± 3.5	*387.0****	*3 yrs < 4 yrs < 5 yrs*
Stationary	48.1 ± 4.2	53.9 ± 3.4	57.2 ± 2.8	*280.9****	*3 yrs < 4 yrs < 5 yrs*
Locomotion	144.5 ± 9.9	160.1 ± 8.3	170.0 ± 5.8	*432.6****	*3 yrs < 4 yrs < 5 yrs*
Object Manipulation	29.2 ± 5.6	34.6 ± 6.0	39.7 ± 5.1	*165.4****	*3 yrs < 4 yrs < 5 yrs*

*Note: *** p < .001*; [a)] Grasping score (range 0-52); Visual-Motor Integration score (range 0-144); Stationary score (range 0-60); Locomotion score (range 0-178); Object manipulation score (range 0-48).

Analysis of variance showed a main effect of age on all PDMS-2 subtests (minimum *Welch's F* = 74.1, *p* < .001) listed in Table 4.1. As expected, the mean raw scores for each motor subtest increased throughout the age group and Dunnett's C post-hoc test confirmed that those increments are significant (*p's* < .001 for all comparisons).

4.4.2. Comparison between boys and girls of Portuguese sample

Table 4.2. Mean raw scores and standard deviations (*M*±*SD*) for each PDMS-2 subtest by sex and age group.

Subtest [a)]	3 years			4 years			5 years		
	Boys (*n*=84)	Girls (*n*=78)	*t*	Boys (*n*=84)	Girls (*n*=105)	*t*	Boys (*n*=87)	Girls (*n*=102)	*t*
Grasping	47.9 ± 2.8	49.7 ± 2.0	-4.70***	50.5 ± 1.7	51.3 ± 1.0	-3.69***	51.2 ± 1.2	51.6 ± 0.8	-2.19*
Visual-motor integration	122.1± 6.5	125.2 ± 7.3	-2.81*	135.1 ± 5.7	137.0 ± 5.2	-2.34*	139.9 ± 4.1	140.9±2.8	-1.97
Stationary	47.6 ± 4.4	48.7 ± 4.0	-1.77	53.6 ± 3.8	54.2 ± 3.1	-1.30	57.2 ± 3.2	57.2 ± 2.4	0.01
Locomotion	145.6 ± 10.7	143.2 ± 8.9	1.52	159.3 ± 9.1	160.7± 7.7	-1.12	170.2 ± 5.7	169.9±5.9	0.37
Object Manipulation	30.6 ± 6.1	27.7 ± 4.6	3.43***	36.6 ± 6.2	32.9 ± 5.4	4.33***	41.8 ± 4.5	37.8 ± 4.8	5.85***

*Note: * p < .05; *** p ≤ .001;* [a)] Grasping score (range 0-52); Visual-Motor Integration score (range 0-144); Stationary score (range 0-60); Locomotion score (range 0-178); Object manipulation score (range 0-48).

Significant differences were found between girls' and boys' performance in Grasping, Visual-motor integration and Object Manipulation subtests (see Table 4.2). Girls presented a better performance on: i) Grasping subtest (3 yrs: $p<.001$, d = -0.75; 4 yrs: $p<.001$, d = -0.55; 5 yrs: $p=.030$, d = -0.32); ii) Visual-motor integration subtest (3 yrs: $p=.005$, d = -0.45; 4yrs: $p=.020$, d = -0.35). Boys showed higher scores on: i) Object Manipulation subtest (3 yrs: p <.001, d = 0.54; 4 yrs: p <.001, d = 0.64; 5 yrs: p <.001, d = 0.86). No differentiation between sexes was found on Stationary and Locomotion subtests at any age group, neither on Visual Motor Integration in the five-year-old age group.

4.4.3. Comparison between the Portuguese sample and U.S. normative sample

The following Figs. 4.1 and 4.2 illustrate the comparison of motor performance between the Portuguese sample and U.S. normative sample, using Z-scores.

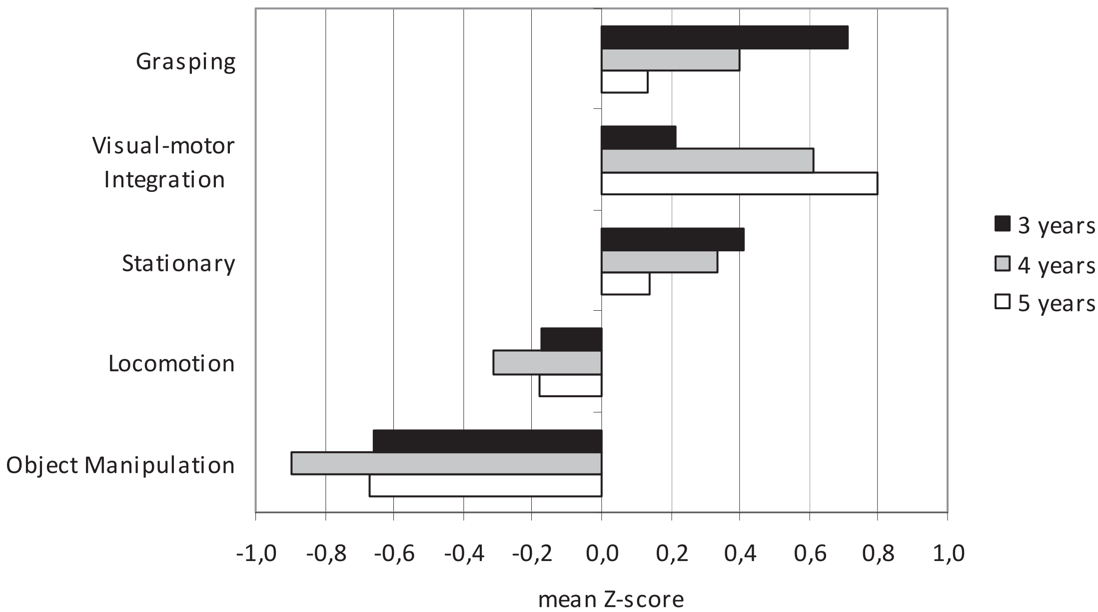

Figure 4.1. Comparison of motor performance between the Portuguese sample and U.S. normative sample on all motor subtests.

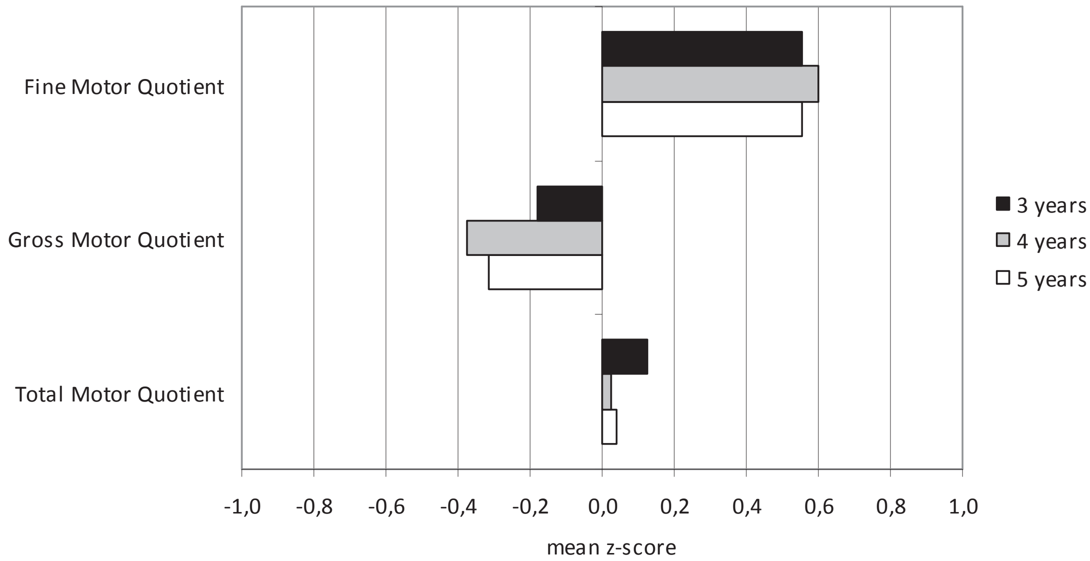

Figure 4.2. Comparison of motor performance between Portuguese sample and U.S. normative sample on all motor quotients.

Table 4.3 presents the results of the comparison tests between the Portuguese and U.S. samples on motor subtests and motor quotients.

Table 4.3. Results of comparison (*t*-test values, *p*-values, and Cohen's d) between the Portuguese sample and U.S. normative sample for the three age groups on all motor subtests and motor quotients.

	3 years			4 years			5 years		
	t	*p*	*Effect Size (d)*	*t*	*p*	*Effect Size (d)*	*t*	*p*	*Effect Size (d)*
Motor Subtests									
Grasping	7.82	**< .001**	0.76	5.16	**< .001**	0.49	1.78	.076	0.18
Visual-motor integration	2.44	**.014**	0.24	7.06	**< .001**	0.67	9.01	**< .001**	0.91
Stationary	4.59	**< .001**	0.45	4.09	**<.001**	0.39	1.67	.095	0.17
Locomotion	2.04	**.004**	-0.20	3.92	**<.001**	-0.37	2.24	.026	-0.22
Object Manipulation	7.73	**< .001**	-0.75	10.95	**<.001**	-1.04	8.22	**< .001**	-0.83
Motor Quotients									
Fine Motor Quotient	6.30	**< .001**	0.61	7.44	**<.001**	0.70	6.82	**< .001**	0.69
Gross Motor Quotient	2.11	**.036**	-0.21	4.74	**<.001**	-0.45	3.93	**< .001**	-0.39
Total Motor Quotient	1.49	.138	0.15	0.30	.767	0.03	0.52	.605	0.05

Note: p-values in bold are statistically significant.

Data presented on Table 4.3 indicate that Portuguese preschoolers performed significantly better than their U.S. peers on Grasping in the three and four-year-old age groups (all *p's* < .001); on Visual-Motor Integration in all age groups (all *p's* ≤ .014); and, also on Stationary subtest in the three and four-year-old age groups (all *p's* < .001). Conversely, the Portuguese children performed significantly lower on Locomotion subtest (all *p's* ≤ .026), and Object Manipulation subtest (all *p's* < .001) in all age groups. It is important to note that the effect size of the differences was moderate to large on Grasping (3yrs), Visual-motor integration (4yrs and 5yrs) and Object Manipulation subtest (all age-groups).

Similar motor performance between Portuguese and American preschoolers was only found on Grasping and Stationary subtests in the five-year-old age group.

Overall, Portuguese children showed significantly higher scores on the Fine Motor Quotient in all age groups (all *p's* < .001, with moderate effect size); and significantly lower scores on the Gross Motor Quotient (all *p's* ≤ .036, with small effect size).

No differences were found on the Total Motor Quotient at all ages (see Fig. 4.2).

4.5. Discussion

The main intent of the present study was to examine the cultural sensitivity (regional relevance) of the PDMS-2 for Portuguese children aged 36 to 71 months and also to analyze the age and sex effects on motor performance. As for age effect, the results of our study suggest that PDMS-2 is a valid and discriminative measure to differentiate the motor competence of Portuguese children aged between 36 and 71 months. As expected, the older age groups performed significantly better than the younger age-group in all motor subtests, which reflects the importance of the child's biological and neurological maturity in the development of motor competence.

Despite these findings, the cross cultural comparison points out that Portuguese and American children have different motor development profiles. Significant differences in all subtests were found, except on the grasping and stationary subtests in the five-year-old age group. Overall, Portuguese children performed above U.S. norms in FMQ and below in GMQ. Differences in rate and sequence of motor development among infants and children from various cultural backgrounds have been reported in many studies (Adolph, Karasik, & Tamis-LeMonda, 2010; Chow, Henderson, & Barnett, 2001; Cintas, 1995; Crowe et al., 1999; Manyson, Harris, & Bachman, 2007; McClain, Provost, & Crowe, 2000; Tripathi et al., 2008). Several factors may help explain the differences in motor development among children from different cultures/countries, such as child's characteristics (e.g., gender, age, race, ethnic, somatic characteristics), family background, child-rearing practices, parental/social expectations (Cintas, 1995), as well as quality and quantity of stimulation provide in home (Cools, Martelaer, Samaey, & Andries, 2011; Hamadani et al., 2010; Sanhueza, 2006; Varzin, Naidu, & Vidyasagar, 1998) and school environments (Anme & Segal, 2003; Barros, Fragoso, Oliveira, Cabral-Filho, & Castro, 2003; Mulligan, Specker, Buckley, O'Connor, & Ho, 1998; Santos et al., 2009; Stipek, Daniels, Calluzzo, & Milburn, 1992).

Concerning the differences between Portuguese and American children, we can speculate that American children have more opportunities for gross motor experiences that promote object manipulation (e.g., throwing, catching) and locomotion skills. The social valorisation of sport, the promotion of physical education programs, and the existence of sport's friendly environment seem to foster sports' practice in American culture, with a special emphasis on ball skills. Furthermore, and for academic and educational reasons, Portuguese preschoolers appear to be more oriented to fine motor tasks (e.g., painting, cutting). In Portugal, because 70.2 % of mothers with children under 6 years are employed (OECD, 2012b), the majority of children spend six to eight hours per day in pre-school. Even though pre-school is not compulsory, 73% of 3-year-olds and 93% of 5-year-olds are enrolled in early childhood education (OECD, 2012a). In the U.S., only 51% of children at age 3 and 74% at age five are enrolled in early childhood education (OECD, 2012a). This might explain the better performance of the Portuguese children in grasping subtest at 3 years old. Probably, Portuguese children receive early stimulation in fine motor tasks (e.g., grasping marker, buttoning or unbuttoning buttons, touching fingers) in their preschool environments. Our results also indicated that differences between

U.S. and Portuguese children on visual-motor integration subtest increase with age. This evidence reinforces the effect of school practices and educational policies of the Portuguese educational system on children’s fine motor performance. Motor tasks such as building with blocks, copying designs, folding or cutting paper, and using markers are frequent activities in traditional Portuguese education system. The Portuguese curriculum guidelines for preschool education are strongly oriented to promote literacy and numeracy skills in preparation for primary school.

Some important sex effects were also observed. Boys performed better in object manipulation skills, while the girls had superior performance in fine motor skills. Studies using total battery scores usually do not find sex differences (e.g., Kambas et al., 2012), but when specific motor dimensions are analyzed (either fine and gross motor, or their sub-components) the majority of results support our findings. Namely, the better performance of boys in ball skills (e.g., Engel-Yeger, Rosenblum, & Josman, 2010; Giagazoglou et al., 2011; Hardy, King, Farrell, Macniven, & Howlett, 2010; Ikeda & Aoyagi, 2008; Livesey, Coleman & Piek, 2007; Thomas & French, 1985; Toriola & Igbokwe, 1986; Vandaele, Cools, de Decker, & de Martelaer, 2011); and a superior performance of girls in fine manual dexterity (Chow et al., 2001; Düger et al., 1999; Kroes et al., 2004; Lejarraga et al., 2002; Livesey et al., 2007; Sigmundsson & Rostoft, 2003). Some standardized tools reflect these differences in their norms (e.g., Koöper Koördinationstest für Kinder, Test of Gross Motor Development, Bruinink-Oseretsky Test of Motor proficiency), but the PDMS-2 does not provide separate norms for boys and girls. Hence, future normative studies with the Portuguese population should take into account sex differentiation.

Lastly, it is interesting to note that the difference between boys and girls on object manipulation increases with age (2.9 points at 3 years, 3.7 points at five years, and 4 points at 5 years). Gender stereotypes (differential use of toys and involvement in children’s games), different opportunities for motor experiences, and parental and social expectations are frequently reported as an explanation for the better performances of boys in gross motor skills and of girls in fine motor skills (e.g., Ikeda & Aoyagi, 2008; Thomas & French, 1985). However, in our study sex differences in Grasping, Visuo-Motor Integration and Object Manipulation exist already in 3-year-old children. The evidence of early sex differences in motor ability is not new in the literature and it is difficult to explain based solely on social/cultural influences. Touwen, in 1976 identified differences between boys and girls in the development of motor milestones in infancy (boys tended to sit and walk earlier than girls, and girls tended to vocalize and grasp sooner). These findings are supported by more recent studies with infants, which have found differences between the two sexes in brain structuring and function (e.g., Liu et al., 2011), indicating that biological differences might also play a role in children's motor performance (Piek et al., 2012).

To our knowledge, this is the first study that characterizes the motor development evaluated by PDMS-2 in a large Portuguese sample, which is a necessary first step to establish its validity for Portuguese children. This study should be replicated with other Portuguese samples and mainly with ages not explored in this study (from 0 to 3 years).The results suggest that Portuguese and U.S. children have different motor development profiles, probably as the result of cultural, environmental, and educational factors that require further investigation. In addition, our data indicate that a possible sex differentiation might be necessary when establishing PDMS-2 norms for the Portuguese population. The cultural differences underline the need to interpret the test results with caution especially if this instrument is used in clinical settings in order to diagnose motor delays and plan future intervention.

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Chapter 5. Influence of age, sex and somatic variables on the motor performance of preschool children. [4]

5.1. Abstract

Background: Biological factors can affect child’s motor development process. However, the magnitude of these effects throughout the developmental process remains fairly unknown.

Aim: To determine the influence of age, sex and selected somatic measures on preschool children's motor performance.

Subjects and methods: Three hundred and sixty-seven preschoolers (172 boys and 195 girls), aged from three to five years old, were recruited from ten public preschools located in the district of Viana do Castelo, Portugal. The children’s motor performance was assessed by five motor subtests of Peabody Developmental Motor Scales-2: grasping, visuo-motor integration, stationary, locomotion and object manipulation subtests. Age, sex, height, weight, and BMI were considered as hypothetical predictors of motor performance. Pearson’s correlation test and multiple linear regression analysis were used to explore the magnitude of the relationship between motor subtests and the hypothetical predictors.

Results: Depending on the motor subtest and age group, the models predicted motor performance from a minimum of 3.6% to a maximum of 34.4%. Age in months and sex stood out as the main predictors of motor performance.

Conclusions: The relationship between motor performance and selected biological factors varied with age and with the specificity of the motor test.

Keywords: motor performance; preschool children; sex; PDMS-2.

[4] Saraiva, L., Rodrigues, L., Cordovil, R. & Barreiros, J. (2013). Influence of age, sex and somatic variables on the motor performance of preschool children. *Annals Human Biology*. 40 (5), 444-450.

5.2. Introduction

The preschool period is considered a critical time for the development and learning of fine and gross motor skills (Gabbard, 2011; Malina, 2004). The acquisition of a broad motor repertoire is an important prerequisite for advanced motor skills and may be related to active and healthy lifestyles (Barnett, van Beurden, Morgan, Brooks, & Beard, 2009; Lubans, Morgan, Cliff, Barnett, & Okely, 2010; Okely, Booth, & Patterson, 2001; Williams et al., 2008; Wrotniak, Epstein, Dorn, Jones & Kondilis, 2006). This exact same idea is stated in a recent model of developmental mechanisms influencing lifestyle trajectories of children (Stodden et al., 2008), which predicts either a positive or negative spiral of engagement in physical activity throughout life. This process will depend on the early development of motor competence, and its related effects on the self-perception of motor competence, physical activity behaviors and physical fitness. The relationship between physical activity and motor competence is cyclical or reciprocal. However, some studies indicate that it is not as much the amount of physical activity that may explain motor competence, but mainly the motor proficiency that seems to predict children's involvement in motor activities during childhood (Lopes, Rodrigues, Maia & Malina, 2011a) and adolescence (Barnett, Morgan, van Beurden, Ball & Lubans, 2011).

Currently, it is accepted that early development of children’s motor competence is dependent on the interaction between environmental and biological factors. Although the quality and the amount of movement experiences during childhood is initially strongly related to the child selected conditions (e.g. biological status at birth), it will be shaped later to the nature of environmental variables and to the equilibrium of maturational processes.

Research indicates that certain characteristics of the child can affect the developmental process at different ages. For example, lower birth weight and lower gestational age are strongly related to poorer motor outcomes in the first years of life (e.g. de Kieviet, Piek, Aarnoudse-Moens & Oosterlaan, 2009; Goyen & Lui 2009; Kuklina, Ramakrishan, Stein, Barnhart, & Martorell, 2006; Sommerfelt et al., 2002). Also, a sex effect on children’s motor performance can be observed at early ages

(Ikeda & Aoyagi 2008; Lung et al., 2011; Spessato, Gabbard, Valentini, & Rudisill, 2012; Thomas & French, 1985). This different motor competence of boys and girls has been attributed to environmental and educational influences but also to biological factors such as advanced neurological development favoring girls, and to some morphological characteristics favoring boys (Gabbard, 2011; Ikeda & Aoyagi, 2008). Despite this well known relationship between motor performance and sex, the magnitude of its effect throughout the developmental process remains fairly unknown, particularly in preschool age.

Regarding the relationship between children's somatic characteristics (e.g. stature, weight and body mass index) and motor performance, correlations are generally low (Bonvin et al., 2012; Logan, Scrabis-Fletcher, Modlesky, & Getchell, 2012; Nervik, Martin, Rundquist, & Cleland, 2011; Oja & Jürimäe, 1997) and vary strongly with the specificity of the motor skill (Castetbon & Andreyeva, 2012; Malina & Bouchard, 1991; Roberts, Veneri, Decker, & Gannoti, 2012). For instance, overweight and obese children tend to have poorer performance than their non-overweight peers, however these differences appear to be more apparent for locomotor skills than object manipulation skills (Cliff et al., 2012; Okely, Booth, & Chey, 2004). This is a topic of great interest but the information relative to preschool children is rather limited.

The aim of the present study was to analyze the influence of age, sex, and selected somatic measures on preschool children's motor performance. Furthermore, we sought to determine the magnitude of the relationship between motor performance and selected biological factors throughout the preschool period.

5.3. Methods

5.3.1. Sample

A convenience sample was recruited from ten public preschools from Viana do Castelo (Northern Portugal, 91.238 inhabitants). The parents or legal guardians of the preschool children were informed about testing procedures, and corresponding written consent was obtained. A total of three hundred sixty-seven children (172 boys and 195 girls) between three to five years of age (*M* = 53.0 months, *SD* = 9.6) participated in this study. Children included in the study met the following criteria: age between 36 and 71 months and absence of any known intellectual, physical or emotional disabilities, as well as without special educational needs, according to an evaluation by special education professionals. Children lived in regions with different population densities: urban (44%), suburban (31%) and rural (25%).

The sample was divided in three age groups: three-year-olds (36 to 47 months, *n*=122), four-year-olds (48 to 59 months, *n*=130) and five-year-olds (60 to 71 months, *n*=115). The child's age was expressed in months at the moment of motor testing and physical assessment. The sample exhibited a balanced ratio of participants according to sex (47% boys and 53% girls) and age (3 yrs: 33%; 4 yrs: 36%; 5 yrs: 31%). There were no significant differences between mean age of boys and girls within each age group. Parents had different education levels: middle school (44%), high school (26%), and college (30%) and no significant differences were found for parent's education levels among age groups.

All data was collected between September 2009 and March 2010. The procedures employed were in accordance with Helsinki's Declaration of Human Ethical guidelines (1975). The study protocol was approved by the Faculty of Human Kinetics (Technical University of Lisbon, Portugal) Ethics Committee, and authorized by the Portuguese Ministry of Education.

5.3.2. Measurements

Measures of children's motor performance: The Peabody Developmental Motor Scales-Second Edition (PDMS-2) (Folio & Fewell, 2000) was used to assess the motor performance. This instrument provides detailed information about fine and gross motor skills development in children from birth to seventy one months of age. The motor subtests of PDMS-2 are: Stationary (ability to sustain control of the body within its center of gravity - 30 items), Locomotion (ability to move from one place to another - 89 items), Object manipulation (ability to manipulate balls - 24 items), Grasping (ability to use hands - 24 items), Visual-motor integration (ability to use his or her visual perceptual skills to perform complex eye-hand coordination tasks - 72 items). The PDMS-2 was previously translated into the Portuguese language, and its validity and reliability was confirmed for Portuguese preschoolers (Saraiva, Rodrigues, & Barreiros, 2011). All PDMS-2 subtests showed good internal consistency (α = 0.76 to 0.95) and test-retest reliability (ICC = 0.85 to 0.95).

The PDMS-2 was administered according to manual guidelines (Folio & Fewell, 2000). Each child was individually tested by one PDMS-2 trained researcher in a quiet area of the school. Depending on children's age, the duration of the assessment ranged from 45 to 60 minutes. Each item of the motor subtests was scored using a three-point rating scale. Raw scores (the sum of the individual items within each subtest) were calculated for Grasping, Visual-motor integration, Stationary, Locomotion, and Object manipulation subtests.

Somatic measures: Height and weight were measured using standard procedures (Lohman et al. 1988) and the body mass index (BMI) was calculated as weight (Kg)/height (m^2). These measurements were converted to age-appropriate z-scores according to the WHO Child Growth Standards (WHO, 2006) and the WHO reference for school-age children and adolescents (de Onis et al., 2007) using the WHO-Anthro 2005 and the WHO-AnthroPlus 2011 software, respectively.

5.3.3. Statistical analysis

Descriptive statistics (mean and standard deviation) were calculated for all variables and presented by age groups and sex. The Student's *t*-test was used to analyze the differences between boys and girls in motor subtests and somatic variables. For each age-group, Pearson's correlations were calculated to estimate the association between age in months, somatic variables and motor subtests. A multiple linear regression analysis was performed for each motor subtests to determine the combination of variables with the best predictive values for each age-group. The study was powered to detect a significant multiple regression model ($F_{(5, 114)}$ = 2.29, with a power of .80 at the 5% level of significance, given an expected medium effect size (f^2 = .15).

All statistical analyses were carried out using the SPSS 19.0 and the level of significance was set at $p < 0.05$.

5.4. Results

Table 5.1 presents the means and standard deviations for all variables, by age group and sex.

Table 5.1. Descriptive statistics for study measures, by age group and sex.

	3 years				4 years				5 year, Mean (*SD*)			
	Total	Boys (*n*=61)	Girls (*n*=61)	*p-values**	Total	Boys (*n*=57)	Girls (*n*=73)	*p-values**	Total	Boys (*n*=54)	Girls (*n*=61)	*p-values**
Age (months), Mean (*SD*)	42.2 (3.4)	42.3 (3.3)	42.1 (3.5)	0.751	53.0 (3.5)	52.5 (3.4)	53.4 (3.5)	0.138	64.4 (3.2)	64.8 (3.4)	64.1 (2.9)	0.254
Children's Motor Performance, Mean (*SD*)												
Grasping	49.0 (2.6)	48.2 (2.8)	49.7 (2.1)	**0.001**	50.8 (1.5)	50.3 (1.8)	51.3 (1.1)	**0.001**	51.3 (1.0)	51.1 (1.2)	51.5 (0.7)	0.054
Visual-Motor Integration	123.2 (7.1)	121.9 (6.9)	124.6 (7.0)	**0.034**	135.7 (5.7)	134.4 (6.1)	136.7 (5.3)	**0.025**	140.0 (3.6)	139.7 (4.3)	140.2 (3.0)	0.471
Stationary	48.7 (3.6)	48.6 (3.8)	48.8 (3.3)	0.723	53.8 (3.5)	53.3 (3.8)	54.2 (3.8)	0.151	57.5 (2.6)	57.8 (2.8)	57.2 (2.3)	0.181
Locomotion	144.1 (8.7)	145.1 (9.6)	143.0 (7.7)	0.179	159.7 (7.5)	159.2 (8.1)	160.0 (7.0)	0.545	168.4 (5.5)	169.1 (6.0)	167.8 (4.9)	0.193
Object manipulation	27.5 (4.5)	28.6 (5.0)	26.5 (3.6)	***0.008***	32.8 (5.6)	34.8 (6.1)	31.3 (4.7)	**<0.001**	36.6 (4.5)	41.8 (4.5)	36.6 (4.5)	***<0.001***
Anthropometric Measures, Mean (*SD*)												
Weight- for-age (z-score)	0.46 (0.9)	0.26 (0.9)	0.67 (1.0)	**0.016**	0.36 (0.9)	0.43 (1.0)	0.29 (0.9)	0.398	0.62 (1.1)	0.66 (1.2)	0.57 (1.0)	0.656
Height-for-age (z-score)	0.02 (0.9)	-0.12 (0.9)	0.15 (0.9)	0.086	-0.03 (1.1)	0.15 (1.2)	-0.18 (1.0)	0.096	0.12 (1.0)	0.06 (0.8)	0.17 (1.1)	0.518
BMI-for-age (z-score)	0.67 (1.0)	0.48 (1.0)	0.85 (1.0)	**0.049**	0.56 (1.1)	0.53 (1.2)	0.59 (1.1)	0.750	0.78 (1.2)	0.90 (1.4)	0.67 (1.1)	0.317

*Student's *t-test* for comparison between boys and girls; *p-values* in bold are statistically significant.

Significant differences were also found between girls' and boys' performance in object manipulation ($p \leq 0.008$), Grasping ($p = 0.001$), and Visual-motor integration ($p = 0.034$) subtests. Boys showed higher raw scores in the Object Manipulation ($p \leq 0.008$), but girls presented a better performance in the Grasping ($p = 0.001$) and Visual-motor integration ($p \leq 0.034$) subtests in the three and four-year-old age groups. No sex differences were found in the Stationary and Locomotion subtests.

Overall results indicate that boys and girls had similar somatic characteristics (height-for-age z-score, weight-for-age z-score and BMI-for-age z-score). Significant sex differences were only observed in the three-year-old age group, with girls showing a higher value for weight-for-age z-score ($p = 0.016$) and BMI-for-age z-score ($p = 0.049$).

The correlations between somatic variables and PDMS-2 subtests in the different age groups are presented in Table 5.2.

Table 5.2. Correlations between the biological factors and PDMS-2 subtests for each age group.

	Grasping	Visual-Motor Integration	Stationary	Locomotion	Object Manipulation
3 years (*n* =122)					
Age (months)	0.307**	0.527**	0.398**	0.526**	0.434**
Weight- for -age (z-scores)	0.033	0.054	0.126	- 0032	0.002
Height-for-age (z-scores)	- 0.010	0.082	0.205*	0.061	- 0.029
BMI-for-age (z-scores)	0.057	0.013	0.011	- 0.096	0.023
4 years (*n* =130)					
Age (months)	0.259**	0.505**	0.320**	0.364**	0.338**
Weight- for -age (z-scores)	0.031	0.088	0.135	0.051	0.214*
Height-for-age (z-scores)	- 0.028	- 0.134	0.106	0.041	0.119
BMI-for-age (z-scores)	0.059	0.224*	0.070	0.022	0.155
5 years (*n* =115)					
Age (months)	- 0.022	0.279**	0.281**	0.150	0.352**
Weight- for -age (z-scores)	0.118	0.079	- 0.112	- 0.070	0.011
Height-for-age (z-scores)	0.189*	0.123	0.155	0.098	0.021
BMI-for-age (z-scores)	0.014	0.006	- 0.245**	- 0.158	0.000

* $P < 0.05$ (2-tailed), ** $P < 0.01$ (2-tailed)

The results presented in Table 5.2 suggest that age was moderately correlated with most subtests (ranging from 0.26 to 0.53). The strength of the correlations between somatic variables and motor performance is not identical for the three age groups. In the three-year-old group, height-for-age z-score and Stationary subtest were positively correlated (*r*= 0.21, *p* = 0.02); in the four-year-old group the correlation between BMI-for-age z-score and Visual-motor integration subtest was positive (*r* = 0.22, *p* = 0.01) as well as the correlation between weight-for-age z-score and object manipulation (*r* = 0.21, *p* = 0.05); finally, in the five-year-old group the height-for-age z-score was positively correlated to the Grasping subtest (*r* = 0.19, *p*=0.04) and the BMI-for-age z-score was negatively correlated to the Stationary subtest (*r* = -0.25, *p* = 0.008).

The multiple regression models for each motor subtest and age group are presented in Table 5.3. Age in months, sex and the somatic variables that showed a significant correlation with the specific motor subtests were included in the models.

Table 5.3. Multiple Regression Final Models for each PDMS-2 subtest and age group.

Grasping		B	S.E.	β	R Square change	R Square	*p*-value
3 years	Constant	39.708	2.638				
	Age (months)	0.238	0.062	0.315	0.094	0.187	**< .001**
	Sex	-1.555	0.422	-0.305	0.093		
4 years	Constant	46.053	1.943				
	Sex	-0.859	0.254	-0.281	0.096	0.144	**< .001**
	Age (months)	0.097	0.036	0.222	0.048		
5 years	Constant	51.298	0.093				
	Height-for-age z score	0.197	0.096	0.189	0.036	0.036	**.043**
Visual-Motor Integration		**B**	**S.E.**	**β**	**R Square change**	**R Square**	***p*-value**
3 years	Constant	78.000	6.642				
	Age (months)	1.108	0.157	0.533	0.278		
	Sex	-2.923	1.062	-0.208	0.043	0.321	**< .001**
4 years	Constant	91.620	6.677				
	Age (months)	0.831	0.126	0.505	0.255	0.255	**< .001**
5 years	Constant	119.396	6.657				
	Age (months)	0.319	0.103	0.279	0.078	0.078	**.002**
Stationary		**B**	**S.E.**	**β**	**R Square change**	**R Square**	***p*-value**
3 years	Constant	31.023	3.617				
	Age (months)	0.418	0.086	0.400	0.158	0.202	**< .001**
	Height-for age (z-score)	0.857	0.335	0.210	0.044		
4 years	Constant	36.573	4.507				
	Age (months)	0.325	0.085	0.320	0.103	0.103	**< .001**
5 years	Constant	42.516	4.603				
	Age (months)	0.239	0.071	0.292	0.079	0.146	**< .001**
	BMI-for-age (z-score)	-0.542	0.183	-0.259	0.067		

Table 5.3. (cont.)

Locomotion		B	S.E.	*β*	R Square change	R Square	*P*-value
3 years	Constant	86.973	8.445				
	Age (months)	1.355	0.200	0.526	0.277	0.277	**< .001**
4 years	Constant	118.276	9.368				
	Age (months)	0.781	0.176	0.364	0.133	0.133	**< .001**
5 years		No significant predictors					
Object Manipulation		**B**	**S.E.**	***β***	**R Square change**	**R Square**	***P*-value**
3 years	Constant	2.789	4.457				
	Age (months)	0.563	0.105	0.428	0.189	0.240	**< .001**
	Sex	2.020	0.713	0.227	0.051		
4 years	Constant	-1.114	6.675				
	Age (months)	0.600	0.125	0.371	0.114		
	Sex	3.996	0.872	0.353	0.132	0.271	**< .001**
	Weight-for age (z-score)	0.949	0.467	0.156	0.024		
5 years	Constant	5.354	8.011				
	Sex	4.861	0.793	0.472	0.254	0.344	**< .001**
	Age (months)	0.488	0.125	0.301	0.090		

Note. The sex variable was recoded as a dummy variable: girls = 0, boys = 1;
B, Unstandardized coefficient; S.E., standard error of the regression coefficient; *β*, Standardized coefficient;

The results of Table 5.3 show that sex and age (in months) were the variables that more often entered the final models as predictors. Depending on the motor subtest and respective age group, the models predicted a minimum of 3.6% and a maximum of 34.4% of the performance. When computing the actual power achieved (pos hoc) for all models, we found that all models achieved a power ≥.87, with exception for the grasping model at 5yrs (power=.61). In Object manipulation subtest, particularly in the five-year-old group, the most important predictor was sex (β = 0.472, p < 0.001), followed by age-in-months (β = 0.301, p < 0.001). Together, these two variables explained 34.4% ($F(2,114)$ = 29.373, p < 0.001) of the object manipulation variance. It is important to note that the influence of sex in the Object manipulation subtest increased throughout the age groups (β = 0.227, β = 0.353, β=0.472 at 3, 4 and 5 yrs, respectively) whereas the effect of age in months decreased (β = 0.428, β = 0.371, β = 0.301, at 3, 4 and 5 yrs, respectively).

The somatic characteristics played a small role in predicting the motor development outcome. Height-for-age accounted for an extra 4.4% explanation of Stationary (3 yrs) and 3.6% of Grasping variance (5 yrs); BMI-for-age added 6.7% to

Stationary variance (5 yrs); and weight-for-age 2.4% to Object Manipulation (4 yrs) variance.

5.5. Discussion

The aim of this study was to analyze the influence of age, sex and selected somatic measures in preschooler's motor development. As expected, age in months was the best predictor for motor performance, and more notably in the youngest age group. Age is a variable that reflects the child's biological and neurological maturity as well as the accumulated effects of stimulation and environmental factors. It is also reasonable that the interaction of maturation and environmental affects may help to explain the increased variability in motor development with advancing age. This interaction is also present in the fact that being a boy or a girl predicts distinct motor performance outcomes at these young ages. Sex explains a substantial part of the variance for Grasping, Visual-motor integration and Object Manipulation subtests, boys performing better in object manipulation skills and girls with a better performance in fine motor skills. This is consistent with the findings of previous studies which reported sex differences in specific motor skills for preschoolers, with boys showing to be more proficient in object manipulation skills (Chow, Henderson, & Barnett, 2001; Düger, Bumin, Uyanik, Aki, & Kayihan, 1999; Engel-Yeger, Rosenblum, & Josman, 2010; Giagazoglou et al., 2011; Hardy, King, Farrel, Macniven, & Howlett, 2010; Ikeda & Aoyagi, 2008; Kroes et al., 2004; Livesey, Coleman, & Piek, 2007; Loovis & Butterfield, 2003; Oja & Jürimäe, 1997; Shala, 2009; Spessato, Gabbard, Valentine, & Rudissil, 2012; Toriola & Igbokwe, 1986; Thomas & French, 1985; Vandaele, Cools, de Decker, de Martelaer, 2011), while girls tend to exhibit superior performance in manual dexterity (Chow et al., 2001; Düger et al., 1999; Kroes et al., 2004; Lejarraga et al., 2002; Livesey et al., 2007; Sigmundsson & Rostoft, 2003).

Sex was not a good predictor in the case of stationary and locomotion competence. This finding is not consistent with previous studies that detected a better performance of girls in Stationary/balance skills (Chow et al., 2001; Engel-

Yeger et al., 2010; Ikeda & Aoyagi, 2008; Kroes et al., 2004; Krombholz, 2006; Lam & Schiller, 2001; Livesey et al., 2007; Shala, 2009; Sigmundsson & Rostoft, 2003). Mixed results were reported regarding the locomotion skills: some studies showing no sex differences (Barnett, van Beurden, Morgan, Brooks, Beard, 2010; Vandaele et al., 2011), while others reported boys (Krombholz, 2006; Oja & Jürimäe, 1997; Toriola & Igbokwe, 1986) or girls (Cliff et al., 2009; Hardy et al., 2010; Ikeda & Aoyagi, 2008) as more proficient. Our results do not support sexual differences in locomotion, in line with Barnett et al. (2010) and Vandaele et al. (2011) findings.

The effect of age and sex is visible in the final model regressions for the Grasping, Visual-motor integration and Object manipulation subtests, but the magnitude of its effect varied across age groups. The influence of age decreases throughout age cohorts; whereas the influence of sex may increase or decrease depending on the motor domain. Within the Object manipulation competence, the results clearly showed that the influence of sex increases along age cohorts. This tendency was also reported by Ikeda and Aoyagi (2008) and Thomas and French (1985) in their meta-analysis. Both studies were unanimous to conclude that the boys' advantage in Object manipulation skills becomes progressively greater throughout childhood and adolescence. In the literature the explanation for this fact has been based in arguments such as social and environmental effects, opportunities for motor experiences, sex stereotyped games and toys, and parental and social expectations (Barnett, Hinkley, Okely, & Salmon, 2013; Cools, Martelaer, Samaey, & Andries, 2011).

On the other hand, the final model regressions of Grasping and Visual-motor integration indicated that sex differences decrease in older age cohorts. It is interesting to observe that girls' superiority at the age of three, in Grasping and Visual-motor integration skills, disappeared by the age of five. The evidence of early sex differences in motor ability is not new in the literature, suggesting strong early effects of biological variables in motor development and a progressive modulation effect of motor experiences across childhood. For example, neonatal girls imitate finger movements more accurately than boys (Nagy, Kompagne, & Orvos, 2007) and recent studies have identified sex differences in the infant's brain structuring and function (e.g., Liu et al., 2011). Other studies also show that girls attain some fine motor tasks earlier, such as drawing a person and grasping a pencil (Lejarraga et al., 2002; Richter & Janson, 2007). Social class, maternal education and sex (female) were associated with earlier attainment of some selected development items after the first year of life (Lejarraga et al., 2002). These facts reinforce the idea that the child's motor development is clearly dependent on the interaction between biological and socio-cultural factors. In our study, the narrowing of differences between boys and girls in fine motor skills throughout preschool ages might be explained by school practices in which both sexes are equally stimulated, but this hypothesis claims for further research.

The somatic measures (height-for-age z-score, weight-for-age z-score and BMI-for-age z-score) played a small role in predicting motor development of preschoolers. The boys and girls of this study had similar morphological characteristics, except in the three-year-old age group in which girls exhibited higher values for weight-for-age z-score (p = 0.016) and BMI-for-age z-score (p = 0.049). The effects of height-for-age z-score and BMI-for-age z-score were visible in Stationary skills. Apparently, the three-year-old children, who presented greater height for their age, tend to perform better. Five-year-old children with a low BMI for their age showed a better performance in Stationary skills. The inverse relationship between BMI and gross motor performance has been documented in previous studies for school children (D'Hondt, Deforche, De Bourdeaudhuij, & Lenoir, 2009; Graf et al., 2004; Mckenzie et al., 2002; Okely et al., 2004; Southall, Okely, & Steele, 2004). On the other hand, recent studies (Bonvin et al., 2012; Castetbon & Andreyeva, 2012; Logan, Scrabis-Fletcher, Modlesky, & Getchell, 2012; Nervik et al., 2011) suggest that the association between BMI and motor performance is small during early years but increases throughout later childhood (D'Hondt et al., 2011; Lopes, Stodden, Bianchi, Maia, & Rodrigues, 2011b). In another study, Oja and Jürimäe (1997) concluded that the motor performance of preschool children aged four to five years was often dependent on height and body mass, but not on BMI. Age, height, and body mass of children explained only a small percentage of the variance in motor performance (6%), and the authors suggested that somatic measures are not strong predictors of motor performance in preschool age.

Our results suggest that at the age of four, a higher weight-for-age is a significant and positive predictor for Object manipulation skills. Although counter intuitive to the general idea that weight and motor competency should be negatively associated, this result aligns with several literature findings. There is a clearly documented negative association between weight status and motor skills that requires propulsion or lifting of the body mass (Marshall & Bouffard, 1994; Morano, Colella, & Caroli, 2011; Okely et al., 2004; Southall, Okely, Steele, 2004). However, positive effects of weight can often be observed in specific motor tasks that require power or strength, like throwing skills (Malina & Bouchard, 1991). Hence, more studies are needed to clarify the effect of the weight and BMI according to each specific motor skill at the preschool age including specific measures of adiposity and fat-free mass.

In conclusion, the influence of most variables on preschooler's motor performance varied with age and motor specificity. Age and sex stood out as predictors of motor performance. In this study, somatic measures cannot be considered good predictors of the motor development in preschoolers. Along cohorts, the decrease of the age effects in the majority of the subtests and the increase of the sex effect on object manipulation, suggests that motor development might also be moderated by other environmental factors. Longitudinal studies are necessary in order to confirm these findings.

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Chapter 6. Biosocial determinants associated with low and high gross motor competence in preschool children

6.1. Abstract

The aim of this study was to identify the biosocial determinants associated with low and high gross motor competence. The sample included 366 children (171 boys and 195 girls) aged from 36 to 71 months of age (*M* = 52.99 ± 9.6). The motor competence was assessed using the PDMS-2. Biosocial variables related to the child's characteristics, the family and preschool environments were explored. For each sex, a multiple logistic regression analysis was performed to find out the biosocial determinants associated with low and high motor competence. Motor variability was mainly explained by social and environmental factors, such as the participation on structured and unstructured physical activity, the gross motor toys/equipment available for play, and the active play time with the father. The findings also highlight the social effect of school peers and some individual characteristics such as having been breastfed and the height of the child. Clearly, boys' and girls' motor competence is different and is associated with different social and environmental factors. This fact reflects in part the different opportunities provided to boys and girls. The existence of a non-linear effect of biosocial variables along the spectrum of motor competence is suggested.

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Keywords: motor competence; biosocial determinants; PDMS-2; preschool children

6.2. Introduction

The acquisition of motor competence during early childhood is of paramount relevance for child's overall development (Borstein & Lamb, 2011; Piek, Hands, & Licari, 2012). Nevertheless, research shows that not all healthy children achieve the same level of motor proficiency along this period of life. The causes for this variability are not yet sufficiently clarified in the literature, particularly under a multidimensional understanding of motor development.

On this issue, literature show that several biosocial factors which can affect the child's developmental process at different ages. For instance, lower birth weight and lower gestational age are strongly related to poorer motor outcomes in the first years of development (e.g. de Kieviet, Piek, Aarnoudse-Moens & Oosterlaan, 2009; Goyen & Lui, 2009). Others child's characteristics, such as age (e.g., Barnett, Hinkely, Okely & Salmon, 2013, Chowdhury, Wrotniak, & Ghosh, 2010, Koutra et al., 2012), sex (e.g., Barnett et al., 2013; Giagazoglou et al, 2011; Livesey, Coleman, & Piek, 2007), somatic characteristics (e.g., Halpern, Giugliani Victora, Barros & Horta, 2002; Lima et al., 2004; Raikes, 2005), and nutritional status (e.g., Chowdhury et al., 2010), can also help to explain the motor variability.

Regarding the environmental effects, the research report that some social and physical factors of family context may be linked to motor competence, including socio-economical status (e.g., Lejarraga et al., 2002; Saccani, Valentini, Pereira, Müller, & Gabbard, 2013; Santos et al. 2009; Wu et al., 2008) family structure (e.g., Santos et al., 2009; Reid, Stahl, Striano, 2010; Wu et al., 2008), child-rearing practices (Kolobe, 2004), parental/social expectations (Cintas, 1995), and the affordances provided at home for motor development (e.g., Bartlett & Fanning 2003; Cools, Martelaer, Samaey, & Andries, 2011; Goyen & Lui 2002; Hamadani et al., 2010; Osorio, Torres-Sánchez, Hernández, López-Carrillo, & Schnaas, 2010; Sanhueza, 2006; Varzin, Naidu, & Vidyasagar, 1998). In addition, recent studies have consistently reported the association of the motor competence with the participation in structured physical activity (Goodway, Crowe, & Ward, 2003; Fransen et al., 2012; Livonen, Saakslahti, & Nissiinen, 2011; Krombholz, 2006) and unstructured physical activity (Barnett et al., 2013; Cliff, Okely, Smith, & McKeen, 2009; Williams et al., 2008).

Despite this knowledge, the influence of biosocial effects on child's motor development is not yet clearly understood, especially if we seek a more comprehensive explanation of the dynamical interaction between the child and multiple environments. In most of the studies, the influence of biological and environmental factors was explored separately without considering the child as an active agent of his/her own development. Furthermore, the researchers have focused mainly on the influence of family environment. Detailed information relative to effects of school, peers, and neighbourhood environments on children's motor competence is rather limited. Thus, it is essential to know the joint effects of immediate contexts (e.g., family, preschool, peers) with the child's characteristics in order to have a more accurate understanding of the causes of motor variability.

To date, research has focused on the identification of risk factors related to low motor competence, or on the exploration of the factors associated to motor competence assuming a linear effect of the variables. To our knowledge, there are no studies that have explored simultaneously the biosocial factors associated with high and low motor competence in order to test whether the factors are different or the same but in an inverse relationship. Therefore, the purpose of this study was to identify the biosocial determinants associated with low gross motor competence and with high gross motor competence of preschool boys and girls. In the literature, the sex differences in motor performance have been attributed to social and environmental effects (Barnett et al., 2013; Cools et al., 2011). For this reason, separate analyses were performed.

6.3. Methods

6.3.1. Sample

A convenient sample was recruited from ten public preschools located in the district of Viana do Castelo (Northern Portugal). Prior to data collection, informed consent was obtained from the school administration, classroom educators and parents or legal guardians of the children. A total of three hundred sixty-six children [171 boys (47.7%) and 195 girls (53.3%)] aged between three to five years (boys: *M*= 52.7 months, *SD*=9.9; and girl: *M*= 53.2 months, *SD* = 9.4) participated in this study. All parents or legal guardians and teachers of these children agreed to participate in a structured interview. Children with neurological, physical or sensory disorders that could have implications on their motor performance were not included in the sample. Socio-demographic characteristics of the sample by sex are summarised in Table 6.1. Overall, the boys and girls have similar demographics' characteristics.

Table 6. 1. Characteristics of the sample by gender.

	Boys (N=171)	Girls (N=195)
Age in months, M (SD)	52.7 (9.9)	53.2 (9.4)
Residence, n (%)		
Urban	69 (40.3)	90 (46.1)
Semiurban	60 (35.1)	54 (27.7)
Rural	42 (24.6)	51 (26.2)
Household income, n (%)		
Low (≤ €225)	34 (19.9)	38 (19.5)
Average (€226 - €449)	39 (22.8)	48 (24.6)
High (≥ €450)	98 (57.3)	109 (55.9)
Parent's education, n (%)		
Elementary	151 (44.5)	168 (43.3)
High school	84 (24.8)	104 (26.8)
College	104 (30.7)	116 (29.9)

6.3.2. Procedures and variables

The study protocol was approved by the Faculty of Human Kinetics (Technical University of Lisbon, Portugal) Ethics Committee, and authorized by the Portuguese Ministry of Education. The procedures employed were in accordance with Helsinki's Declaration of Human Ethical guidelines (1975). The children's motor and physical assessment and teachers' interviews were carried out by the same researcher in the preschools settings. The parental interview was conducted on their own home or another mutually convenient location by one of four trained interviewers. Both structured interviews were designed to collect information on child's characteristics (biological factors), family and school environment (physical and social factors). All data was collected between September 2009 and March 2010.

***Gross Motor Competence*:** The Peabody Developmental Motor Scales-Second Edition (PDMS-2) (Folio & Fewell 2000) was used to assess the children's gross motor performance. The PDMS-2 was previously translated into the Portuguese language, and its construct validity and reliability was confirmed for Portuguese preschoolers (Saraiva, Rodrigues, & Barreiros, 2011). All PDMS-2 subtests showed good internal consistency (Cronbach's alpha = .76 to .95) and good test-retest reliability (intraclass correlation coefficient = .85 to .95).

Each child was individually tested by one PDMS-2 trained researcher in a quiet area of the school. The Stationary (ability to sustain control of the body within its center of gravity, 30 items), Locomotion (ability to move from one place to another, 89 items), and Object manipulation (ability to manipulate balls by children with 12 months of age or older, 24 items) subtests were administered according to manual guidelines (Folio & Fewell, 2000). Raw scores (the sum of the individual items within each subtest) were calculated for each subtests and converted in standard scores using the American norm references (since the Portuguese norm references were not available at the time we started our study). Then, the standard scores of each subtest were summed and converted into Gross Motor Quotient (GMQ) using the norm-referenced tables. The PDMS-2 norms establish a mean value of 100 points (± 15) for each motor quotient. The criterion cut-off of ±1 standard deviation was used to define low and high motor competence children. Children with 1SD bellow the average (for girls GMQ ≤ 85; for boys GMQ ≤ 87) were classified as having lower motor competence and 1SD above the average (for girls GMQ ≥ 100; for boys GMQ ≥ 106) were considered as having higher motor competence.

In the present study, the hypothetical predictors of preschooler's motor competence were grouped into three broad categories: child's characteristics (biological factors), family environment and preschool environment, which are outlined below:

Child's characteristics (biological factors): Two groups of biological variables were considered: i) Proximal biological variables, such as weight-for-age z-score (WAZ), height-for-age z-score (HAZ), and body mass index-for-age z-score (BMIAZ); ii) Distal biological variables (status at birth), which included the gestational age, and weight at birth.

Stature and body mass were measured using standard procedures (Lohman, Roche, & Martorell, 1988), and the body mass index (BMI) was calculated as weight (Kg)/height (m2). These measurements were converted to age-appropriate z-scores according to the WHO Child Growth Standards (WHO, 2006) and the WHO reference for school-age children and adolescents (de Onis et al., 2007) using the WHO-Anthro 2005 and the WHO-AnthroPlus 2011 softwares, respectively. The age was expressed in months at the time of the test date. The child's distal biological data was gathered from their individual Child Health Care Booklet which the parents provided in a photocopy form.

Parents were also asked if the child was breastfeed and if yes, how long the child exclusively did so. Parents' responses were grouped into three categories: never breastfeed; < 3 months and ≥ 3 months.

Family environment (social and physical factors): In the first part of the parental interview (appendix A), information on the family background such as household income, parental education level, type of residence (rural, semi-rural and urban), and child's birth order were asked. The parental educational level was categorized in three groups in accordance with the Portuguese Educational System: Elementary (up to 9 years of schooling); High School (10-12 years); College (higher education). The household income was stratified into three groups according to the financial category assigned by Portuguese social and school system: low (≤ €225 per capita); average (€226 to €449 per capita); high (≥ €450 per capita).

In a second part of the interview, the parents' were asked to report on the physical conditions of the home. Questions such as: "What type of living space is it, apartment or individual house?", "how many rooms does home have?" and the area of the child's room were asked. In addition, the parents were asked to report "How many people (adults and children) share the home?" as well as how many people sleep in the child's room. Based on these data two variables were created: crowding (people per room: ≤ 1 or > 1) and spatial density of the child's room (space per child: ≤ 10 m^2/child or > 10 m^2/child). Both variables were categorized based on its median value. Moreover, the parents were asked about the amount of gross motor toys available at home (bikes, jump ropes, rackets, skates, balls, etc.). This variable was then divided into 2 groups based on median value of gross motor toys: ≤ 5 or >5 gross toys). All these variables were used to explore the effects of the home physical environment on child's motor competence.

Finally, parents were asked to report the opportunities for child's motor experiences outside school, with questions such as "Does the child has active playtime with his father, mother or peers?" and "How much time per day (both school days and weekends) is the child involved in structured physical activities or free active play?" The average time of the unstructured physical activity was estimated and was divided into two groups on the basis of the median value: <1hr/day or ≥ 1 hr/day). Total time of structured physical activity per week was calculated and then categorized into two groups based on median value: < 1hr/week or ≥ 1hr/week.

Preschool environment (social and physical factors): Information on characteristics of children's classroom, such as number, age, sex and the time to attendance at day-care were collected by teacher interview (appendix B). Based on age and sex of children in the classroom, two categorical variables were created to analyse the effects of school's peers on children's motor competence: Classroom gender composition (same gender, more boys or more girls); and the child's age relative to class's age average (older than class's age or younger than class's age).

During interview, teachers were also asked to report the opportunities for physical activity in the school, as time and frequency of physical education per week (< 1hr/week or ≥ 1hr/week) and the total recess time per day (< 1hr/day or

≥1hr/day). Finally, teachers were asked to report details about physical characteristics of school such as area of gym and recess space, and the amount of portable and fixed play equipment for physical activity available in recess space. Based on these data four categorical variables were created: Total area of physical activity space which was calculated by adding recess and gym space ($\leq$ 901.5 m^2 or >901.5 m^2); Space per child recess ($\leq$ 12 m^2/child or > 12m^2/child); total number of portable outdoor play equipment (≤ 2 or >2); and total number of fixed outdoor play equipment (≤ 4 or > 4). All these variables were dichotomized at the median.

6.3.3. Statistical analysis

Separate analyses were performed for boys and girls. Descriptive statistics (frequencies or means and standards deviation) were calculated to characterize all variables of the study. Univariate logistic regression analyses were initially conducted to find out if each of the biosocial factors (child's characteristics, family and preschool environment) were associated with low and high motor competence, when compared with all other children. A multivariate logistic analysis was conducted using only the variables with a *p*-value of 0.1 or less in the previous analysis. A stepwise selection procedure (backward and forward elimination (likelihood ratio, *p* in <0.05, *p* out >0.10) was used to ensure the best choice of variables for the four models (boys, high and low; girls, high and low). The quality of the models was assessed by the Hosmer and Lemeshow goodness of fit value. Results are presented as odds ratios (OR) with 95% confidence intervals (CI). All statistical analyses were carried out using the SPSS 19.0 and the level of significance was set at $p < 0.05$.

6.4. Results

Table 6.2 presents the mean scores and standard deviation of the gross motor quotient, according to sex and level of motor competence.

Table 6. 2. Mean and standard deviation of the Gross Motor Quotient, according to sex and level of motor competence (MC)

	Boys			Girls		
	Total	Low MC	High MC	Total	Low MC	High MC
N (%)	171 (100)	31 (18.1)	23 (13.5)	195 (100)	26 (13.3)	32 (16.4)
Gross Motor Quotient, *M* (*SD*)	96.2 (8.4)	83.8 (3.5)	109.3 (3.9)	92.9 (6.3)	83.0 (3.0)	102.0 (3.4)

Overall, boys presented significantly higher mean scores than girls on Gross Motor Quotient (96.2 *vs.* 92.9), $t(364)=4.307$, $p<.001$. According to the criterion cut-off of ±1 standard deviation, 18.1% (*n*=31) of the boys' sample and 13.3% (*n*=26) of girls' of sample were classified as having low motor competence; on the other hand, 13.5% (*n*=23) of the boys and 16.4% (*n*=32) of the girls were categorized as having high motor competence. The descriptive data of all independent variables for the whole sample and by sex is presented in appendix C.

6.4.1. Associations with Low Motor Competence

The unadjusted Odds Ratios (OR) and 95% Confidence Intervals (CI) estimated for boys' and girls' low motor competence are presented in table 6.3.

The variables associated with boys' low motor competence were: never been breastfed (OR=5.47; CI= 1.58; 18.98), having a mother with high school education (OR=3.10; CI= 1.12; 8.54), having less than 1hour per day of unstructured physical activity (OR=2.97; CI= 1.30; 6.77), and being older than the average age of the class (OR=2.90; CI= 1.25; 6.75). As to girls, low motor competence was associated with not playing actively with the father (OR=3.24; CI= 1.30; 8.12), having less than 1 hour per week of structured physical activity (OR=4.01 CI=1.15; 13.90), and belonging to a predominantly male group at pre-school (protective factor) (OR=0.33; CI= 0.12; 0.92).

Table 6.3. Unadjusted Odds Ratios (OR) and 95% Confidence Intervals (CI) estimates for low motor competence (dependent variable) by sex.

	Boys				**Girls**			
	Average and High (*n*=140)	**Lower MC (*n*=31)**	**Unadjusted OR (95%CI)**	***p***	**Average and High (*n*=169)**	**Lower MC (*n*=26)**	**Unadjusted OR (95%CI)**	***p***
CHILD'S CHARACTERISTICS								
Weight-for-age (z score), M (SD)	0.42 (0.88)	0.53 (1.49)	1.11 (0.76; 1.63)	0.581	0.520 (0.96)	0.36 (0.88)	0.83 (0.53; 1.30)	0.414
Height-for-age (z score), M (SD)	0.02 (0.90)	0.06 (1.37)	1.04 (0.71; 1.54)	0.830	0.071 (0.98)	-0.18 (0.98)	0.76 (0.49; 1.54)	0.217
BMI-for-age (z score), M (SD)	0.60 (1.02)	0.72 (1.87)	1.08 (0.79; 1.49)	0.616	0.698 (1.08)	0.68 (0.89)	0.99 (0.67; 1.49)	0.938
Gestational age, M (SD)	38.5 (1.81)	38.6 (1.56)	1.05 (0.83; 1.32)	0.689	38.53 (1.84)	38.15(2.94)	0.92 (0.77; 1.11)	0.382
Birth weight, M (SD)	3.3 (0.45)	3.3 (0.51)	1.02 (0.43; 2.42)	0.957	3.21 (0.47)	3.19 (0.55)	0.91 (0.38; 2.17)	0.824
Breastfeeding, n (%)								
No	6 (4.4)	6 (19.4)	5.47 (1.58;18.98)	**0.007**	22 (13.0)	5 (19.2)	1.92 (0.61; 6.10)	0.268
< 3 months	37 (27.2)	8 (25.8)	1.18 (0.47; 2.98)	0.721	54 (32.0)	10 (38.5)	1.57 (0.62; 3.93)	0.339
≥ 3 months	93 (68.4)	17 (54.8)	Ref.		93 (55.0)	11 (42.3)	Ref.	
FAMILY ENVIRONMENT								
Family's sociodemographics								
Residence, n (%)								
Urban	55 (39.3)	14 (45.2)	1.27 (0.47; 3.46)	0.637	82 (48.5)	8 (30.8)	0.46 (0.165; 1.27)	0.131
Semiurban	50 (35.7)	10 (32.3)	1.00 (0.35; 2.88)	1.000	45 (26.6)	9 (34.6)	0.93 (0.34; 2.58)	0.894
Rural	35 (25.0)	7 (22.5)	Ref.		42 (24.9)	9 (34.6)	Ref.	
Household income, n (%)								
Low (≤ €225)	27 (19.3)	7 (22.6)	1.44 (0.53; 3.89)	0.478	32 (18.9)	6 (23.1)	1.18 (0.42; 3.29)	0.759
Average (€226- €449)	30 (21.4)	9 (29.0)	1.66 (0.66; 4.19)	0.283	43 (25.5)	5 (19.2)	0.73 (0.25; 213)	0.564
High (≥ €450)	83 (59.3)	15 (48.4)	Ref.		94 (55.6)	15 (57.7)	Ref.	
Mother's education, n (%)								
Elementary	52 (36.7)	11 (35.5)	1.70 (0.61; 4.71)	0.311	62 (36.9)	11 (42.3)	1.20 (0.47; 3.11)	0.703
High school	33 (23.7)	13 (41.9)	3.10 (1.12; 8.54)	**0.029**	45 (26.8)	6 (23.1)	1.77 (0.30; 2.72)	0.857
College	55 (39.6)	7 (22.6)	Ref.		61 (36.3)	9 (34.6)	Ref.	
Father's education, n (%)								
Elementary	69 (50.0)	20 (64.5)	1.74 (0.64; 4.72)	0.277	80 (47.6)	15 (57.7)	2.69 (0.74; 9.80)	0.134
High school	33 (23.9)	5 (16.1)	0.91 (0.25; 3.26)	0.884	45 (26.8)	8 (30.8)	2.55 (0.63; 10.24)	0.188
College	36 (26.1)	6 (19.4)	Ref.		43 (25.6)	3 (11.5)	Ref.	

Table 6.3 continued

	Boys				Girls			
	Average and High (*n*=140)	**Lower MC (*n*=31)**	**Unadjusted OR (95%CI)**	***p***	**Average and High (*n*=169)**	**Lower MC (*n*=26)**	**Unadjusted OR (95%CI)**	***p***
Birth order, n (%)								
Only child	53 (37.8)	9 (29.0)	1.53 (0.51; 4.55)	0.447	73 (43.2)	13 (50.0)	1.34 (0.55; 3.24)	0.522
First	27 (19.3)	7 (22.6)	1.47 (0.60; 3.64)	0.402	21 (12.4)	3 (11.5)	1.07 (0.27; 4.25)	0.922
Second or more	60 (42.9)	15 (48.4)	Ref.		75 (44.4)	10 (38.5)	Ref.	
Physical factors (home)								
House type, n (%)								
Apartment	44 (31.4)	12 (38.7)	1.38 (0.62; 3.09)	0.436	64 (37.9)	8 (30.8)	0.73 (0.30; 1.77)	0.486
Individual house	96 (68.6)	19 (61.3)	Ref.		105 (62.1)	18 (69.2)	Ref.	
Crowding (persons/ rooms), n (%)								
>1	27 (19.9)	7 (23.3)	1.23 (0.45; 3.16)	0.669	28 (17.0)	5 (20.0)	1.22 (0.42; 3.53)	0.710
≤1	109 (80.1)	23 (76.7)	Ref.		137 (83.0)	20 (80.0)	Ref.	
Space per child room, n (%)								
< 10 m^2/child	41 (29.3)	14 (45.2)	1.99 (0.90; 4.41)	0.090	69 (41.1)	10 (38.5)	0.90 (0.38; 2.09)	0.801
≥ 10 m^2/child	99 (70.7)	17 (54.8)	Ref.		99 (58.9)	16 (61.5)	Ref.	
Gross motor toys, n (%)								
≤ 5	39 (27.9)	11 (35.5)	1.42 (0.65; 3.25)	0.400	60 (35.5)		0.96 (0.40; 2.29)	0.930
> 5	101 (72.1)	20 (64.5)	Ref.		109 (64.5)	9 (34.6)	Ref.	
Social factors						17 (65.4)		
Active playtime with father, n (%)								
No	44 (31.4)	15 (48.4)	2.05 (0.93; 4.51)	0.076	77 (45.6)	19 (73.1)	3.24 (1.30; 8.12)	**0.012**
Yes	96 (68.6)	16 (51.6)	Ref.		92 (54.4)	7 (26.9)	Ref.	
Active playtime with mother, n (%)								
No	108 (77.1)	28 (90.3)	2.77 (0.79; 9.69)	0.112	125 (74.0)	21 (80.8)	1.48 (0.53; 4.16)	0.459
Yes	32 (22.9)	3 (9.7)	Ref.		44 (26.0)	5 (19.2)	Ref.	
Active playtime peers, n (%)								
No	46 (32.9)	14 (45.2)	1.68 (0.76; 3.71)	0.197	82 (48.5)	13 (50.0)	1.061 (0.47; 2.42)	0.888
Yes	94 (67.1)	17 (54.8)	Ref.		87 (51.5)	13 (50.0)	Ref.	
Unstructured physical activity, n (%)								
< 1hr/day	58 (41.4)	21 (67.7)	2.97 (1.30; 6.77)	**0.010**	96 (56.8)	19 (73.1)	2.06 (0.82; 5.17)	0.122
≥ 1hr/day	82 (58.6)	10 (32.3)	Ref.		73 (43.2)	7 (26.9)	Ref.	
Structured physical activity, n (%)								
< 1hr/week	78 (55.7)	22 (71.0)	1.94 (0.84; 4.52)	0.123	111 (65.7)	23 (88.5)	4.01 (1.15; 13.90)	**0.029**
≥ 1hr/week	62 (44.3)	9 (29.0)	Ref.		58 (34.3)	3 (11.5)	Ref.	

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Table 6.3 continued

	Boys				Girls			
	Average and High (*n*=140)	**Lower MC (*n*=31)**	**Unadjusted OR (95%CI)**	***p***	**Average and High (*n*=169)**	**Lower MC (*n*=26)**	**Unadjusted OR (95%CI)**	***p***
PRESCHOOL ENVIRONMENT								
Social factors								
Childcare up to 3 year's old, n (%)								
no	87 (62.6)	22 (71.0)	1.48 (0.59; 3.75)	0.407	120 (71.0)	21 (80.8)	2.71 (0.60; 12.20)	0.193
Up to 12 months	11 (7.9)	2 (6.4)	1.07 (0.19;5.87)	0.942	18 (10.7)	3 (11.5)	2.58 (0.39; 16.95)	0.323
Over 12 months	41 (29.5)	7 (22.6)	Ref.		31 (18.3)	2 (7.7)	Ref.	
The child's age relative to class's age average, n (%)								
Older than class's age	76 (54.3)	22 (71.0)	2.90 (1.25; 6.75)	**0.013**	88 (52.1)	10 (38.5)	1.74 (0.75; 4.05)	0.200
Younger than class's age	64 (45.7)	9 (29.0)	Ref.		81 (47.9)	16 (61.5)	Ref.	
Classroom gender composition, n (%)								
Same	11 (7.9)	6 (19.3)	Ref.		16 (9.5)	1 (3.9)	0.27 (0.13; 2.17)	0.219
More Boys	78 (55.7)	14 (45.2)	0.33 (0.11; 1.04)	0.057	66 (39.0)	5 (19.2)	0.33 (0.12; 0.92)	**0.035**
More girls	51 (36.4)	11 (35.5)	0.40 (0.12; 1.30)	0.126	87 (51.5)	20 (76.9)	Ref.	
Physical Education, n (%)								
≤ 1 hr/week (one time)	95 (67.9)	25 (80.6)	1.97 (0.76; 5.15)	0.165	123 (72.8)	19 (73.1)	1.02 (0.40; 2.57)	0.975
> 1 hr/week (two times)	45 (32.1)	6 (19.4)	Ref.		46 (27.2)	7 (26.9)	Ref.	
Recess time, n (%)								
≤ 1 hr/day	62 (44.3)	15 (48.4)	1.18 (0.54; 2.57)	0.678	85 (50.3)	15 (57.7)	1.35 (0.59; 3.10)	0.483
> 1 hr/day	78 (55.7)	16 (51.6)	Ref.		85 (49.7)	11 (42.3)	Ref.	
Physical factors								
Total area of physical activity space, n (%)								
≤ 901.5 m^2	71 (50.7)	13 (41.9)	0.70 (0.32; 0.70)	0.378	84 (49.7)	18 (69.2)	2.28 (0.94; 5.52)	0.069
> 901.5 m^2	69 (49.3)	18 (58.1)	Ref.		85 (50.3)	8 (30.8)	Ref.	
Space per child recess, n (%)								
≤ 12 m^2/child	80 (57.1)	22 (71.0)	1.83 (0.79; 4.27)	0.160	94 (55.6)	19 (73.1)	2.17 (0.87; 5.42)	0.099
> 12 m^2/child	60 (42.9)	9 (29.0)	Ref.		75 (44.4)	7 (26.9)	Ref.	
Portable outdoor play equipment, n (%)								
≤ 2	82 (58.6)	21 (67.7)	1.49 (0.65; 3.39)	0.347	93 (55.0)	14 (53.8)	1.22 (0.68; 2.17)	0.504
> 2	58 (41.4)	10 (32.3)	Ref.		76 (45.0)	12(46.2)	Ref.	
Fixed outdoor play equipment, n (%)								
≤ 4	97 (69.3)	25 (80.6)	1.85 (0.71; 4.83)	0.211	108 (63.9)	17 (65.4)	1.07 (0.45; 2.54)	0.884
> 4	43 (30.7)	6 (19.4)	Ref.		61 (36.1)	9 (34.6)	Ref.	

The multiple logistic regression models found to explain the girls' and boys' low motor competence are reported in table 6.4 and 6.5, respectively.

Table 6.4. Multiple logistic regression model estimates for boys' low motor competence.

	Adjusted OR (95% IC)*	*p*
Breastfeeding		
No	5.92 (1.62; 21.63)	**0.007**
< 3 months	1.27 (0.492; 3.26)	0.625
≥ 3 months	Ref.	
Unstructured physical activity		
< 1 hr/day	3.03 (1.29; 7.11)	**0.011**
≥ 1 hr/day	Ref.	

* OR, Odds Ratio; 95% CI, 95% Confidence Interval; multiple logistic regression model (dependent variable- Low motor competence; Independent variables entered in the model were only those with a $p \leq .10$ in the unadjusted analysis: breastfeeding, mother's education; space per child room; active playtime with father; unstructured physical activity; child's age relative to class's age average; classroom gender composition. Hosmer-Lemeshow goodness-of-fit test statistic=0.319 and p= 0.956.

When taking into account all the variables in a multivariate model, the results of the multiple logistic regression (table 6.4) reinforce that boys who were never breastfed (OR=5.92; CI= 1.62; 21.63) and who had less than 1 hour per day of unstructured physical activity (OR=3.03; CI= 1.29; 7.11) were more likely to have low motor competence.

Table 6.5 Multiple logistic regression model estimates for girls' low motor competence.

	Adjusted OR (95% IC)*	*p*
Active playtime with father		
No	3.46 (1.34; 8.95)	**0.010**
Yes	Ref.	
Structured physical activity		
< 1 hr/week	3.81 (1.07; 13.56)	**0.039**
≥ 1 hr/week	Ref.	
Classroom gender composition		
Same	0.26 (0.03; 2.17)	0.215
More boys	0.29 (0.10; 0.85)	**0.024**
More girls	Ref.	

* OR, Odds Ratio; 95% CI, 95% Confidence Interval; multiple logistic regression model (dependent variable- Low motor competence; Independent variables entered in the model were only those with a $p \leq .10$ in the unadjusted analysis: active playtime with father; structured physical activity; classroom gender composition; total area of physical activity space. Hosmer-Lemeshow goodness-of-fit test statistic=1.218 and p= 0.976.

The multiple regression model estimated for girls' low motor competence (table 6.5) confirmed the findings found in univariate analysis. Girls who do not play actively with the father (OR=3.46; CI= 1.34; 8.95), and that have less than 1 hour per week of structured physical activity (OR=3.81; CI=1.07; 13.90) were more likely to have low motor competence. Furthermore, the girls who belong to a predominantly male group (protective factor) (OR=0.29; CI= 0.10; 0.85) were less likely to have low motor competence compared with girls who belonging to a predominantly girls group.

6.4.2. Associations with High Motor Competence

In Table 6.6 we report the unadjusted Odds Ratios (OR) and 95% Confidence Intervals (CI) estimated for boys' and girls' low motor competence.

The variables significantly associated with boys' high motor competence were: having a room with $10m^2$ or more (OR=3.61; CI=1.03; 12.73), having 1 hour or more of structured physical activity per week (outside school) (OR=3.08; CI=1.23; 7.73), attending childcare more than 12 months (OR=3.30; CI=1.31; 8.30) and having more than 1 hour (two times) of physical education per week (OR=2.48; CI=1.01; 6.06).

Girls' high motor competence was associated with belonging to a school with more than four fixed outdoor play equipment (OR=2.35; CI=1.09; 5.07).

Table 6.6. Unadjusted Odds Ratios (OR) and 95% Confidence Intervals (CI) estimates for high motor competence (dependent variable) by sex.

	Boys				Girls			
	Low and average (*n*=148)	Higher MC (*n*=23)	Unadjusted OR (95%CI)	*p*	Low and average (*n*=163)	Higher MC (*n*=32)	OR (95%CI)	*p*
CHILD'S CHARACTERISTICS								
Weight-for-age (z score), M (SD)	0.38 (1.0)	0.79 (0.8)	1.46 (0.96; 2.21)	0.078	0.51 (0.97)	0.45 (0.8)	0.94 (0.63; 1.40)	0.754
Height-for-age (z score), M (SD)	-0.03 (1.0)	0.39 (0.9)	1.49 (0.98; 2.28)	0.064	0.02 (1.03)	0.12 (0.7)	1.11 (0.76; 1.63)	0.597
BMI-for-age (z score), M (SD)	0.59 (1.3)	0.81 (0.9)	1.15 (0.81; 1.65)	0.430	0.73 (1.06)	0.54 (1.0)	0.84 (0.59; 1.21)	0.351
Gestational age, M (SD)	38.5 (1.8)	38.3 (1.8)	0.95 (0.75; 1.20)	0.648	38.4 (2.12)	39.0 (1.3)	1.24 (0.96; 1.59)	0.104
Birth weight, M (SD)	3.3 (0.5)	3.3 (0.4)	1.22 (0.46; 3.20)	0.689	3.2 (0.49)	3.3 (0.4)	1.80 (0.80; 4.02)	0.153
Breastfeeding, n (%)								
No	10 (6.9)	2 (8.7)	Ref.		26 (16.0)	1 (3.1)	Ref.	
< 3 months	39 (27.1)	6 (26.1)	0.77 (0.13; 4.40)	0.768	53 (32.5)	11 (34.4)	5.40 (0.66; 44.08)	0.116
≥ 3 months	95 (66.0)	15 (65.2)	0.79 (0.16; 3.96)	0.774	84 (51.5)	20 (62.5)	6.19 (0.79; 48.38)	0.082
FAMILY ENVIRONMENT								
Family's sociodemographics								
Residence, n (%)								
Urban	60 (40.5)	9 (39.2)	Ref.		76 (46.6)	14 (43.7)	Ref.	
Semiurban	53 (35.8)	7 (30.4)	0.88 (0.31; 2.53)	0.813	39 (23.9)	15 (46.9)	2.09 (0.92; 4.76)	0.080
Rural	35 (23.7)	7 (30.4)	1.33 (0.46; 3.90)	0.599	48 (29.5)	3 (9.4)	0.34 (0.09; 1.24)	0.103
Household income, n (%)								
Low (≤ €225)	32 (21.6)	2 (8.7)	Ref.		31 (19.0)	7 (21.9)	Ref.	
Average (€226-€449)	35 (23.7)	4 (17.4)	1.83 (0.31; 10.67)	0.502	43 (26.4)	5 (15.6)	0.52 (0.15; 1.77)	0.293
High (≥ €450)	81 (54.7)	17 (73.9)	3.36 (0.73; 15.37)	0.119	89 (54.6)	20 (62.5)	1.00 (0.38; 2.58)	0.992
Mother's education, n (%)								
Elementary	54 (36.7)	8 (34.8)	Ref.		61 (37.7)	12 (37.5)	Ref.	
High school	42 (28.6)	4 (17.4)	0.64 (0.18; 2.28)	0.494	42 (25.9)	9 (28.1)	1.09 (0.42; 2.82)	0.860
College	51 (34.7)	11 (47.8)	1.45 (0.54; 3.91)	0.456	59 (36.4)	11 (34.4)	0.95 (0.39; 2.32)	0.906
Father's education, n (%)								
Elementary	77 (52.7)	12 (52.2)	Ref.		76 (46.9)	19 (59.4)	Ref.	
High school	34 (23.3)	4 (17.4)	0.76 (0.23; 2.51)	0.646	46 (28.4)	7 (21.9)	0.61 (0.24; 1.56)	0.301
College	35 (24.0)	7 (30.4)	1.28 (0.47; 3.54)	0.630	40 (24.7)	6 (18.7)	0.60 (0.22; 1.62)	0.314
Birth order, n (%)								
Only child	55 (37.2)	7 (30.4)	Ref.		75 (46.0)	11 (34.4)	Ref.	
First	30 (20.3)	4 (17.4)	1.05 (0.28; 3.87)	0.944	20 (12.3)	4 (12.5)	1.36 (0.39; 4.74)	0.626
Second or more	63 (42.5)	12 (52.2)	1.50 (0.55; 4.07)	0.429	68 (41.7)	17 (53.1)	1.71 (0.75; 3.90)	0.206

Table 6.6 continued

	Boys				Girls			
	Low and average (*n*=148)	Higher MC (*n*=23)	Unadjusted OR (95%CI)	*p*	Low and average (*n*=163)	Higher MC (*n*=32)	Unadjusted OR (95%CI)	*p*
Physical factors (home)								
House type, n (%)								
Apartment	49 (33.1)	7 (30.4)	Ref.		60 (36.8)	12 (37.5)	Ref.	
Individual house	99 (66.9)	16 (69.6)	1.13 (0.44; 2.93)	0.799	103 (63.2)	20 (62.5)	0.97 (0.44; 2.13)	0.941
Crowding (persons/ rooms), n (%)								
> 1	32 (22.1)	2 (9.5)	Ref.		30 (19.0)	3 (9.4)	Ref.	
≤ 1	113 (77.9)	19 (90.5)	2.69 (0.60; 12.17)	0.199	128 (81.0)	29 (90.6)	2.27 (0.65; 7.94)	0.201
Space per child room, n (%)								
< 10 m^2/child	52 (35.1)	3 (13.0)	Ref.		66 (40.7)	13 (40.6)	Ref.	
≥ 10 m^2/child	96 (64.9)	20 (87.0)	3.61 (1.03; 12.73)	**0.046**	96 (59.3)	19 (59.4)	1.01 (0.46; 2.17)	0.990
Gross motor toys, n (%)								
≤ 5	44 (29.7)	6 (26.1)	Ref.		62 (38.0)	7 (21.9)	Ref.	
> 5	104 (70.3)	17 (73.9)	1.20 (0.43; 3.24)	0.721	101 (62.0)	25 (78.1)	2.19 (0.90; 5.37)	0.086
Social factors								
Active playtime with father, n (%)								
No	53 (35.8)	6 (26.1)	Ref.		83 (50.9)	13 (40.6)	Ref.	
Yes	95 (64.2)	17 (73.9)	1.58 (0.59; 4.25)	0.364	80 (49.1)	19 (59.4)	1.52 (0.70; 3.27)	0.289
Active playtime with mother, n (%)								
No	119 (80.4)	17 (73.9)	Ref.		124 (76.1)	22 (68.7)	Ref.	
Yes	29 (19.6)	6 (26.1)	0.45 (0.53; 4.00)	0.475	39 (23.9)	10 (31.3)	1.45 (0.63; 3.31)	0.384
Active playtime peers, n (%)								
No	52 (35.1)	8 (34.8)	Ref.		77 (47.2)	18 (56.2)	Ref.	
Yes	96 (64.9)	15 (65.2)	1.02 (0.40; 2.56)	0.974	86 (52.8)	14 (43.8)	0.70 (0.33; 1.49)	0.353
Active playtime peers, n (%)								
No	52 (35.1)	8 (34.8)	Ref.		77 (47.2)	18 (56.2)	Ref.	
Yes	96 (64.9)	15 (65.2)	1.02 (0.40; 2.56)	0.974	86 (52.8)	14 (43.8)	0.70 (0.33; 1.49)	0.353
Unstructured physical activity, n (%)								
< 1hr/day	71 (48.0)	8 (34.8)	Ref.		95 (58.3)	20 (62.5)	Ref.	
≥ 1 hr/day	77 (52.0)	15 (65.2)	1.73 (0.69; 4.32)	0.242	68 (41.7)	12 (37.5)	0.84 (0.38; 1.83)	0.658
Structured physical activity, n (%)								
< 1hr/week	92 (62.2)	8 (34.8)	Ref.		111 (68.1)	23 (71.9)	Ref.	
≥ 1 hr/week	56 (37.8)	15 (65.2)	3.08 (1.23; 7.73)	**0.017**	52 (31.9)	9 (28.1)	0.84 (0.36; 1.93)	0.674

Table 6.6 continued

	Boys				Girls			
	Low and average (*n*=148)	Higher MC (*n*=23)	Unadjusted OR (95%CI)	*p*	Low and average (*n*=163)	Higher MC (*n*=32)	Unadjusted OR (95%CI)	*p*
PRESCHOOL ENVIRONMENT								
Social factors								
Childcare up to 3 year's old, n (%)								
no	99 (67.3)	10 (43.5)	Ref.		119 (73.0)	22 (68.7)	Ref.	
Up to 12 months	12 (8.2)	1 (4.3)	0.83 (0.10; 7.02)	0.860	18 (11.0)	3 (9.4)	0.90 (0.25; 3.32)	0.876
Over 12 months	36 (24.5)	12 (52.2)	3.30 (1.31; 8.30)	**0.011**	26 (16.0)	7 (21.9)	1.46 (0.56; 3.77)	0.438
The child's age relative to class's age average, n (%)								
Older than class's age	74 (50.0)	12 (52.2)	Ref.		77 (47.2)	11 (34.4)	Ref.	
Younger than class's age	74 (50.0)	11 (47.8)	0.92 (0.38; 2.21)	0.846	86 (52.8)	21 (65.6)	2.13 (0.97;4.71)	0.061
Classroom gender composition, n (%)								
Same	15 (10.1)	2 (8.7)	Ref.		14 (8.5)	3 (9.4)	Ref.	
More Boys	78 (52.7)	14 (60.9)	1.35 (0.28; 6.54)	0.713	56 (34.4)	15 (46.9)	1.25 (0.32; 4.92)	0.750
More girls	55 (37.2)	7 (30.4)	0.96 (0.18; 5.08)	0.957	93 (57.1)	14 (43.7)	0.70 (0.18; 2.76)	0.613
Physical Education, n (%)								
≤ 1 hr/week (one time)	108 (73.0)	12 (52.2)	Ref.		115 (70.6)	27 (84.4)	Ref.	
> 1 hr/week (two times)	40 (27.0)	11 (47.8)	2.48 (1.01; 6.06)	**0.047**	48 (29.4)	5 (15.6)	0.44 (0.16; 1.22)	0.115
Recess time, n (%)								
≤1 hr/day	68 (45.9)	9 (39.1)	Ref.		87 (53.4)	13 (40.6)	Ref.	
>1 hr/day	80 (54.1)	14 (60.9)	1.32 (0.54; 3.24)	0.542	76 (46.6)	19 (59.4)	1.67 (0.78; 3.61)	0.190
Physical factors								
Total area of physical activity space, n (%)								
≤ 901.5 m^2	71 (48.0)	13 (56.5)	Ref.		89 (54.6)	13 (40.6)	Ref.	
> 901.5 m^2	77 (52.0)	10 (43.5)	0.71 (0.29; 1.72)	0.447	74 (45.4)	19 (59.4)	1.76 (0.81; 3.80)	0.151
Space per child recess, n (%)								
≤ 12 m^2/child	91 (61.5)	11 (47.8)	Ref.		99 (60.7)	14 (43.7)	Ref.	
> 12 m^2/child	57 (38.5)	12 (52.2)	1.74 (0.72; 4.21)	0.218	64 (39.3)	18 (56.3)	1.99 (0.93; 4.28)	0.079
Portable outdoor play equipment, n (%)								
≤ 2	92 (62.2)	11 (47.8)	Ref.		91 (55.8)	16 (50.0)	Ref.	
> 2	56 (37.8)	12 (52.2)	1.79 (0.74; 4.33)	0.195	72 (44.2)	16 (50.0)	1.26 (0.59; 2.70)	0.545
Fixed outdoor play equipment, n (%)								
≤ 4	106 (71.6)	16 (69.6)	Ref.		110 (67.5)	15 (46.9)	Ref.	
> 4	42 (28.4)	7 (30.4)	1.10 (0.42; 2.88)	0.839	53 (32.5)	17 (53.1)	2.35 (1.09; 5.07)	**0.029**

The multiple logistic regression models for the girls' and boys' high motor competence are presented in table 6.7 and 6.8, respectively.

Table 6.7. Multiple logistic regression model estimates for boys' high motor competence.

	Adjusted OR (95% IC)*	***p***
Structured physical activity		
< 1 hr/week	Ref.	
≥ 1 hr/week	3.01 (1.17; 7.74)	**0.022**
Physical Education		
≤ 1 hr/week (one time)	Ref.	
> 1 hr/week (two times)	2.75 (1.07; 7.05)	**0.035**
Height-for-age (z score)	1.57 (1.01; 2.43)	**0.045**

* OR, Odds Ratio; 95% CI, 95% Confidence Interval; multiple logistic regression model (dependent variable-High motor competence; Independent variables entered in the model were only those with a $p \leq .10$ in the unadjusted analysis: height-for-age; space per child room; childcare up to 3 year's old, structured physical activity and physical education; Hosmer-Lemeshow goodness-of-fit test statistic=3.2691 and p= 0.916.

When adjusting for the multivariate effects, the results showed that boys who have 1 hour or more of structured physical activity per week outside school (OR=3.01; CI=1.17; 7.74), more than 1 hour (two times) of physical education per week (OR=2.75; CI=1.07; 7.05), and a high height-for-age (OR=1.57; CI=1.01; 2.43), were more likely to have high motor competence.

Table 6.8. Multiple logistic regression model estimates for girls' high motor competence.

	Adjusted OR (95% IC)*	***p***
Gross motor toys		
≤ 5	Ref.	
> 5	2.65 (1.05; 6.68)	**0.040**
The child's age relative to class's age average		
Older than class's age	Ref.	
Younger than class's age	2.44 (1.08; 5.23)	**0.033**
Fixed outdoor play equipment		
≤ 4	Ref.	
> 4	2.56 (1.16; 5.65)	**0.020**

* OR, Odds Ratio; 95% CI, 95% Confidence Interval; multiple logistic regression model (dependent variable-High motor competence; Independent variables entered in the model were only those with a $p \leq .10$ in the unadjusted analysis: breastfeeding. residence, gross motor toys; the child's age relative to class's age average; space per child recess; fixed outdoor play equipment. Hosmer-Lemeshow goodness-of-fit test statistic=1.218 and p= 0.976.

The findings of the multivariate analysis, present in table 6.8, indicate that girls with more than five gross motor toys (OR=2.65; CI=1.05; 6.68), younger than most of the classmates (OR= 2.44; CI= 1.08; 5.23), and belonging to a school with more than four fixed outdoor play equipment (OR =2.56; 1.16; 5.65) were more likely to have high motor competence. All variables with $p \leq .10$ in the unadjusted analysis entered in the adjusted model, except the space per child recess.

All variables associated to low and high motor competence according to sex are summarized in table 6.9.

Table 6.9. Summary of variables associated to low and high motor competence by sex.

	Low Motor competence	High Motor competence
Boys	- never been breastfed; - having less than 1 hour per day of unstructured physical activity;	- high height-for-age; - having 1 hour or more of structured physical activity per week (outside school); - having more than 1 hour (two times) of physical education per week;
Girls	- no active playtime with father; - having less than 1 hour per week of structured activity; - belonging to a class with a majority of boys (protective factor);	- having more than five gross motor toys; - belonging to a school with more than four fixed outdoor play equipment; - being younger than most of the classmates;

6.5. Discussion

The main objective of this study was to identify the biosocial determinants associated with low and high gross motor competence of preschool boys and girls. For this purpose, the joint effect of the child's characteristics (biological factors) and of the family and preschool environments (social and physical factors) was explored. Overall, the findings of this study provide strong evidence that motor competence of preschool children is mainly influenced by some social and physical factors of family and preschool environments. The child's characteristics were of little relevance for explaining the motor variability of boys and girls.

Significant associations were found between motor competence and the factors particularly related to motor experience, such as gross motor toys available at home, active playtime with father, the fixed play equipment available in recess, participation in structured physical activity (e.g., physical education and participation in sports) and in active playtime. This evidence reinforces clearly the assumption that opportunities for structured and unstructured physical activity are essential to promote the development of children's motor competence (Goldfiel, Haryey, Grattan & Adamo, 2012; Logan, Robinson, Wilson & Lucas, 2011; NASPE, 2009). In our study, the boys who have 1 hour or more per week of structured physical activity are 3.01 times more likely to have high motor competence compared with those who have less than 1 hour of structured physical activity. On the other hand, boys who have less than 1 hour per day of active playtime are 2.97 times more likely to have low motor competence compared with those who have 1 hour or more of active playtime. This finding support the guidelines of the NASPE (2009) which recommend that preschoolers should engage in at least 60 minutes, and up to several hours, of unstructured physical activity each day, and should not be sedentary for more than 60 minutes at a time, except when sleeping.

Interestingly, a social effect of school peers on children's motor competence was also observed in this study. For instance, girls younger than most of their classmates were more likely to have a higher motor performance. In contrast, boys older than the most of their classmates are more likely to have low motor performance. The interpretation of this fact leads us to conclude that the older peers can play an important role as models for their younger peers and consequently help to promote their development. For this reason, it will be beneficial for children to be included in heterogeneous classes, and to have the opportunity to socialize with older peers. An effect of classroom gender composition on motor competence was also found in this study. Particularly, girls who belong to a predominantly male group (protective factor) are less likely to have low motor competence compared with girls who belong to a predominantly female group. A possible explanation for this protective effect may be attributed to the fact that boys tend to be more active (Bradley, McMurray, Harrell, & Deng, 2000; Eaton & Enns, 1986; Faucette et al., 1995; Hinkley, T., Crawford, D., Salmon, J., Okely, A. D., & Hesketh, K., 2008; Maccoby, 1998), and generally have a better gross motor performance compared to girls (e.g., Ikeda & Aoyagi, 2008; Lung et al., 2011; Spessato, Gabbard, Valentini, & Rudisill, 2012; Thomas & French, 1985). These characteristics probably will help to positively stimulate girls that otherwise would tend to participate in more sedentary, individual, non-competitive activities. Probably because girls tend to be less active, the challenge provided by older girls and masculine peer's activities constitutes an important reinforcement of their motor stimulation, resulting on an increased motor performance. On the other hand, boys are known for a higher level of motor activity and physical challenges when playing between peers. This normal masculine activity seems to be sufficient for protecting boys from not acquiring a normal motor proficiency, but when the level of motor challenge is not enough (as when most of their peers are younger) the likelihood of being on the low motor competence group increases. Since to our knowledge, this is the first study that examined the influence of school peers on children's motor competence, more studies are needed to confirm this effect.

In the literature, the explanation for sex differences on motor performance has been based in arguments such as social and environmental effects, opportunities for motor experiences, sex stereotyped games and toys, and parental and social expectations (Barnett et al., 2013; Cools et al., 2011). In fact, in our study different biosocial factors were found to explain the motor variability of boys and girls. Clearly, the factors associated to low motor competence in girls are related to a lack of stimulation (e.g., having less than 1hour per week of structured physical activity and no active playtime with the father); on the other hand, the factors linked to high motor competence in boys seems to reflect a greater opportunity to participate in structured physical activities. These findings are in part consistent with the literature, which has shown that fathers engage in more physical play with sons than with daughters (Jacklin, DioPietro, & Maccoby, 1984; Lindsey & Mize, 2001; MacDonald & Parke, 1986). In addition, males are more likely to receive strong support from family to begin and continue in sports (Gabbard, 2011). The lack of motor stimulation provided to girls might explain why girls do not have the same levels of motor competence as boys at these ages. This fact might lead girls to never develop their skills to full potential.

Regarding the explanatory model of boys' high gross motor competence, it is important to note that boys who have high height-for-age are more likely to have high motor performance. This evidence leads us to conclude that in addition to the structured motor stimulation, the maturational advance (high height-for-age) can also help to explain the better motor competence of the boys when compared to their peers. On this matter, the literature particularly reports associations between low motor competence and low height-for-age (Chowdhury et al., 2010) or low weight-for-age (Halpern et al., 2002, Lima et al., 2004; Raikes, 2005), regardless the sex.

Another interesting association found in this study is related to breastfeeding. Our findings indicate that boys who were never breastfed are more likely to have low motor competence compared with those that were breastfed for 3 or more months. The association of breastfeeding with motor competence is not a new subject in research; however the findings reported are not consistent. Some studies did not find a clear association between duration of breastfeeding and the level motor development (Florey, Leech & Blackhall, 1995; Angelsen, Vik, Jacobsen & Bakketeig, 2001), while others reported positive association (Andraca et al., 1998; Halpern et al., 2002; Thordottir, Gunnarsdottir, Kvaran & Gretarsoon, 2005; Vestergaard et al, 1999). As previously underlined by Thordottir et al. (2005), certain constituents of breast milk, for example, docosahexaenoic acid, are known to be associated with infant mental development (Uauy & De Andraca, 1995; Koletzko & Rodriguez-Palmero, 1999). Docosahexaenoic acid in breast milk is associated with maternal intake of the fatty acid (Helland, Saarem, Saugstad & Drevon, 1998) and maternal supplementation may be favorable for later mental development of children (Helland, Smith, Saarem, Saugstad, & Drevon, 2003). However, there is little evidence that they affect motor development. Another possibility explaining the mechanism by which breastfeeding is associated with children's development is that the intimacy of breastfeeding might be important for the infant development (Lucas & Morley, 1992). This issue deserves to be clarified in future studies.

6.6. Conclusion

To our knowledge this is the first study that sought simultaneously to address the biosocial factors associated with low and high motor competence by sex. Another strong point of this study lies in exploring the joint effects of biological and environmental factors on motor competence in preschool children. For this purpose, variables related to the characteristics of children and their main developmental contexts including family, school and peers were explored. In conclusion, the motor variability of preschool children was mainly explained by social/environmental factors of family and school environments, such as the participation on structured physical activity (sports, physical education), on unstructured physical activity, the gross motor toys/equipment available for play, and the active play with the father. The findings of the study also highlight the social effect of school peers, namely sex and age composition of the classroom.

In this study, different factors were found to explain the motor variability of boys and girls. This fact reflects in part the different opportunities provided to boys and girls, which might explain the different levels of motor competence. Finally, it should be stressed that the associations found for low and high competence suggest the existence of a non-linear effect of biosocial variables in the spectrum of motor competence. It was expected that the same factor was associated with high and low competence but in an inverse relation. However, this trend was not verified in our study, for example, we found that girls who had more toys had a better performance, but the inverse relationship was not found. This is a new issue in the literature that has methodological implications for future studies, since the variable effect can be amplified or annulled by the net reaction with the level of motor proficiency. A model that could accommodate this differential effect along the full spectrum of motor proficiency is an important step for a more comprehensive understanding of the biosocial effects on motor development.

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Chapter 7. Conclusions

7.1. Overview of main findings

The interest in knowing why children show different levels of motor competence, led us to conduct this thesis. This is a complex issue and it is not yet sufficiently clarified in the literature, particularly under a multidimensional understanding of motor development. In this thesis, a set of studies sought to contribute to a better understanding of the causes of motor variability of children in pre-school. Based on the main results of these empirical studies we can draw the following conclusions and interpretations:

A sexual differentiation in motor competence was found in preschool children.

The studies presented in chapters 3 e 4 provide evidences that sex differences in motor performance can be observed in preschool age. Significant differences were found between girls' and boys' performance in object manipulation, grasping, and visual-motor integration subtests. Girls had superior performance in grasping and visual-motor integration skills while boys performed better in object manipulation skills. No sex differences were found in the stationary and locomotion subtests. The evidence of early sex differences in motor ability is not new in the literature, suggesting strong early effects of biological variables in motor development and a progressive modulation effect of motor experiences across childhood. The different motor profile between boys and girls is consistent with the majority of studies found in the literature.

Age and sex effect on motor performance varied with age group and motor specificity.

The influence of the age, sex and somatic variables on motor competence was explored in Chapter 5. Clearly, age and sex stood out as predictors of motor competence; however the magnitude of its effects varied along age cohorts and motor specificity. In all gross and fine motor subtests, the influence of age decreased throughout age cohorts; whereas the influence of sex increased or decreased depending on the motor domain. Within the object manipulation competence, the results visibly showed that the influence of sex increases along age cohorts. The boys' advantage in object manipulation skills becomes progressively greater throughout preschool age, which suggests a progressive modulation effect of motor experiences across childhood.

On the other hand, the sex effect on grasping and visual-motor integration subtests decreased throughout age cohorts. It is interesting to observe that girls' superiority at the age of three, in grasping and visual-motor integration skills, disappeared by the age of five in our study. This narrowing of the differences between boys and girls in fine motor skills throughout preschool ages might be explained by school practices in which both sexes are equally stimulated, but this hypothesis claims for further research.

The somatic measures (height-for-age z-score, weight-for-age z-score and BMI-for-age z-score), birth weight and gestational age played a small or non-existent role in predicting motor development of preschoolers.

In fact, the findings of the studies presented in chapters 5 and 6 support that the relationship between children's somatic characteristics (e.g. stature, weight and body mass index) and motor performance in preschool age is generally low (Bonvin et al., 2012; Logan, Scrabis-Fletcher, Modlesky, & Getchell, 2012; Nervik, Martin, Rundquist, & Cleland, 2011; Oja & Jürimäe, 1997) and varies with the specificity of the motor skill (Castetbon & Andreyeva, 2012; Malina & Bouchard, 1991; Roberts, Veneri, Decker, & Gannoti, 2012).

Among all somatic characteristics considered as hypothetical predictors, only the height-for-age entered in the explanatory model of boys' high gross motor competence. Also, the influence of birth weight and gestational age were not confirmed. This fact may be partly explained by the limited number of preterm and low birth weight on our sample.

The motor variability of preschool children was mainly explained by social/environmental factors

In Chapter 6, the study aimed to determinate the joint effects of biological and social/environmental factors on low and high motor competence. We concluded that the motor competence is mainly explained by factors associated to family and school environments. Significant associations were found between motor competence and social/environmental factors such as the participation on structured physical activity (sports, physical education), on unstructured physical activity, the gross motor toys/equipment available for play, and the active play with the father. The findings of the study also highlight the social effect of school peers, namely sex and age composition of the classroom. Cleary, these findings support assumption that children's motor development is influenced by multiple contexts. According to Bronfenbrenner and Morris (2006), children are affected by their interpersonal relationships, the social institutions that touch their lives, their culture, and the period in which they are developing.

Different social and environmental factors were found to explain the motor variability of boys and girls.

Noticeably, the factors associated to low motor competence in girls are related to a lack of stimulation (e.g., having less than 1h per week of structured physical activity and no active playtime with the father); on the other hand, the factors linked to high motor competence in boys seem to reflect a greater opportunity to participate in structured physical activities. These evidences reinforce the idea that the sex differences in motor competence are a result of social and environmental effects, such as different opportunities for motor experience, gender typed behaviours, sex stereotyped games and toys, and parent and social expectations (Barnett, Hinkley, Okely, & Salmon, 2013; Cools, De Martelaer, Samaey, & Andries, 2011).

Different biosocial factors were found to explain the high and low gross motor competence

Finally, a non-linear effect of biosocial variables in the spectrum of motor competence was found. This means that the associations found for low and high motor competence were not the same in an inverse relationship. For example, playing less than 1 hour per day is a factor associated with low motor competence in boys. However, playing more than 1 hour per day (or more) is not associated with high motor competence in boys. This is a new issue in the literature that has methodological implications for future studies, since the variable effect can be amplified or annulled by the net reaction with the level of motor proficiency. A model that could accommodate this differential effect along the full spectrum of motor proficiency is an important step for a more comprehensive understanding of the biosocial effects on motor development.

7.2. Methodological consideration and future research

The major strengths of this study were: i) to consider the joint effects of a wide range of biological and environmental factors on motor competence in preschool children; and ii) to examine simultaneously the biosocial factors associated with low and high motor competence by sex. Nevertheless, some limitations should be recognized. First of all, our study was a cross-sectional design and causal inferences cannot be made. Longitudinal study designs should be considered in further research, not only to provide more insight on the question of the causal direction, but also to understand how the biological and environmental effects vary over time.

In this study, a convenience sample was used. Although this procedure allowed us to have a large sample, it precluded the generalization of the results and limited the representativeness of some categories in our sample due to their small variation. This may have resulted in insufficient power to detect some associations in these categories (e.g., gestational age and birth weight). A greater variability of the sample in these categories should be considered in future studies.

In this study, the effects of multiple contexts of child development were evident, namely, the effect of family, school and peers. Future studies should also include variables associated with the neighbourhood, such as the access to parks or playgrounds or the safety perception of the neighbourhood (e.g., traffic, concern with strangers). Other variables associated with child's characteristics, for instance self-perceived motor competence, should be considered.

In this field of research, the biosocial effects should also be explored according to the age, sex, level of motor competence and motor specificity of the children. For example, it will be useful to understand which factors explain the variability in the object manipulation skills or in the fine motor skills.

7.3. Practical implications

The results of this thesis reinforce clearly the assumption that active playtime and structured physical activity are essential to promote an optimal motor development of children. Undoubtedly, family and school have a key role in the child's motor development in preschool age. In both environments, space, time, and materials are important for the child to engage in active play. Organized activities at school and outside of school are also essential to achieve an adequate level of motor competence. Our findings indicate that having older peers in the classroom has a positive impact in children's motor development during preschool. This is an issue that should be taken into account by teachers. From a teaching and learning point of view, the findings reinforce the need to create tasks that develop the object manipulation skills in children. Clearly, children have better performance on fine motor skills, compared to gross motor skills. This question is still more critical for girls because they present a considerably lower level in the gross motor skills than boys. In addition, there is a need to encourage girls to practice more manipulative skills, since gender stereotypes in our society lead to fewer opportunities for girls to develop their gross motor skills.

Finally, it should be stressed that the validation of the Peabody Developmental Motor Scales - second edition (PDMS-2) (Folio & Fewell, 2000), which was one of the end-products of this thesis represents an important step for the future evaluation of Portuguese children. The PDMS-2 is one of the most widely used instruments in clinical and research settings and allows a multidimensional interpretation of motor development. In this thesis, this instrument was fully translated and it was confirmed that PDMS-2 is an accurate and valid tool to assess the gross and fine motor skills of Portuguese preschoolers.

7.4. General conclusion

The biosocial effect on motor performance varied with age group, sex, motor specificity and level of motor competence. The findings support the assumption that motor development during early childhood cannot be explained by a singular cause. The motor variability of preschool children was mainly explained by social/environmental factors. The motor competence of boys and girls was explained by different biosocial factors that may suggest different practice opportunities. Biosocial variables seem to have a non-linear effect along the spectrum of motor competence.

7.5. References

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Appendix

A. Parental interview (in Portuguese)

1	**CARACTERIZAÇÃO DA CRIANÇA E ANTECEDENTES PESSOAIS**
1.1	IDENTIFICAÇÃO
1.1.1	Código (n.º/jardim/educadora)
1.1.2	Sexo
1.1.3	Data nascimento (dd/mm/aaaa)
1.1.5	Codigo Postal
1.2	GRAVIDEZ, PARTO E 1º ANO DE VIDA **(informação com base no boletim de saúde)**
1.2.1	Duração da gestação:
1.2.2	Peso ao nascer:
1.2.3	Compr. à nascença:
1.2.4	Perímetro cefálico:
1.2.5	Índice de APGAR ao 1º minuto
1.2.6	Índice de APGAR ao 5º minuto
1.2.7	A criança foi amamentada ao peito? sim ☐ não ☐ Em caso afirmativo, durante quanto tempo?
1.3	TIPO DE ACOLHIMENTO DURANTE OS PRIMEIROS ANOS DE VIDA DA CRIANÇA
1.3.1	Por favor, indique o(s) tipo(s) de acolhimento dado à criança após a licença de maternidade/paternidade:

1) Em casa com a mãe ☐ 2) Ama ☐ 3) Em casa com a empregada ☐
4) Em casa com avós ☐ 5) Creche ☐ 6) Outra ☐ Qual? ____

1.3.2	Durante quanto tempo frequentou a creche?
1.3.3	Com que idade foi para o Jardim de Infância?
1.3.4	Há quanto tempo frequenta o presente jardim de infância?
2	**CARACTERIZAÇÃO FAMILIAR**
2.1	Caracterize todos os membros do agregado familiar com quem vive a criança de uma forma permanente quanto à idade e grau de parentesco.

	Grau de parentesco	Idade		Grau de parentesco	Idade
2.1.1			2.1.5		
2.1.2			2.1.6		
2.1.3			2.1.7		

2.2	N.º de pessoas no lar	2.3	N.º de filhos do casal	2.4	Ordem de nascimento

2.5 A figura maternal da criança:

1) Mãe biológica ☐ 4) Cohabitante com pai ☐
2) Mãe adoptiva ☐ 5) Irmã mais velha ☐
3) Madrasta ☐ 6) Sem figura maternal ☐
7) Outra, quem? ____

2.6 A figura paterna da criança:

1) Pai biológico ☐ 4) Cohabitante com mãe ☐
2) Pai adoptivo ☐ 5) Irmão mais velho ☐
3) Padrasto ☐ 6) Sem figura paternal ☐
7) Outro, quem? ____

2.7 Tipo de Agregado

2.8 Habilitação académica do pai:

1) Sem escolaridade ☐ 2) Sabe ler e escrever ☐ 3) 1º ciclo completo (4ª cl.) ☐ 4) 2º ciclo completo (prep.) ☐
5) 3º ciclo (9º ano) ☐ 6) Secundário (12º ano) ☐ 7) C. de formação Profissional ☐ 8) Curso Superior Incompleto ☐
9) Curso Superior Completo ☐ 10) Pós-graduação ☐ 11) Mestrado ☐ 12) Doutoramento ☐

2.9 Habilitação académicas da mãe:

1) Sem escolaridade ☐ 2) Sabe ler e escrever ☐ 3) 1º ciclo completo (4ª cl.) ☐ 4) 2º ciclo completo (prep.) ☐
5) 3º ciclo (9º ano) ☐ 6) Secundário (12º ano) ☐ 7) C. de formação Profissional ☐ 8) Curso Superior Incompleto ☐
9) Curso Superior Completo ☐ 10) Pós-graduação ☐ 11) Mestrado ☐ 12) Doutoramento ☐

2.10	Ocupação profissional do pai:	2.10.1	N.º de horas por semana dispendido com o trabalho:
2.11	Ocupação profissional da mãe:	2.11.1	N.º de horas por semana dispendido com o trabalho:

[1]/[6]

3 CARACTERÍSTICAS ESTRUTURAIS DO CONTEXTO FAMILIAR

3.1 TIPO DE HABITAÇÃO

3.1.1 Qual o tipo de habitação?

1) Apartamento em bloco habitacional ☐
2) Apartamento em moradia com menos de três familias ☐
3) Moradia/vivenda unifamiliar térrea ☐
4) Moradia/vivenda unifamiliar com dois ou mais pisos ☐

3.1.2 Qual o n.º de divisões da habitação, sem incluir a cozinha e a(s) casa(s) de banho? ☐

3.1.3 Qual a área aprox. da habitação? ☐

3.2 ESPAÇO DA CRIANÇA NA HABITAÇÃO

3.2.1 Qual a área aproximada do quarto da criança? ☐

3.2.2 Com quantas pessoas compartilha o quarto? ☐

3.2.3 A sua habitação possui um espaço exterior para a criança brincar (ex.pátio, terraço, jardim ou quintal) ? sim ☐ não ☐

3.2.3.1 Que tipo de espaço?

3.2.3.2 Qual a área aproximada desse espaço? ☐ m^2

3.2.4 Na habitação existe um quarto/espaço específico para a criança brincar? sim ☐ não ☐

3.2.4.1 Que tipo de espaço? ☐

3.2.4.2 Qual a área aproximada desse espaço? ☐

3.2.5 A criança tem a liberdade de brincar:

1) Apenas em alguns espaços do interior da habitação ☐
2) Apenas em alguns espaços do interior e exterior da habitação ☐
3) Não tem qualquer restrição dentro das possibilidades da habitação ☐

3.3 BRINQUEDOS E MATERIAS EXISTENTES NA HABITAÇÃO

3.3.1 Quantos aparelhos audio-visuais ou informáticos (TV, computador, consola de jogos, leitor de CD/DVD) a criança possui no seu quarto? ☐

3.3.2 E nos restantes compartimentos da casa? ☐

3.3.3 O acesso aos aparelhos é livre? sim ☐ não ☐

3.3.4 A sua criança utiliza os aparelhos audio-visuais ou informáticos para actividades predominantemente:

3.3.4.1 Visuais (ver tv, filmes) ☐ 3.3.4.2 Músicais (ouvir mús., cantar) ☐ 3.3.4.3 Movimento (dança) ☐ 3.3.4.4 Jogos electrónicos ☐

3.3.5 No caso da sua criança utilizar jogos electrónicos/videojogos, qual o tipo de jogos que costuma brincar?

3.3.5.1 Jogos predominantemente cognitivos (capacidade de memória, raciocínio, classificação, seriação) ☐
3.3.5.2 Jogos predominantemente perceptivos/sensoriais (capacidade de reacção, timing) ☐
3.3.5.3 Jogos de Movimento (ex. saltar, correr, rebater) ☐

3.3.6 Refira aproximadamente o tipo/quantidade de brinquedos e materiais pedagógicos que a sua criança possui em casa.

A	3.3.6.1	**Brinquedos e materiais de fantasia, faz-de-conta, dramatização e de socialização** (ex., bonecas, fantoches, veículos, animais, miniaturas de cenas familiares)	0 1 2 3 4 5 +5
B	3.3.6.2	**Brinquedos e materiais de construção e criatividade** (ex., legos, puzzles e formas de encaixar, contas de enfiar, brinquedos para brincar com areia e água)	0 1 2 3 4 5 +5
C	3.3.6.3	**Brinquedos e materiais para desenhar, colorir, recortar, colar, moldar** (ex., lápis de cores, papel, plasticina, pinceís, tesousa sem pontas, giz e quadro)	0 1 2 3 4 5 +5
D	3.3.6.4	**Livros, materiais pedagógicos destinados à aquisição de conceitos da mat., linguagem,ciências e outros tipos de jogos** (ex., tipo dominó, carta de pares)	0 1 2 3 4 5 +5
E	3.3.6.5	**Instrumentos musicais** (ex. xilofone, tambor, flauta, pianinhos)	0 1 2 3 4 5 +5
F	3.3.6.6	**Equipamento audio-visual e informático** (ex., leitor de CD/DVD, CDs ou DVs com músicas ou filmes infantis, consola de jogos, portátil infantil)	0 1 2 3 4 5 +5
G	3.3.6.7	**Brinquedos de manipulação, locomoção e equilibrio para actividades motoras** (ex., bolas, cordas, raquetes, triciclos, bicicleta, patins, baloiços, escorregas, túneis)	0 1 2 3 4 5 +5

3.3.7 A criança possui mais brinquedos de: ☐

3.3.8 A criança possui menos brinquedos de: ☐

3.3.9 Refira os brinquedos ou materiais pedagógicos que a sua criança costuma **brincar mais vezes**?

3.3.9.1 ☐ 3.3.9.2 ☐ 3.3.9.3 ☐

3.3.10 Refira os brinquedos ou materiais pedagógicos que a sua criança costuma brincar mais vezes, **fora de casa**?

3.3.10.1 ☐ 3.3.10.2 ☐ 3.3.10.3 ☐

[2]/[6]

4 ACTIVIDADE DIÁRIA DA CRIANÇA

4.1 ROTINA DIÁRIA DA CRIANÇA

4.1.1 Tendo como referência um típico dia da semana (dia útil), refira aproximadamente o horário e duração diária da criança nas seguintes tarefas:

Dias úteis

Horário		**Duração** (horas ou minutos)	
a) Despertar		Prolongamento do horário do jardim (compl. de apoio à família)	
Chegada do Jardim		g ATL	
Saída do Jardim		Tempo na casa de familiares (ex. avós, tios)	
		c) Brincar no parque infantil ou outro espaço de lazer	
Chegada a casa		d) Ver televisão ou video filmes	
		e) Computador/consola (video-jogos)	
b) Deitar		f) Brincar com brinquedos em casa	

4.1.2 Em média quanto tempo por dia a criança **dorme** durante os dias úteis da semana (considerar dia e noite)? (b-a)

4.1.3 Em média quanto tempo/dia a criança **brinca** durante os dias úteis da semana e fora do período escolar? (± c+e+f)+g (?)

4.1.4 Em média quanto tempo por dia a criança **vê televisão ou video-filmes** durante os dias úteis da semana e fora do período escolar? (d)

4.1.5 Em média quanto tempo/dia a criança dispende em actividades físicas **não estruturadas com dispendio energético significativo (**ex.correr , jogar à bola, andar bicicleta/triciclo) nos dias úteis da semana e fora do período escolar? (-(c+e+f)

4.1.6 Para além das actividades que ocorrem dentro do período escolar, a criança realiza semanalmente outras actividades estruturadas, ex. música, inglês, Ed. Física (considerar também as act.(s) realizadas no ATL ou no C.A. Familia)? sim não

	Que tipo de actividade?		Tempo total semanal (h)		Local
4.1.6.1		4.1.6.1.1		4.1.6.1.1.1	
4.1.6.2		4.1.6.2.1		4.1.6.2.1.1	
4.1.6.3		4.1.6.3.1		4.1.6.3.1.1	
4.1.6.4		4.1.6.4.1		4.1.6.4.1.1	

4.1.7 No percurso **casa-jardim de infância** refira:

4.1.7.1 Qual a distância Casa/Jardim de Infância?

4.1.7.2 A pé ou transportada?

4.1.7.3 Qual o tempo dispendido na deslocação?

4.1.7.4 Quem acompanha a criança?

4.1.8 No percurso **jardim de infância-casa** refira:

4.1.8.1 A pé ou transportada?

4.1.8.2 Qual o tempo dispendido na deslocação?

4.1.8.3 Quem acompanha a criança?

[3]/[6]

4.1.9	Tendo como referência o último Sábado (dia típico), refira aproximadamente o horário ou duração diária da criança nas seguintes tarefas:

Sábado

Horário		Duração (horas ou minutos)	
Despertar		**Em casa**	
		Ver televisão ou video filmes	
		Computador/consola (video-jogos)	
		Brincar com brinquedos	
		Período de sono durante o dia	
		Fora de casa	
		Act.(s) Estruturadas (música, dança, natação, etc.)	
		Brincar em parques infantis ou outros espaços lúdicos	
		Act. físicas com os pais ou outros familiares/amigos (ex.andar bicicleta, ir à piscina)	
		Passear com os pais e/ou outros familiares/amigos	
Deitar		Actividades de animação cultural (ex. teatro, cinema, biblioteca infantil) ou religiosas	

4.1.10	Tendo como referência o último de Domingo (dia típico), refira aproximadamente o horário ou duração média diária da criança nas seguintes tarefas:

Domingo

Horário		Duração (horas ou minutos)	
Despertar		**Em casa**	
		Ver televisão ou video filmes	
		Computador/consola (video-jogos)	
		Brincar com brinquedos	
		Período de sono durante o dia	
		Fora de casa	
		Act.(s) Estruturadas (música, dança, natação, etc.)	
		Brincar em parques infantis ou outros espaços lúdicos	
		Act. físicas com os pais ou outros familiares/amigos (ex.andar bicicleta, ir à piscina)	
		Passear com os pais e/ou outros familiares/amigos	
Deitar		Actividades de animação cultural (ex. teatro, cinema, biblioteca infantil) ou religiosas	

4.1.11	Em média quanto tempo por dia a criança **brinca** durante o fim de semana, dentro e fora de casa?	
4.1.12	Em média quanto tempo por dia a criança **vê televisão ou video-filmes** no fim-de-semana?	
4.1.13	Em média quanto tempo por dia a criança realiza actividades físicas **não estruturadas com dispendio energético significativo** (ex.correr com outras crianças, jogar à bola, andar bicicleta/triciclo) durante o fim de semana?	

[4]/[6]

5 ENVOLVIMENTO FAMILIAR

5.1 Em média, quantas horas por dia, os pais estão com a criança (considerar apenas o tempo em que a criança está acordada)?

5.1.1	**Pai**	5.1.1.1	Dia útil		5.1.1.2	Fim de semana	
5.1.2	**Mãe**	5.1.2.1	Dia útil		5.1.2.2	Fim de semana	

5.2 O pai e/ou a mãe costumam brincar com a criança? sim ☐ não ☐

5.3 Que tipo de brincadeiras o pai e a mãe costumam brincar com a criança?

5.3.1	**Pai**	5.3.1.1		5.3.1.2		5.3.1.3	
5.3.2	**Mãe**	5.3.2.1		5.3.2.2		5.3.2.3	

5.4 **Em média, quanto tempo por dia, o pai e a mãe brincam efectivamente com a criança?**

5.4.1	**Pai**	5.4.1.1	Dia útil		5.4.1.2	Fim de semana	
5.4.2	**Mãe**	5.4.2.1	Dia útil		5.4.2.2	Fim de semana	

5.5 Para além dos pais, a criança costuma brincar com outros familiares ou adultos? sim ☐ não ☐

5.5.1 Em caso afirmativo, especifique com quem: ☐

6 ENVOLVIMENTO DA CRIANÇA COM O GRUPO DE PARES (FORA DO CONTEXTO ESCOLAR)

6.1 O seu filho(a) costuma brincar com outras crianças fora do contexto escolar? sim ☐ não ☐

6.1.1 Em caso afirmativo, refira:

6.1.1.1	N.º de vezes por semana (dias úteis)		6.1.1.1.1	Tempo médio por dia durante a semana?	
6.1.1.2	N.º de vezes ao fim-de-semana		6.1.2.1	Tempo médio por dia durante o fim de semana?	

6.2 Refira quais são os principais espaços/locais onde o seu filho(a) costuma brincar com outras crianças:

6.2.1. ☐ 6.2.2 ☐ 6.2.3 ☐

6.3 Brinca mais vezes com crianças do: 1) Mesmo sexo ☐ 2) Sexo oposto ☐ 3) Indiferente ☐

6.4 Brinca mais vezes com crianças: 1) Mais novas ☐ 2) Da mesma idade ☐ 3) Mais velhos ☐

6.5 Caso não sejam da mesma idade, especifique qual a diferença de idades predominante: ☐

6.6 Quanto às brincadeiras ou actividades lúdicas que o seu filho(a) realiza com os seus companheiros, refira as:

6.7	**Mais frequentes**	6.7.1		6.7.2		6.7.3	
6.8	**Preferidas**	6.8.1		6.8.2		6.8.3	

7 UTILIZAÇÃO DE ESPAÇOS DE LAZER/RECREATIVOS NA VIZINHANÇA

7.1 Com que frequência é que a sua criança costuma ir aos seguintes espaços de lazer e fora do período escolar?

		1) **Nunca**	2) **Algumas vezes**	3) **Muitas vezes**
7.1.1.	Parque Infantil residencial	☐	☐	☐
7.1.2	Parque infantil público	☐	☐	☐
7.1.3	Parque infantil do Centro comercial	☐	☐	☐
7.1.4.	Jardim Público/Parque da cidade	☐	☐	☐
7.1.5	Piscina	☐	☐	☐
7.1.6	Praia/rio/lago/monte/ campo	☐	☐	☐
7.1.7	Espaços multi-desportivos	☐	☐	☐

[5]/[6]

7.2	Indique os três principais espaços de lazer e recreativos que a criança costuma frequentar, referindo a sua frequência semanal, n.º de horas por dia, o tipo de transporte utilizado e o tempo na deslocação.						
	Espaço de lazer		n.º de vezes /sem.		tempo/dia (min.)		Tipo de transporte
7.2.1.		7.2.1.1		7.2.1.2		7.2.1.3	
7.2.2		7.2.2.1		7.2.2.2		7.2.2.3	
7.2.3		7.2.3.1		7.2.3.2		7.2.3.3	

7.3 Com quem a criança costuma ir a esses espaços de lazer?

8 OUTROS ASPECTOS

8.1 Os pais ou irmãos da criança praticam alguma actividade física/ desportiva de uma forma regular? sim ☐ não ☐

Em caso afirmativo, refira:

	Quem?		Que tipo de actividade?		Tempo total semanal
8.1.1		8.1.1.1		8.1.1.2	
8.1.2		8.1.2.1		8.1.2.2	
8.1.3		8.1.3.1		8.1.3.2	

8.2 Como caracteriza a sua criança em termos de actividade física?

1) Sedentária(o) ☐ 2) Pouco Activa(o) ☐ 3) Activa(o) ☐ 4) Muito activa (o) ☐

8.3 E em relação às outras crianças?

1) Mais activo(a) que as outras ☐ 2) Menos activo(a) que as outras ☐ 3) Igual às outras ☐

9 OBSERVAÇÕES

Entrevistado:

Entrevistador:

[6]/[6]

B. Teacher interview (in Portuguese)

Data: ___/___/___

1	**CARACTERÍSTICAS PESSOAIS DA EDUCADORA**
1.1	Código
1.2	Sexo
1.3	Idade
1.4	Habilitações Académicas
1.5	Tempo de experiência profissional
1.6	Modelo curricular adoptado:
1.7	Tempo de actividade educativa continua com o grupo
2	**CARACTERÍSTICAS DO GRUPO DE CRIANÇAS**
2.1	N.º de crianças no grupo/sala
2.2	Indique o número de crianças existentes em cada um dos seguintes grupos etários:

Entre [2, 3 [anos	Entre [5, 6 [anos
Entre [3, 4 [anos	Entre [5, 6 [anos
Entre [4, 5 [anos	Entre [6, 7 [anos

2.3	N.º de crianças do sexo feminino	2.4	N.º de crianças do sexo masculino
2.5	Idade da criança mais nova (meses)	2.6	Idade da criança mais velha (meses)
2.7	Idade média do grupo/sala		

3	**CARACTERÍSTICAS ESTRUTURAIS DO CONTEXTO ESCOLAR**		
3.1	CARACTERÍSTICAS GERAIS DO JARDIM DE INFÂNCIA		
3.1.1	Tipo de Jardim de Infância:		
3.1.2	N.º total de crianças a frequentar o JI	3.1.3	N.º de grupos/salas de crianças
3.1.4	Área (m^2) da sala de actividades do seu grupo	3.1.5	Rácio adulto/criança
3.1.6	Especificamente para o seu grupo de crianças, mencione e caracterize os espaços que o edificio escolar comporta para desenvolver todas as áreas de conteúdo previstas nas orientações curriculares:		

		área (m2)	n.º de utilizadores	Área (m2)/criança
Sala de actividades		m^2		
Sala Polivalente		m^2		
Ginásio		m^2		
Recreio (espaço exterior)		m^2		
ATL		m^2		
Sala multimédia		m^2		
Biblioteca		m^2		
Outros:		m^2		
		m^2		

3.1.7	Área total do espaço destinado à actividade motora estruturada ou informal	m^2
3.1.8	Área total do espaço destinado às outras actividades curriculares	m^2

[1]/[3]

Data: ___/___/___

3.2 ESPAÇO E EQUIPAMENTO ESPECÍFICO PARA ACTIVIDADE MOTORA ESTRUTURADA OU INFORMAL

3.2.1 Tipo de Equipamento fixo existente no espaço de recreio

Abrigos	☐	Equipamento para equilíbrio	☐
Alvos de parede	☐	Pontes Basculantes	☐
Balancés	☐	Torres/Fortes	☐
Baloiços	☐	Redes para trepar, escadas de corda	☐
Cabanas	☐	Balizas	☐
Caixas de Areia	☐	Cestos de basquetebol	☐
Escorregas	☐	Outros: ______________	☐

3.2.2 N.º total de equipamentos fixos existentes no espaço de recreio ☐

3.2.3 Tipo de Equipamento/material portátil existentes no espaço de recreio

Bolas	☐	Triciclos/trotinetes	☐
Arcos	☐	Cestos de basquetebol	☐
Cordas	☐	Pneus	☐
		Outros: ______________	☐

3.2.4 Tipo e quantidade de equipamento e material existente no recreio e espaço interior da escola

	recreio	n.º de crianças	interior	n.º de crianças
Bolas e outros materias desportivos para pontapear, lançar, agarrar, driblar, rebater, andar, etc. (alvos, cestos, balizas, ringues, cordas para saltar, discos, andas, etc.)	____	____	____	____
Triciclos, trotinetes, carros e outros brinquedos para a criança montar e se deslocar (com ou sem pedais)	____	____	____	____
Brinquedos para baloiçar e rodar, baloiços, cavalos de baloiço e brinquedos para rodopiar	____	____	____	____
Brinquedos e materiais utilizados para movimentos de exploração que envolvem todo o corpo (deslizar, escorregar, trepar, rastejar, rolar, etc.). São exemplos: escorregões, túneis, aparelhos para trepar, colchões e outras formas almofadadas para exercício, piscinas, etc.	____	____	____	____
Brinquedos e materiais de puxar e empurrar (ex. carrinho de mão, aparador de relva, carrinho de compras)	____	____	____	____

3.2.5 Com que frequência o material/equipamento fixo está disponível para as crianças brincarem? ☐

3.2.5.1 Durante quanto tempo estão disponíveis para as crianças brincar? ☐

3.2.6 Com que frequência o material/equipamento portátil está disponível para as crianças brincarem? ☐

3.2.6.1 Durante quanto tempo estão disponíveis para as crianças brincar? ☐

3.3 MATERIAL ESPECÍFICO PARA MOTRICIDADE FINA

3.3.1 Tipo/quantidade de material

brinquedos pequenos para construções ☐ materiais de arte ☐ jogos de manipulação ☐ puzzles ☐

3.3.2 Com que frequência o material/equipamento está disponível para as crianças brincarem? ☐

3.3.2.1 Durante quanto tempo estão disponíveis para as crianças brincar? ☐

[2]/[3]

Data: ___/___/___

4 ACTIVIDADE DIÁRIA DA CRIANÇA NO CONTEXTO ESCOLAR

4.1 Tendo como referência um dia tipico da semana, refira os horários ou a duração dos seguintes momentos da rotina diária do seu grupo/sala:

Dias úteis

Horas		**Duração**	
Início	_____	Tempo de roda	_____
Refeição (meio da manhã)	_____	Aprendizagem estruturada (da iniciativa da educadora)	_____
Refeição (almoço)	_____	Actividades livres (da iniciativa da criança)	_____
Refeição (meio da tarde)	_____	Recreio da manhã	_____
		Recreio da tarde	_____
Saída do Jardim	_____	Tempo Tv ou video-filmes	_____

4.2 Em média quanto tempo por dia a criança **brinca** no período escolar? _____

4.3 Em média quanto tempo por dia a criança realiza actividades físicas **não estruturadas com dispendio energético significativo** (ex. no recreio correr com outras crianças, jogar à bola, andar bicicleta/triciclo) no período escolar? _____

4.4 Em média quantas vezes por semana a criança realiza actividades físicas estruturadas (**sessões de motricidade**) no período escolar? _____

4.4.1 Qual a duração das sessões de motricidade? _____

4.4.2 Estas sessões estão integradas nas actividades de complemento curricular (AECs)? _____

Que tipo de actividades são proporcionadas nessas sessões?

Actividades gimnicas/básicas ☐ Actividades Aquáticas ☐ Actividades expressivas ☐ _____

4.5 **Com que frequência as crianças são estimuladas nas seguintes habilidades motoras?**

	nunca	menos que mensal	mensalmente	semanalmente	diariamente
Habilidades posturais	☐	☐	☐	☐	☐
Habilidades de locomoção	☐	☐	☐	☐	☐
Habilidades de manipulação de objectos	☐	☐	☐	☐	☐
Habilidades de manipulação fina	☐	☐	☐	☐	☐
Habilidades de integração-visuo-motora	☐	☐	☐	☐	☐

[3]/[3]

C. Descriptive data of all variables in the whole sample and according to sex.

	Total *N*=366	Boys *n*=171	Girls *n*=195	*p*
CHILD'S CHARACTERISTICS				
Age (months), M (SD)	53.0 (9.58)	52.7 (0.75)	53.2 (0.67)	0.634
Gross Motor Quotient, M (SD)	94.5 (7.51)	96.2 (0.64)	92.9 (0.45)	**<0.001**
Weight-for-age (z score), M (SD)	0.31 (0.99)	0.02 (1.00)	0.372 (0.98)	0.547
Height-for-age (z score), M (SD)	0.47 (0.98)	0.44 (1.01)	0.437 (0.95)	0.900
BMI-for-age (z score), M (SD)	0.66 (1.13)	0.62 (1.21)	0.695 (1.06)	0.538
Gestational age, M (SD)	38.48 (1.9)	38.5 (1.77)	38.48 (2.01)	0.978
Birth weight M (SD)	3.23 (0.47)	3.26 (0.46)	3.21 (0.48)	0.281
Breastfeeding, n (%)				
No	39 (10.8)	12 (7.2)	27 (13.9)	
< 3 months	109 (30.1)	45 (26.9)	64 (32.8)	**0.028**
≥ 3 months	214 (59.1)	110 (65.9)	104 (53.3)	
FAMILY ENVIRONMENT				
Family's sociodemographics				
Residence, n (%)				
Urban	159 (43.4)	69 (40.3)	90 (46.2)	
Semiurban	114 (31.2)	60 (35.1)	54 (27.7)	0.302
Rural	93 (25.4)	42 (24.6)	51 (26.1)	
Household income, n (%)				
Low (≤ €225)	72 (19.7)	34 (19.9)	38 (19.5)	
Average (€226- €449)	87 (23.8)	39 (22.8)	48 (24.6)	0.921
High (≥ €450)	207 (56.5)	98 (57.3)	109 (55.9)	
Mother's education, n (%)				
Elementary	135 (37.1)	62 (36.5)	73 (37.6)	
High school	97 (26.6)	46 (27.0)	51 (26.3)	0.972
College	132 (36.3)	62 (36.5)	70 (36.1)	
Father's education, n (%)				
Elementary	184 (50.7)	89 (52.7)	95 (49.0)	
High school	91 (25.1)	38 (22.5)	53 (27.3)	0.567
College	88 (24.2)	42 (24.8)	46 (23.7)	
Family Type, n (%)				
no nuclear	33 (9.0)	20 (11.7)	13 (6.7)	
nuclear	333 (91.0)	151 (88.3)	182 (93.3)	
Birth order, n (%)				
Only child	148 (40.4)	62 (36.2)	86 (44.1)	0.096
First	58 (15.9)	34 (19.9)	24 (12.3)	
Second or more	160 (43.7)	75 (43.9)	85 (43.6)	

	Total N=366	Boys n=171	Girls n=195	p
Physical factors (home)				
House type, n (%)				
Apartment	128 (35.0)	56 (32.7)	72 (36.9)	0.403
Story house	238 (65.0)	115 (67.3)	123 (63.1)	
Crowding (persons/ rooms), n (%)				
> 1	67 (18.8)	34 (20.5)	33 (17.4)	0.453
≤ 1	289 (81.2)	132 (79.5)	157 (82.6)	
Space per child room, n (%)				
< 10 m^2/child	134 (36.7)	55 (32.2)	79 (40.7)	0.091
≥ 10 m^2/child	231 (63.3)	116 (67.8)	115 (59.3)	
Gross motor toys, n (%)				
≤ 5	119 (32.5)	50 (29.2)	69 (35.4)	0.211
> 5	247 (67.5)	121 (70.8)	126 (64.6)	
Social factors				
Active playtime with father, n (%)				
No	155 (42.3)	59 (34.5)	96 (49.2)	**0.004**
Yes	211 (57.7)	112 (65.5)	99 (50.8)	
Active playtime with mother, n (%)				
No	282 (77.0)	136 (79.5)	146 (74.9)	0.290
Yes	84 (23.0)	35 (20.5)	49 (25.1)	
Active playtime peers, n (%)				
No	150 (41.6)	60 (35.1)	95 (48.7)	**0.008**
Yes	211 (58.4)	111 (64.9)	100 (51.3)	
Unstructured physical activity, n (%)				
<1hr/day	234 (63.9)	79 (46.2)	115 (59.0)	**0.015**
≥1 hr/day	132 (36.1)	92 (53.8)	80 (41.0)	
Structured physical activity, n (%)				
<1hr/ week	234 (63.9)	100 (58.5)	134 (68.7)	**0.042**
≥1 hr/week	132 (36.1)	71 (41.5)	61 (31.3)	
PRESCHOOL ENVIRONMENT				
Social factors				
Childcare up to 3 year's old, n (%)				
no	250 (68.5)	109 (64.1)	141 (72.3)	
Up to 12 months	34 (9.3)	13 (7.7)	21 (10.8)	**0.029**
Over 12 months	81 (22.2)	48 (28.2)	33 (16.9)	
The class's age average, n (%)				
Older than child	183 (50.0)	86 (50.3)	97 (49.7)	0.917
Younger than child	183 (50.0)	85 (49.7)	98 (50.3)	
Classroom gender composition, n (%)				
Same gender	34 (9.3)	17 (9.9)	17 (8.7)	
More Boys	163 (44.5)	92 (53.8)	71 (36.4)	**0.001**
More girls	169 (46.2)	62 (36.3)	107 (54.9)	

	Total N=366	Boys n=171	Girls n=195	p
Physical Education, n (%)				
≤ 1 hr/week (one time)	262 (71.6)	120 (70.2)	142 (72.8)	0.576
> 1 hr/week (two times)	104 (28.4)	51 (29.8)	53 (27.2)	
Recess time), n (%)				
≤1 hr/day	177 (48.4)	77 (45.0)	100 (51.3)	0.232
>1 hr/day	189 (51.6)	94 (55.0)	95 (48.7)	
Physical factors				
Total area of physical activity space, n (%)				
≤ 901.5 m2	186 (50.8)	84 (49.1)	113 (57.9)	0.543
> 901.5 m2	180 (49.2)	87 (50.9)	82 (42.1)	
Space per child recess, n (%)				
≤ 12 m^2/child	215 (58.7)	102 (59.6)	125 (64.1)	0.742
> 12 m^2/child	151 (41.3)	69 (40.4)	70 (35.9)	
Portable outdoor play equipment, n (%)				
≤3	210 (57.4)	103 (60.2)	107 (54.9)	0.301
>3	156 (42.6)	68 (39.8)	88 (45.1)	
Fixed outdoor play equipment, n (%)				
≤5	247 (67.5)	122 (71.3)	125 (64.1)	0.140
>5	119 (32.5)	49 (28.7)	70 (35.9)	

Note: *p-values* in bold are statistically significant.