

Fundamental motor skills in preschoolers participating in a Developmental Physical Education program: preliminary results of a descriptive cross-sectional study

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HIGHLIGHTS

- All participants showed a motor age similar to or greater than their chronological age.
- Systematic practice and specialist teachers are key to developing motor skills.
- The Developmental Physical Education program supports children's motor performance.

ABBREVIATIONS

BMI	Body Mass Index
GMQ	Gross Motor Quotient
G3	Three-year-old age group
G4	Four-year-old age group
G5	Five-year-old age group
PE	Physical Education
TGMD-2	Test of Gross Motor Development

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BACKGROUND: Many studies indicate delays in the motor development of Brazilian preschoolers. These delays may be partly attributed to the sporadic presence of physical education teachers in early childhood education and the lack of preschoolers' participation in physical activity programs focused on developing these skills.

AIM: To investigate the gross motor quotient and motor age of children participating in a Developmental Physical Education program.

METHODS: The Test of Gross Motor Development (TGMD-2) was used to assess the motor developmental level of 19 children enrolled in an early childhood education center. Participants were divided into three age groups: three, four, and five years old.

RESULTS: After 12 weeks of classes, all participants demonstrated acceptable motor development, with a motor age at or above their chronological age. Thirteen children (68.42%) received average descriptive ratings, three (15.8%) received above-average ratings, and three (15.8%) received superior ratings.

INTERPRETATION: Participation in a systematic and regular Developmental Physical Education program appears to support the acquisition and refinement of fundamental motor skills in young children.

KEYWORDS: Motor development | Motor skills | TGMD-2

INTRODUCTION

Early childhood education in Brazil aims to expand the range of experiences, knowledge, and skills of developing children¹. It is the first step in completing basic education and covers children from zero to five years of age. This age group is characterized by several neuropsychomotor changes that lead the child to become more coordinated, to have a greater ability to control his or her own body, and to develop various skills that support his or her autonomy. These neuropsychomotor changes, combined with meaningful experiences during this period, provide lasting benefits for the child's learning, behavior, and overall health^{2,3}.

Despite their specialized knowledge in motor behavior⁴ (a crucial aspect for understanding and supporting children's developmental trajectories), specialized physical education (PE) teachers are still considered optional in early childhood education, as outlined in the Brazilian Law of Guidelines and Bases of National Education (Law 9.394/1996). This is true even though these professionals have specialized training and knowledge in motor behavior, a discipline that studies the changes in individuals' motor skills throughout the lifespan and provides valuable insights into various aspects of human development.

Capelle et al.⁵ demonstrated that teacher-led physical interventions significantly enhance fundamental motor skills in children aged 3-5 years, with superior outcomes compared to child-centered or family-led approaches. Similarly, Battaglia et al.⁶ found significant improvements in motor skills after 16 weeks of PE classes led by a specialist, outperforming a control group without consistent PE instruction. In addition, Rodrigues et al.⁷ further analyzed the impact of different teaching contexts, revealing that while initial differences were minimal, children taught by PE teachers showed sustained motor skill improvements after 12 months, whereas those taught by pedagogy teachers exhibited no significant progress. However, despite these benefits, the presence of a PE specialist alone does not seem to ensure adequate motor skill acquisition and refinement⁸.

Understanding the role of physical education teachers in promoting motor development in early childhood education is socially

relevant because many studies have shown that the basic motor skills of children between the ages of three and ten years are below developmental expectations⁹⁻¹². In addition, age may be a crucial consideration in children's gross motor development, with children of different ages achieving satisfactory levels of motor skills when motor experiences are adequate and of good quality^{12,13}.

Therefore, the purpose of this study was to describe the effects of participation in a standardized developmental program facilitated by a specialized physical education teacher on gross motor development during early childhood. Specifically, the study examined the gross motor development of children aged three to five years of both sexes and compared the motor development between boys and girls, all of whom were enrolled in an early childhood education unit and participated in a Developmental Physical Education program.

METHODS

Study design

This study employed a descriptive, cross-sectional design to analyze data collected at a single point in time. The participants were nineteen children aged three to five years. All children were enrolled in a daycare center of a public university in the interior of the state of São Paulo, Brazil.

The inclusion criteria for the study required children to be actively participating in a Developmental Physical Education program and to be between the ages of three and five years. Children were excluded from the study if they had physical or mental disabilities that could affect their performance in the activities or if they attended PE classes less than 80% of the time. Written informed consent from a parent or guardian, and informed assent were obtained from each child. The consent and assent forms were approved by the local ethics committee (protocol number: 53670916.5.0000.5398). All study procedures adhered to the principles outlined in the Declaration of Helsinki.

These children were divided into age groups as follows: G3 group (children aged three years to three years and eleven months; 2 girls, 4 boys), G4 group (children aged four years to four years and eleven months; 1 girl, 4 boys), and G5 group (children aged five years to five years and eleven months; 3 girls, 5 boys). Chronological age and anthropometric measurements (body mass, height and BMI classification) for each age group are presented in Table 1 and Figure 1.

Protocol

All children participated in a Developmental Physical Education program, consisting of classes that emphasized the development of locomotor, manipulative, and stabilization skills, as described by Gallahue and Donnelly¹⁴. Classes lasted 20 minutes for the three-year-old group and 30 minutes for the four- and five-year-old groups, meeting twice a week for all age groups. The school provided the necessary materials and adequate space for the PE classes, including a mini sports field, green spaces, a sandbox, classrooms, a video room, and a mirror room with tatami mats.

PE classes were divided into three main areas throughout the semester:

- Stabilization Skills: Developing and refining axial movements, jumping, vertical supports, and inverted supports (10 classes).
- Locomotion Skills: Developing and refining movements such as galloping, various types of jumping (single-legged, bipedal, horizontal jumping), lateral movement, running, striding, and vertical jumping (8 classes).
- Object Manipulation Skills: Improving skills such as throwing, kicking, catching, rolling, receiving, volleying, and horizontal hitting (8 classes).

At the time of the motor assessment, the children had participated in these classes for at least 12 weeks.

Assessment Procedures

The children participated in two different sets of tests during their PE classes:

- Anthropometric Measurements: Height and body mass were measured to calculate Body Mass Index (BMI) using the "Atenção Primária à Saúde APS online calculator"¹⁵. BMI values were then classified as low BMI for age, adequate (eutrophic) BMI, overweight, or obese.

- Gross Motor Skills Assessment (TGMD-2): The TGMD-2 test¹⁶, validated for Brazilian children¹⁷, was used to assess 12 motor skill items divided into two subtests:

- ✓ Locomotion Skills: Running, galloping, hopping, leaping, horizontal jumping, and sliding.
- ✓ Object Control Skills: Hitting a stationary ball, dribbling while stationary, catching, kicking, overhead throwing, and underhand rolling.

All test trials were videotaped using two digital cameras. The total duration of the TGMD-2 assessment averaged 20 minutes per child. Before each subtest trial, participants received detailed instructions on the skill to be performed, according to the TGMD-2 examiner's manual¹⁶, including a demonstration by the evaluator.

Data Analysis

Video recordings of the tests were used to analyze and score each skill according to the TGMD-2 examiner's manual¹⁶.

Scoring was conducted by three examiners who have demonstrated reliability in both test-retest and inter-rater evaluations. Test-retest reliability was determined using the scores from two assessments performed by the same evaluator on four randomly selected children, which accounted for 21% of the total sample, regardless of their age. Cronbach's alpha coefficients indicated high test-retest reliability (locomotor subtest = 0.997; object control subtest = 0.993). Inter-rater reliability was quantified using the inter-rater agreement index, calculated by dividing the number of concordant ratings between examiners by the total number of ratings, for each subtest and each child¹⁶. The inter-rater agreement index was 79% for the locomotor subtest and 86% for the object control subtest.

Following the assessment of inter-observer reliability, we calculated several measures of motor development, including raw scores and standard scores for locomotion and object control skills. The raw score represents the total number of criteria correctly performed by a child in each subtest. The standard score is the sum of the raw scores for each child across the two subtests. Percentiles were then derived by comparing the sample distribution to the normative data provided in the TGMD-2 examiner's manual¹⁶. Equivalent locomotor age and equivalent object control age were determined for each child from the raw scores of each subtest, following the standards outlined in the TGMD-2 examiner's manual¹⁶. Finally, the gross motor quotient (GMQ) was calculated as the sum of the raw scores from the two subtests. This quotient numerically reflects the child's performance and classifies it as follows: (1) very poor, (2) poor, (3) below average, (4) average, (5) above average, (6) superior, and (7) very superior.

Descriptive analyses (mean, standard deviation, percentage) were used to describe the classifications for each age group. The Shapiro-Wilk test was used to assess data normality, and where necessary, data were transformed using a square root transformation. Paired samples t-tests were then performed on the entire group to investigate differences between chronological age and motor age (locomotor and object control). The group was further divided by age and sex to analyze the potential effects of these factors on the outcome variables. The statistical significance level was set at $p \leq 0.05$ (SPSS, version 17.0).

RESULTS

Table 1 presents the average chronological age, body mass, height, and BMI for each age group (G3, G4, and G5). Based on BMI classification, all children were classified as eutrophic, with the exception of three participants (one from each age group) who were classified as obese: two girls and one boy.

Table 1. Means and standard deviations of chronological age, body mass, height, and body mass index (BMI) for the three-year-old (G3), four-year-old (G4), and five-year-old (G5) age groups.

Age	Chronological Age	Body mass (kg)	Height (cm)	Body Mass Index
G3	3.73 (± 0.23)	15.5 (± 1.86)	98.75 (± 7.63)	16.44 (± 1.50)
G4	4.41 (± 0.23)	16 (± 2.18)	105 (± 5.13)	15.14 (± 1.79)
G5	5.28 (± 0.32)	18.3 (± 4.09)	114.5 (± 3.65)	14.89 (± 1.98)

Table 2 presents the raw and standard scores for the TGMD-2 subtests for children participating in the Developmental PE program.

Table 2. Raw and standard scores for the locomotor and object control subtests for the three-year-old (G3), four-year-old (G4), and five-year-old (G5) age groups

Age	Locomotor subtest		Object control subtest	
	Raw	Standard	Raw	Standard
G3	24.67 (± 7.39)	10.83 (± 2.32)	20.17 (± 0.89)	10.17 (± 1.47)
G4	26.8 (± 6.53)	11 (± 1.22)	22.8 (± 5.97)	9.8 (± 0.3)
G5	39 (± 5.32)	12.63 (± 2.50)	32.25 (± 3.41)	10.88 (± 1.64)
Mean	30.15 (1.04)	11.49 (± 0.69)	25.07 (± 2.54)	10.28 (± 0.73)

Table 3 presents the means and standard deviations of chronological age, locomotor age, and object control age for the entire group of children and for each age group (G3, G4, and G5) separately. For the entire group, locomotor age was significantly higher than chronological age ($t(18) = -2.731$, $p = .014$), as was object control age ($t(18) = -2.731$, $p = .022$). There was no statistically significant difference between chronological age and object control age ($t(18) = -0.795$, $p > .05$).

Table 3. Means and standard deviations of chronological age, equivalent locomotor age, and equivalent object control age for the entire group of

children ($n = 19$) and for each age group: G3 ($n = 6$), G4 ($n = 5$), and G5 ($n = 8$).

Age (years)	Chronological Age	Locomotor Age	Object Control Age
G3	3.7 (± 0.23)	4.0 (± 1.18)	4.0 (± 1.18)
G4	4.1 (± 0.23)	4.4 (± 1)	4.1 (± 1)
G5	5.3 (± 0.32)*	7.3 (± 0.59)	5.7 (± 0.59)*
Mean	4.4 (± 0.78)*	5.5 (± 2.10)	4.7 (± 0.78)*

The comparison between chronological age and locomotor age, and between chronological age and object control age, within each age group revealed the following: Children in the G3 and G4 age groups showed no statistically significant differences between chronological age and locomotor age ($p > .05$), between chronological age and object control age ($p > .05$), or between locomotor age and object control age ($p > .05$). However, children in the G5 group had a significantly higher locomotor age compared to both their chronological age ($t(7) = -1.478$, $p = .013$) and their object control age ($t(7) = -2.575$, $p = .037$). There was no statistically significant difference between chronological age and object control age in the G5 group ($p > .05$).

When the children were divided by sex, boys ($n = 13$) had a significantly higher locomotor age ($M = 5.53$, $SD = 1.87$) compared to their chronological age ($M = 4.42$, $SD = 0.79$; $t(12) = -2.671$, $p = .020$) and compared to their object control age ($M = 4.47$, $SD = 1.27$; $t(12) = -2.379$, $p = .035$). Girls ($n = 6$) showed no statistically significant differences between chronological age ($M = 4.53$, $SD = 0.97$), locomotor age ($M = 5.5$, $SD = 2.70$), and object control age ($M = 4.70$, $SD = 1.33$) ($p > .05$).

Regarding the individual qualitative motor descriptive ratings, results indicated that the majority of children (68%) demonstrated average motor skill performance. The remaining children were classified as having above-average performance (31.6%), specifically within the G3 and G5 age groups, according to the TGMD-2 normative tables.

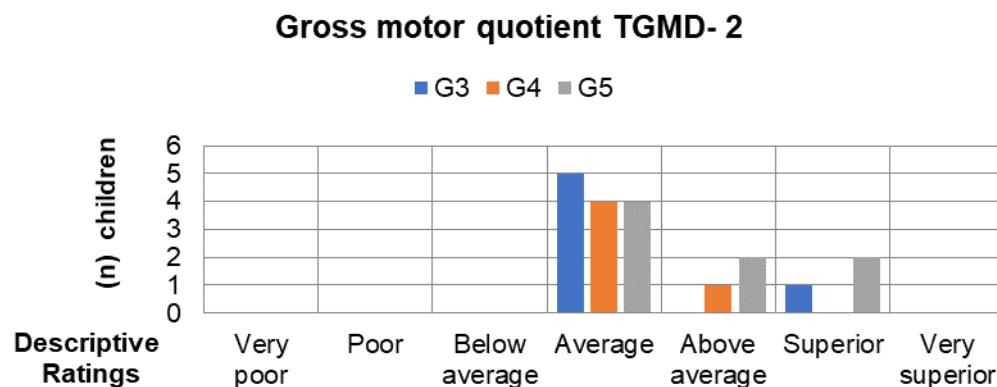


Figure 1. Descriptive ratings of the gross motor quotient (GMQ) for the three-year-old (G3), four-year-old (G4), and five-year-old (G5) age groups.

DISCUSSION

This study investigated the Gross Motor Quotient (GMQ) and motor age of children aged three to five years who participated in a Developmental Physical Education program led by a specialized professional. All participants demonstrated satisfactory motor development, with locomotor and object control motor ages at or above their chronological age. Of the children, 13 (68.42%) received average descriptive ratings, 3 (15.8%) received above-average ratings, and 3 (15.8%) received superior global descriptive ratings.

Our findings regarding the motor profile are consistent with previous studies¹⁸⁻²⁰, which indicate that locomotor age tends to be greater than chronological age and object control age in children. However, when children were categorized by age group and sex, only the five-year-old children demonstrated a locomotor equivalent age exceeding both their chronological age and their object control age. This indicates that children in the G5 group exhibited better motor skill ratings compared to the younger groups, which is expected for their age. Three-year-old children are typically in the initial stage of fundamental motor skill development, while older children have more opportunities to refine their skills and progress to more advanced stages¹⁴.

Additionally, when results were analyzed by sex, only boys had a locomotor equivalent age greater than both their chronological age and their object control equivalent age. Despite the limited sample size, these findings are consistent with other studies indicating that boys aged three to five years tend to demonstrate superior motor performance compared to girls^{21,22}. While these sex-

specific differences were observed, it's important to note that overall, the TGMD-2 assessment revealed that all children demonstrated motor performance classified as average, above-average, or superior, with motor ages equivalent to or exceeding their chronological ages.

Complementary observations concerning the children's anthropometric profile revealed that only three participants were classified as obese (two girls and one boy), while the remaining 16 participants were classified as eutrophic (indicating normal body composition development as indexed by BMI). Notably, the obese children in our study exhibited GMQ scores classified as average or above-average. This finding aligns with previous research suggesting that BMI does not necessarily impair TGMD-2 performance²³.

Limitations

A limitation of this study is the small sample size, particularly when categorizing participants by age and sex. This limited sample size may affect the generalizability of the results. Additionally, although the PE classes consistently encouraged active participation and discouraged inactivity, the physical activities themselves were not fully standardized. Repetitions of motor skills may have varied across classes and among children, potentially influencing outcomes. The study also did not employ a pre-test/post-test design or include a control group. These elements would have provided a more rigorous assessment of the Developmental Physical Education program's effects. Finally, the study did not assess the quantity or quality of physical activity outside of school, which might have influenced the children's motor performance.

CONCLUSION

This descriptive study provides an overview of the motor development of children aged three to five years participating in a systematic and regular Developmental Physical Education program led by a PE teacher. The results indicate that most motor skills were rated as average, with about 31% of the children demonstrating above-average performance for their age group. While these findings suggest a possible positive influence of systematic developmental practices and guidance from a PE teacher, the study's descriptive design precludes establishing causal relationships. Future research using controlled designs is needed to confirm these effects.

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