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Effect of a physical education program in early childhood education on the performance of fundamental movement skills based on teaching styles: divergent discovery and practical

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Abstract

Background and Study Aim Various proposals suggest that Physical Education classes (PE) should prioritize the development of fundamental movement skills (FMS), particularly in preschool children. Despite the crucial nature of mastering FMS, there is a paucity of evidence regarding the impact of PE classes on FMS development. The primary objective of this study is to investigate the effect of a physical education program on the performance of preschool students with varying levels of development in fundamental movement skills, employing divergent discovery and practical teaching styles.

Material and Methods Seventy-seven children (35 boys), aged between 4.5 and 6 years were divided into three groups: Control Group (CG) with 25 participants, Divergent Discovery Group (DDG) with 24 participants, and Practice Group (PG) with 28 participants. The intervention program spanned six months, with two 50-minute classes per week for the experimental groups. Conversely, the control group participated in the Classroom Program proposal. All three groups underwent the TGMD-3 motor test. Performance measurement involved the sum of the raw score in the locomotor and object control classes.

Results The findings revealed that the Control Group, Divergent Discovery Group, and Practice Group exhibited improved FMS performance from pre to post. Concerning intergroup differences, no significant disparities were observed in the pre-test. However, post-intervention results indicated that both the Divergent Discovery Group and Practice Group demonstrated superior FMS performance compared to the Control Group.

Conclusions Physical Education classes for Early Childhood Education play a crucial role in fostering significant effects on children's motor development when offered in an appropriate context and through a systematically structured intervention.

Keywords: children, intervention, fundamental motors skills, TGMD3

Introduction

One of the richest periods in a child's development occurs during preschool. Among several domains of development (e.g., cognitive, social), it is at this stage that children should develop a set of motor skills called fundamental movement skills (FMS) [1]. A fundamental movement skill can be considered a set of movement patterns performed in a coordinated sequence; this sequence takes the form of what we know as running, jumping, throwing, galloping, kicking, among others [2].

In addition to being of great importance for good levels of physical activity during childhood [3] and adolescence [4], FMS is also the basis for acquiring a set of sports skills [5, 6] that the child must develop throughout life. Research worldwide indicates that preschool-aged children perform poorly in the domain of FMS [7, 8]. Considering that low levels of FMS performance can generate a negative cascade effect in several domains of child development [9], it is imperative to create programs that can reverse this scenario. It is already recognized that the improvement in FMS performance levels occurs through encouragement, guidance, and the provision of motor practices appropriate to the needs of children [10, 11].

When we reflect on these conditions, Physical Education classes during the preschool phase seem to be the most appropriate and democratic environment to promote this facet of human development. According to Barela [12], the breadth of motor experiences in early childhood education combined with a relevant curriculum proposal, the quality of the practice, a safe environment, appropriate equipment, and the mediation of a trained teacher (who recognizes and respects the characteristics and needs of children) can represent a unique learning opportunity for the development of FMS.

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In Brazil, there is a great diversity of proposals, namely: the City Curriculum, proposed by São Paulo [13], which brings interactions and games as principles for pedagogical action; the Program proposed by Florianópolis [14], which presents in its curriculum the strategies of the pedagogical action of physical education in early childhood education to the Pedagogical Action Centers (NAPs); the Curriculum Reference Document for Mato Grosso – Early Childhood Education, DRCMT [15], among others. However, few of them were developed with FMS development in mind.

It should be noted here that renowned institutions such as UNESCO [16] and researchers around the world draw attention to the important role of school Physical Education in relation to the motor development of children and young people [9]. Based on this assumption, a curricular proposal in Physical Education that was conceived thinking about favoring the development of FMS in preschool children was created by Ferraz [17]. This proposal in Physical Education was made up of activities that involve the systematic practice of body movement culture, bringing fundamental movement skills as a guiding axis emphasizing the content blocks: 1) Movement: Games Dance (e.g. traditional games from children's culture; rhythmic games). 2) Movement: Capacities, Possibilities, Structure, and Function (e.g., walking, running, and jumping). In addition to the curricular proposal, different teaching styles can enhance or restrict FMS development, especially for preschool children (a phase conducive to the development of FMS) [18]. Although teaching styles are very popular in the teaching of Physical Education, there is little evidence about their benefits for FMS development even when we refer to one of the first teaching styles presented for the area: the Divergent Discovery and Practice teaching style [19, 20].

The Divergent Discovery teaching style allows students to engage in the discovery of new content, develops emotional confidence and the cognitive ability to produce multiple solutions to the same question or to a series of unknown situations, which seek to expand the parameters of the content, beyond what is known and expected. This style allows for ample experimentation by the children, enabling the exploration of movements. The Practice teaching style, on the other hand, develops independent practice of a task. This teaching style allows children a greater degree of decision-making in solving the presented motor problems, providing freedom and flexibility in the learning process. Although the proposal elaborated by Ferraz [17] was conceived thinking about the development of the FMS, it should be considered that there is little incidence of research focused on the effectiveness of these curricular proposals regarding the development of fundamental movement skills [21]. It is also necessary to consider that within the school context there are children with different levels of development in the FMS; that is, one can question the efficiency of the programs in the face of such a heterogeneous population. Considering the nature of the proposal created by Ferraz [17], which favors the development of FMS, and the structure of teaching styles, our hypothesis is that the performance of the experimental groups will be superior to the performance of the control group after the intervention program. Thus, the objective of the present study was to analyze the effect of a physical education program on the performance of preschool students with different levels of development in the fundamental movement skills, based on the styles of teaching Divergent Discovery and Practice.

Materials and Methods

The project was submitted to and approved by the Research Ethics Committee of the School of Physical Education and Sport at the University of São Paulo. Opinion No.: 3.286.717, CAAE - 09647219.4.0000.5391.

Participants

Seventy-seven children (35 boys and 42 girls), aged between 4.5 and 6 years (mean = 5.32; SD = 0.45), and belonging to a Public School of Early Childhood Education in São Paulo – EMEI, participated in this study.

Research Design

Collection Procedure and Materials

The children's data were collected on the premises of the respective EMEI at the beginning of the 2019 school year (late February and early March) over a period of 15 days. Upon receiving the list of students from the classes participating in the project, they were divided, according to the school's convenience, into three different groups: Control Group (CG) (n=25), Experimental Group 1 - Divergent Discovery (DDG) (n=24), and Experimental Group 2 - Practice (PG) (n=28).

The equipment used for data collection included a digital camera (Sony Model HDR-XR150), a tripod, a volleyball, a tennis ball, a plastic racket, a baseball bat, mini cones.

Assessment of Fundamental Movement Skills

The test used to assess FMS was the TGMD-3 proposed by ULRICH [22]. The TGMD-3 allows evaluating 13 FMS, 6 locomotives and 7 object controls. Each of the 13 motor skills includes three to five components, referred to as performance criteria (items), which represent the appropriate movement pattern for each skill. Following protocol guidelines, task instructions were provided by the researcher who demonstrated and provided verbal explanations of each skill to be performed. In this

execution, each student had three attempts: the first to verify the understanding of the skill and the others for analysis. When necessary, the researcher provided an additional demonstration for the child who did not understand the task.

Criteria are pre-established to evaluate children's motor performance. In this way, if the child performs all the criteria correctly, a score of one (1) will be assigned; otherwise, he or she will receive a score of zero (0) for that component. The sum of these performance criteria for each skill (raw score) was the performance measure used in the present study. This measure comprises the raw scores of each subtest being 0–46 points for locomotor skills, and 0–54 for object control skills. The estimated time for applying the test to each child was approximately 15-20 minutes. The three groups were submitted to the TGMD - 3 motor test battery before starting the Physical Education class program, called pre-test, and after the physical education class program, called post-test.

Data Analysis Quality Control

Assessment Procedure

Training was carried out with the researcher according to the indications in the evaluator's manual [22, 23] for data collection and analysis, through the application of the test in a pilot study.

Analysis Procedure

Reliability in video analysis:

All participants were filmed performing the 13 motor skills of the TGMD-3 to later have their performance analyzed with the help of Kinovea 0.9.5 software. Each child received a number (ID) that identified them before and after the intervention period. A video file was saved for each of the 13 skills the child performed. In total, 2444 video files were created. Of these, 260 videos referring to 130 participants (10 in each of the 13 motor skills) were randomly selected and analyzed by two evaluators to assess the inter-evaluator agreement values.

The inter-rater agreement process relied on an evaluator with extensive experience in the motor skills assessment process, having already evaluated approximately 8000 videos in previous research using the TGMD-II test. The second evaluator was the first author of this research. The same children (10 for each skill, 130 in total) were assessed independently by both raters. After evaluating each of the 13 skills, the two evaluators met, and an analysis was performed to verify the percentage of agreement. All discordant components were discussed among the evaluators. If the percentage of agreement was less than 80%, another 10 new children (randomly selected) were evaluated for a new agreement process. When necessary, a third evaluator (also experienced in video analysis using the TGMD-II) was called in to discuss any doubts.

After achieving agreement above 80% in each of the components of the 13 motor skills, a Cohen's K analysis was performed to verify the levels of inter-rater agreement. The results of Cohen's K analysis for inter-rater agreement are found in table 1.

The results found for inter-rater evaluation indicate moderate (Skip) to high (Gallop) results. The same children used to perform inter-rater agreement were reassessed to check for intra-rater agreement. The intra-rater assessment took place one day after the first assessment. As in the inter-evaluator analysis, a concordance analysis was performed and only after reaching values greater than 80%, in each of the components, was the evaluator able to evaluate. A Cohen's K analysis was also performed to estimate the intra-rater agreement values, which are shown in table 2.

Values considered moderate (Run) to high (Hop) were found for both inter and intra-rater agreement levels.

Intervention Program

The teaching methodology presented in the table below (Table 3) exemplifies the structuring of the proposed activities concerning the teaching styles that were adopted for each experimental group. The contents of the systematized classes were structured in equivalence in the DDG and PG and they are presented in Supplementary Material.

The intervention program ran for 6 months, with 2 weekly classes of 50 minutes for the experimental groups. Classes for the experimental groups were taught by a teacher licensed in physical education, with professional experience in both teaching styles

Table 1. Cohen's K values (inter-rater) followed by standard error.

Locomotors	Kappa	Object Control	Kappa
Run	0.65 ± .140	Strike 2 hands	0.57 ± .148
Gallop	0.88 ± .110	Dribble	0.61 ± .141
Skip	0.51 ± .140	Catch	0.75 ± .159
Hop	0.66 ± .149	Kick	0.56 ± .164
Slide	0.64 ± .153	Overhead throw	0.53 ± .170
Horizontal jump	0.67 ± .150	Underhand throw	0.58 ± .139
		Strike 1 hand	0.57 ± .159

Table 2. Cohen's K values (intra-rater) followed by standard error.

Locomotors	Scores	Object Control	Scores
Run	0.61 ± 1.42	Strike 2 hands	0.87 ± 1.78
Gallop	0.91 ± 1.11	Dribble	0.66 ± 1.33
Skip	0.86 ± 1.61	Catch	0.86 ± 1.03
Hop	0.92 ± 1.12	Kick	0.66 ± 1.33
Slide	0.91 ± 1.53	Overhead throw	0.74 ± 1.23
Horizontal jump	0.84 ± 1.22	Underhand throw	0.77 ± 1.21
		Strike 1 hand	0.81 ± 1.82

Table 3. Structuring of teaching styles.

Structure teaching styles	The general objective of the styles	Content blocks for each style	Specificity of content blocks
DIVERGENT DISCOVERY	Expand experimentation, since the student can explore the various possibilities of movement related to the object, games, or proposed motor skills.	Movement: Games, Toys (Movement: Dance, singing circle and mime)	Games based on rules, traditional games from Children's culture, Toys and Games, contests, fights, and Symbolic Games. Different rhythmic structures, singing and dancing circles, mimes, and dramatization.
PRACTICE	Share with the students the execution and evaluation decisions in the class, guiding only what should be done, not how it should be done.	Movement: Capabilities and Possibilities (Movement: structure and function)	Basic motor skills of object control, locomotion, balance and concepts of movement in dimensions. Body parts and what they can do, breathing and heartbeat, state of relaxation and contraction.

Note: Adapted from Ferraz [17]

for early childhood education. The control group, on the other hand, participated in the proposal that encompasses the Classroom Program of EMEI (Municipal School of Early Childhood Education) called: Exploration of Body Language. The proposed activities involved free-time games performed mainly in the park space, 5 days a week, lasting approximately 50 minutes. These classes were offered by the classroom teachers themselves.

Statistical Analysis

An exhaustive analysis was conducted, involving the frequency distribution of participants' performance in each of the 13 motor skills. Verification of possible outliers occurred through graphic representation of extremes and quartiles. The assumption of normal data distribution in all collections was assessed using the Shapiro-Wilk test, which indicated an absence of normality.

Considering the initial results revealing the absence of a normal distribution in performance, the descriptive analysis utilized median (Me) and interquartile ranges (IQ) in addition to non-parametric inferential analyses.

To identify differences between the three groups, both pre and post-intervention, the Kruskall-Wallis test for independent groups was performed. In cases of identified differences, the Mann-Whitney U test was employed and corrected using the Bonferroni method, suitable for non-parametric tests with more than two independent groups [24].

Furthermore, a non-parametric analysis, using the Mann-Whitney U test, was conducted to identify possible differences between genders in locomotor and object control skills across all performance measures.

The Wilcoxon test for repeated measures was employed to investigate the influence of the intervention program on motor skills performance in the three participating groups. A supplementary descriptive analysis illustrated the mean magnitude of change (post-performance – pre-performance) in FMS performance, considering both locomotor skills and object control skills (0-46 points for locomotor skills and 0-54 for ball skills) for the three groups.

Within each group, children were subdivided into three other groups based on their performance in the first collection: group P33, for children who started with performance below the 33rd percentile; group P66, for children who started with performance between the 33rd and 66th percentile; and P99 group, for children with performance above the 66th percentile. The effect size (represented by r) in non-parametric analyses with repeated measures was estimated using the procedure suggested by Field

[24]. The magnitude of effects is usually grouped into three levels: r = 0.10 (small effect); r = 0.30 (medium effect); and r = 0.50 (large effect). All these calculations were performed using the SPSS 25.0 statistical package.

Results

The results will be presented in the following order:

1) Effects of the intervention programs in the two experimental groups and the control group on the sum of locomotor skills;

2) Effects of intervention programs in both experimental groups and the control group on the sum of components of object control skills;

3) Effect of intervention programs on the magnitude of change in children with different performance levels (P33, P66, and P99) in the three groups (CG, DDG, PG).

Effect on the sum of components of locomotor skills

When considering only the raw score of the Fundamental Movement Skills (FMS) in the locomotor class, the results indicate that the Control Group (CG), Divergent Discovery Group (DDG), and Practice Group (PG) show significant differences only after the intervention program (H(2) = 16.560, p < .001); there was no significant difference before the intervention program (H(2) = 1.34, p = .511). Post-program, differences were found only between CG and DDG (H = -17.259, p < 0.05, r = 0.44) and CG and PG (H = -24.476, p < 0.001, r = 0.50). There were no significant differences between DDG and PG (H = -7.217, p = .733).

Wilcoxon analysis indicated a significant change in the performance of locomotor skills for all three groups, namely (Table 4).

In the locomotor class, Mann-Whitney U analysis did not identify significant differences between the performance of boys and girls in any of the groups, neither before (CG, p = .129; DDG, p = .424; PG, p = .734) nor after the intervention program (CG, p = .129; DDG, p = .955; PG, p = .946).

Effect on the sum of Object Control components

The same analysis was performed for the raw score in the FMS of the object control class. The results indicated that Groups CG, DDG and PG showed significant differences before (H (2) = 6.797, p < 0.05) and after (H (2) = 16.604, p < 0.001) the intervention program. Despite the differences found before the program, the *post hoc analysis* did not identify significant differences between Groups CG and DDG (H = - 14.645, p = 0.064), CG and PG (H = - 13.627, p = 0.078) and DDG and PG (H = 1.108, p = 1.0). Significant differences were found only after the program between CG and DDG (H = -21.961, p < 0.05, r = 0.49), CG and PG (H = -22.261, p < 0.001, r = 0 , 49). No significant differences were identified between DDG and PG (H = -.301, p = 1.0).

Wilcoxon analysis indicated a significant change in the performance of object control skills for the three groups (Table 5).

In the object control class, the results indicated significant differences between boys and girls only in DDG after the intervention program (U = 35.500, p < 0.05; r = 0.30) with superior performance for boys. No significant differences were found between boys and girls in the other groups, neither before (CG, p = .907; DDG, p = 0.06; PG, p = .164) nor after the program (CG, p = .978; PG, p = 0.085).

Effects on children with different levels of development

The descriptive analysis illustrates the average magnitude of change within each group, considering the initial performance (prior to the intervention program) in the sum of locomotor skills and object control skills.

Based on the results (Figure 1), it can be observed that despite exhibiting similar performances before the intervention program, the improvement in

Table 4. Median and interquartile range (IQ) before and after the intervention program in locomotor skills.

Groups	Pré-Test	Pos-Test	Z	p	R
Control Group	20.50 (7)	27.50 (8.2)	3.761	0.001	0.53
Divergent Discovery Group	20 (6.5)	31 (3)	4.292	0.001	0.61
Practice Group	21.50 (4.7)	33 (3.7)	4.627	0.001	0.61

Table 5. Median and interquartile range (IQ) before and after the intervention program in object control skills.

Groups	Pré-Test	Pos-Test	Z	Sig	r
Control Group	17 (5.5)	25.5 (5)	4.381	0.001	0.61
Divergent Discovery Group	19 (4.7)	30 (7.7)	4.297	0.001	0.62
Practice Group	19.5 (4.7)	30 (7.5)	4.633	0.001	0.61

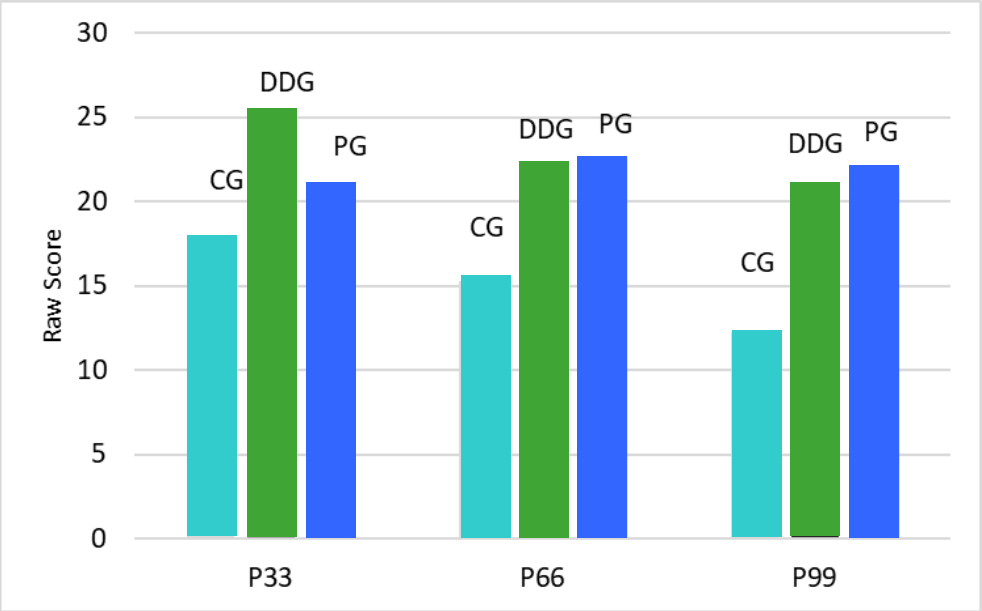

Figure 1. Delta of change from pre- to post-intervention moment for each of the three groups.

average performance was more pronounced in the experimental groups across all three subgroups (P33, P66, and P99). Figure 1 depicts the performance improvement delta within each group concerning the initial performance. Consistent with the previous findings, it can be concluded that the intervention program facilitated greater performance gains among participants in the experimental groups, irrespective of their initial performance levels.

Discussion

The present study aimed to investigate the effect of a physical education program on the performance of preschool students with different levels of development in fundamental movement skills, based on Divergent Discovery and Practical teaching styles.

The results indicated that all groups significantly improved in both locomotor and object control skills. However, the greatest gains occurred for children in the experimental groups. Similar findings were reported in other studies assessing the effects of intervention programs on fundamental movement skills' performance [25, 26]. However, it is worth noting that the present study sought to investigate the effects of a proposed curriculum on the performance of preschool children. In this case, our concern was to test the effectiveness of a proposal that could be easily implemented on a large scale and in different regions of the country.

It is crucial to underscore that the characteristics of the employed teaching styles significantly contributed to the greater gains observed in children from the experimental groups. Specifically, the Divergent Discovery teaching style empowered students to actively explore new content, fostering emotional confidence and cognitive abilities to generate multiple solutions to the same problem or a series of unknown situations [27]. This approach aimed to expand the content parameters beyond what is conventionally known and expected.

In the case of the Divergent Discovery Group, differentiation was achieved through outcome-based strategies. While the same task was assigned to everyone, it was intentionally open-ended, allowing for multiple interpretations. This deliberate design encouraged students to respond differently and produce a variety of outcomes, enhancing their engagement and creativity in the learning process [27].

The Practice teaching style fostered independent task practice, granting children a greater degree of decision-making in solving the presented motor problems and promoting freedom and flexibility in the learning process [28]. In the Practice group, differentiation was implemented through selected tasks, where the teacher predetermined the activities. Children could then engage in practice without altering their trajectory, while receiving valuable feedback from the teacher. This approach aimed to provide a structured yet adaptive learning environment, allowing for personalized development within the established framework [28].

The teacher, responsible for the intervention, provided guidance on movement execution before and during activities, differentiating the teaching styles from more traditional approaches. Both styles facilitated essential factors for improving performance, such as providing adequate opportunities, encouragement, and guidance [18, 26]. These characteristics likely motivated children with varying performance levels to engage actively in class.

The research also aimed to explore the

intervention program's influence on children with different levels of fundamental movement skill development. According to Stodden [29], children with low motor competence tend to avoid activities in which they do not feel competent. In this way, creating motivating content for all students is undoubtedly a challenge faced by Physical Education teachers worldwide.

Descriptive results indicated that the intervention programs led to greater performance gains in fundamental movement skills for children in the experimental groups, regardless of their initial performance. This outcome can be attributed to the encouragement of children to find diverse motor solutions for the same problem within the teaching styles employed. Consequently, even students with lower motor performance felt motivated to practice and actively participate during the intervention.

Despite the descriptive nature of these results, they underscore the importance of intervention programs in Physical Education classes during preschool. First, it is known that the improvement in motor performance produces a cascade effect that promotes improvement in several other domains of human development, ranging from health-related factors [4, 30] to the development of social skills [31].

It should also be noted that, although the control group also improved from pre to post, the difference in the magnitude of change between groups can be a determining factor in the child's future. Research indicates that the gain of one or more components of a skill (for example, trunk rotation during throwing) can directly impact the acquisition of more complex skills, such as sports [5, 6, 32]. According to the results of two of these recent studies, low performance in the FMS can be considered a proficiency barrier that can restrict the acquisition of more complex skills [5, 6], thus impacting the child's future.

The results also revealed that boys and girls performed similarly in all groups, except for the Divergent Discovery Group (DDG) for object control skills, where boys outperformed girls. Several studies indicate that in object control skills, boys perform better than girls [7, 33]. In our study, the difference found in only one group may have some explanations.

It is known that girls have lower performances than boys because they are less encouraged to practice object control skills [7, 25]. In this case, it can be assumed that boys and girls participating in the study received similar opportunities during their preschool years. Regarding the group that showed differences (Practice Group), an extra analysis investigated the percentage of children who practiced sports outside school hours. The results of this analysis indicated that the PG was the group with the highest frequency of boys who practiced sports outside school hours, with 80% of the children. In the other groups, only 10% (6% of the DDG and 4% of the CG) performed sports, which may explain the difference only in this group.

Overall, the results substantiate the hypothesis of the present study, demonstrating that positive changes in motor development can be realized through a conducive environment enriched with materials for the development of fundamental movement skills. Additionally, the findings support the efficacy of a proposed intervention planned and tailored to address the actual needs and motor demands of the targeted age group. This alignment between the intervention and the age-specific requirements underscores the significance of intervention programs.

Despite the favorable results, the present study has limitations, such as the sample size. Although our effect size analysis considers the sample size and our choice for a smaller sample size was made to approximate the reality of Physical Education teachers (e.g., class time and number of students per class), it is suggested that future studies test the effects of teaching styles in larger samples.

Finally, the results found corroborate the studies already established and stimulate us to reflect on the need to align structured programs, which establish objectives, adequate content, organization, implementation of methodological strategies in favor of the development of motor skills together with a careful evaluation of the teaching-learning process. In this scenario, the physical education teacher equipped with appropriate pedagogical proposals can be the key element for children to develop their full potential.

Conclusions

The results found in the present study reinforce the great importance of planning the physical education curriculum for early childhood education, aiming at engaging children in pleasurable activities and valuable experiences. In this sense, we understand that Physical Education classes for preschool using both teaching styles (Divergent Discovery and Practice) is an interesting strategy to help them discover and realize their full motor potential. In addition, this strategy reinforces the essential role of the teacher in the process of learning and developing fundamental movement skills. It is recommended that future studies explore the effects of teaching styles in larger sample sizes and among older children. This approach will contribute to a more comprehensive understanding of the influence of teaching styles on motor development.

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