Sintra grows healthy: examining the impact of professional development and co-teaching in Physical Education on primary students' motor competence

Sintra crece saludable: impacto del desarrollo profesional y la co-enseñanza en Educación Física sobre la competencia motriz en primaria

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Abstract

Introduction: Motor competence is a fundamental component of children's physical development, influencing lifelong physical activity and overall health. Schools play a key role in fostering motor competence through physical education; however, evidence on effective instructional models remains scarce, particularly at the primary school level in Portugal.
Objective: This study evaluated the impact of a professional development program for generalist primary school teachers, with and without co-teaching involving specialist physical education teachers, on students' basic motor competencies.
Methodology: This quasi-experimental study involved 26 teachers and 220 students, assigned to three groups: professional development plus co-teaching, professional development only, and a control group. The intervention included a 25-hour accredited program and eight weeks of physical education co-teaching. Students' motor competence was assessed pre- and post-intervention using the MOBAK test battery. Results were analyzed using repeated measures ANOVA. Propensity score matching was applied to improve group comparability.
Results: All groups demonstrated significant improvements in motor competence. No additional benefits were observed for the intervention groups compared to the control.
Discussion: The COVID-19 pandemic disrupted the study timeline, delaying the start and shortening the intervention period, which may have influenced its impact. While professional development and co-teaching remain promising strategies, the non-randomized design and variability in implementation may have influenced the outcomes.
Conclusions: This study provides early evidence on the implementation of co-teaching in primary physical education settings in Portugal. Future research should systematically compare co-teaching with other instructional models, incorporate process control, and include follow-up assessments to determine effective, sustainable approaches for improving motor competence and informing educational policy and practice.

Keywords

Co-teaching; motor competence; Physical Education; teacher professional development.

Resumen

Introducción: La competencia motriz es clave en el desarrollo físico infantil, influyendo en la actividad física y la salud. Las escuelas desempeñan un papel fundamental en su desarrollo mediante la educación física, pero la evidencia sobre modelos de enseñanza efectivos siendo limitada, especialmente en el nivel de primaria en Portugal.
Objetivo: Este estudio evaluó el impacto de un programa de desarrollo profesional para maestros generalistas de primaria, con y sin co-enseñanza con especialistas en educación física, en la competencia motriz básica de los estudiantes.
Metodología: Se realizó un estudio cuasiexperimental con 26 docentes y 220 estudiantes, asignados a tres grupos: desarrollo profesional más co-enseñanza, solo desarrollo profesional y un grupo de control. La intervención incluyó un programa acreditado de 25 horas y ocho semanas de co-enseñanza. La competencia motriz se evaluó antes y después con la batería MOBAK. Los resultados se analizaron mediante ANOVA de medidas repetidas. Se aplicó emparejamiento por puntaje de propensión para mejorar la comparabilidad.
Resultados: Todos los grupos mejoraron significativamente su competencia motriz. No se encontraron beneficios adicionales en los grupos de intervención.
Discusión: La pandemia de COVID-19 acortó la intervención, lo que pudo haber influido en su impacto. La variabilidad en la implementación y el diseño no aleatorizado también pudieron afectar los resultados.
Conclusiones: Este estudio aporta evidencia inicial sobre la implementación de la co-enseñanza en educación física primaria en Portugal. Futuros estudios deberían comparar sistemáticamente la co-enseñanza con otros modelos instruccionales, incorporar control de proceso e incluir evaluaciones de seguimiento para identificar enfoques eficaces y sostenibles que mejoren la competencia motriz e informen políticas y prácticas educativas.

Palabras clave

Co-enseñanza; competencia motriz; desarrollo profesional docente; Educación Física.

Introduction

Movement is fundamental to human life, and childhood represents the most critical period for developing motor competence—an individual's ability to perform a wide range of motor skills. Progress during this stage influences one's lifelong trajectory of health and physical activity (Goodway et al., 2021; Stodden et al., 2009), supports numerous health outcomes (Burton et al., 2023; Cattuzzo et al., 2016), and is likely associated with social-emotional development, academic performance, and executive functions (P. J. Hill et al., 2023). Motor competence is teachable (Hardy et al., 2013; Morgan et al., 2013), and its development is shaped by the social and physical environment (Venetsanou & Kambas, 2010), positioning schools as essential settings for motor development (Herrmann, Seelig, et al., 2019). This understanding is formally recognized in the definitions of quality physical education (European Commission, 2015; UNESCO, 2015). However, despite this consensus, research shows that the progression of motor competence tends to slow between early and middle childhood relative to age-related expectations (Bolger et al., 2020). Understanding why this is the case requires close attention to how physical education is delivered in schools and under what conditions it supports meaningful motor development.

There are different models for delivering physical education in primary schools, each with its own complexities. In many education systems, generalist teachers are responsible for all curricular areas (Hardman et al., 2014) but often receive minimal preparation for teaching physical education and limited professional development opportunities (Carney & Winkler, 2008; Petrie & Hunter, 2011). While their comprehensive understanding of students may be beneficial (Petrie, 2011; Talbot, 2008), many lack the confidence, content knowledge, and pedagogical skills necessary for effective instruction (Tsangaridou, 2012). Hiring specialist physical education teachers, a common practice in secondary schools, can enhance outcomes, but may present integration challenges in primary settings (Brooks & Dinan Thompson, 2013). The external provider approach, although feasible in some contexts (Petrie et al., 2014), relies heavily on funding (Powell, 2014) and may raise concerns regarding pedagogical qualifications (Lavin et al., 2008). Mixed co-teaching models, such as pairing a generalist teacher with a sports coach or a specialist physical education teacher, have demonstrated potential in overcoming these challenges and enhancing the quality of physical education (Jones & Green, 2015), particularly when backed by ongoing professional development (Jess et al., 2017; Lander et al., 2016).

Portugal represents a system where generalist teachers oversee all curricular areas in primary school (grades 1-4), including physical education. However, the delivery varies significantly across schools, featuring different models of specialist involvement that lack a systematic structure or evidence-based rationale (Neves, 2019). While the 2018 legislation (Decreto-Lei n.o 54/2018, 2018) formally introduced co-teaching—allowing for collaboration between generalist teachers and specialist physical education teachers—robust local evidence on the effectiveness of this model, compared to the traditional generalist-only approach, remains absent. Clarifying the impact of these approaches on student development is essential for guiding informed political and pedagogical decisions at the national, local, and school levels (Dudley et al., 2022).

The "Sintra Grows Healthy" is a community-based participatory research project in the Municipality of Sintra that involves partnerships between municipal authorities, schools, health organizations, and academic institutions (Ferreira et al., 2020). It aims to develop and evaluate an evidence-based, sustainable intervention model that promotes children's health-related quality of life, fosters healthy eating and regular physical activity, enhances social-emotional skills, and helps prevent childhood obesity. As part of the "Sintra Grows Healthy" school-based intervention, this study investigates the impact of a professional development program, designed to improve the quality of physical education instruction by generalist primary school teachers, on students' basic motor competencies. Additionally, it evaluates whether incorporating co-teaching can enhance professional development in physical education, providing valuable evidence to inform policy and practice.

Method

Study design and procedures

This study utilized a pragmatic quasi-experimental design with three arms during the 2020–2021 school year. Generalist primary school teachers were assigned to one of three conditions based on their school's capacity for implementing co-teaching and availability for enrollment in the professional development program: the first group received a 25-hour professional development program, followed by approximately eight weeks of co-teaching with a specialist physical education teacher (PD+CT group); the second group received the same program without co-teaching (PD group); and the third group continued with their usual physical education practices without any intervention (control group). Students taught by participating teachers were assessed for basic motor competencies at baseline (November/December 2020) and post-intervention (June 2021). Due to COVID-19-related school closures between January and March 2021, the co-teaching phase was delayed and shortened, ultimately taking place between April and May 2021. This study adhered to the Declaration of Helsinki. It was approved by the Ethics Committee of the Faculty of Medicine, University of Lisbon (no. 401/17) and the Faculty of Human Kinetics, University of Lisbon (no. 28/2020).

Participants

Two public school clusters in the municipality of Sintra, Portugal, were selected through a pragmatic, non-random process based on their administrative agreement to participate. One cluster was designated for the intervention, depending on the feasibility of implementing co-teaching (i.e., the availability of a qualified physical education specialist and compatible scheduling). After confirming each school's availability for the academic year, all primary teachers at those schools were invited to participate. Eligible generalist teachers were required to be full-time teachers. Students taught by the participating teachers were then recruited. All students enrolled in these classes were eligible. Inclusion required written informed parental consent and child assent. The second cluster served as the control group, with teacher and student recruitment adhering to the same ethical procedures.

Intervention components

Professional Development Program

The program, entitled "Quality of Physical Education for Promoting Health and Active Lifestyles in Primary School Children – The Importance of Motor Competence," was designed to enhance the quality of primary physical education instruction, with a particular focus on teaching, assessing, and fostering students' basic motor competencies. It was delivered separately to the PD+CT and PD groups by four university teacher education professors specializing in physical education didactics, physical literacy, and physical activity promotion. Among them, one had 40 years of professional experience, another had 25 years, and two had 15 years. The program consisted of four sessions—three conducted online due to COVID-19 restrictions and one in person—with a total duration of 25 hours, including 12.5 hours of direct instruction and 12.5 hours of autonomous work. The program content covered theoretical and practical aspects of motor skill development, assessment methods such as the MOBAK test battery, and strategies for implementing evidence-based practices in the physical education curriculum. Officially accredited, the program contributed to teachers' career progression upon successful completion.

Co-teaching

Generalist teachers were engaged in a co-teaching arrangement with a specialist physical education teacher from the same school. Each specialist had over 10 years of professional experience. To document the implementation of co-teaching, participating teachers were asked to provide reflective reports detailing their collaboration with specialist physical education teachers. The intended model involved specialists working alongside generalist teachers in physical education classes (one per week), offering real-time instructional support, modelling effective strategies, and reinforcing content from the professional development program. However, as the teachers' reports reflected, the implementation varied across schools. Some teachers reported consistent co-teaching, with both educators actively planning and delivering lessons, fostering shared instructional responsibility. One teacher noted, "The collaboration was frequent and beneficial, ensuring all procedures were followed together, leading to a very productive working method." Others experienced irregular support, with co-teaching occurring

only in selected sessions. As one teacher described, "The presence of the specialist teacher was irregular, which made it difficult to maintain a consistent line of collaborative work." Additionally, the dynamics of collaboration differed, with some generalist teachers taking a more active instructional role, while others relied more on the specialist. One teacher shared, "I felt more confident in trying new strategies and taking a more active role in leading the lesson because I had the specialist's support if needed." Conversely, another remarked, "Since this is their area of expertise, they will always be the most suitable to guide certain tasks."

Measurements

Sociodemographic data

Prior to the initial assessment of basic motor competencies, legal guardians completed a questionnaire to provide general information about the students, including their age, sex, and grade level.

Physical activity

Accelerometer-based physical activity assessment was not feasible in this study due to logistical and practical constraints. While parent-reported measures are generally considered less valid for assessing children's physical activity levels (Sirard & Pate, 2001), some researchers suggest they can provide a reasonable estimate of activity-related behaviors and correlates (Dowda et al., 2007) and serve as a practical, cost-effective alternative in large-scale studies (Chaumeton et al., 2011). To enhance validity, parents or legal guardians were asked to report objective information about their child's participation in structured physical activity. Specifically, legal guardians provided details on: 1) Participation in school physical education classes, including frequency (times per week) and average session duration; 2) Engagement in extracurricular physical activities, including frequency (times per week) and average session duration. The total weekly time spent in organized physical activity was calculated by summing the reported minutes from physical education classes and extracurricular activities.

Additionally, perceived physical activity was assessed using a single parent-reported question: "Overall, considering the physical activity your child engages in at school and outside of school, how would you rate their activity level?" (5-point Likert scale, ranging from inactive to very active). This measure has been previously used in local research (Carreiro da Costa & Marques, 2011) and provides an accessible way to capture overall activity patterns while minimizing respondent burden.

Anthropometric measures

Students' height and body mass were measured by trained researchers using a stadiometer with a vertical stop and a movable headpiece (SECA, model 213) and a portable electronic scale (SECA, model 813), with a precision of 0.1 cm and 0.1 kg, respectively. Measurements were taken with students wearing light clothing and without shoes or socks. Participants were instructed to stand upright, remain motionless, keep their head level, and extend their arms naturally alongside their body. BMI was calculated by dividing body mass (kg) by height squared (m^2). BMI-for-age Z-scores were calculated by comparing each student's BMI to age- and sex-specific reference values from the WHO Child Growth Standards (World Health Organization, 2006). The results were then classified into weight status categories according to WHO criteria.

Basic motor competencies

Students' basic motor competencies were assessed using the MOBAK test battery (Herrmann et al., 2015; Herrmann & Seelig, 2016). Two versions were used according to grade level: MOBAK 1–2 for first and second graders, and MOBAK 3–4 for third and fourth graders. MOBAK evaluates two domains: object control (throwing, catching, bouncing, dribbling) and self-movement (balancing, rolling, jumping, running). Each domain includes four tasks, each scored from 0 to 2 points. The total score ranges from 0 to 16, with a higher score indicating greater motor competence. The assessments were performed by two experienced researchers and 14 trained sports technicians. The technicians completed a 12.5-hour training program to ensure consistent and reliable administration of the MOBAK procedures. Reliability checks showed strong inter- and intra-observer agreement, with a mean reliability score of 86.58% (CI: 83.15–90.06%). Intra-observer reliability was assessed in two rounds, with response intervals ranging from 2 to 6 days, as technicians completed the tasks independently within the designated time.

Data management and analysis

All assessment and questionnaire data were initially recorded on paper forms and later transferred to digital databases. Quality control procedures were implemented to ensure the accuracy and completeness of the data. Access to the data was restricted to authorized research team members, with rigorous measures in place to protect participant confidentiality throughout the study. The dataset was screened and pre-processed, retaining only students with complete MOBAK assessments at both baseline and post-intervention time points for analysis.

Preliminary analysis revealed significant differences in students' baseline MOBAK scores between the PD+CT and other groups. Given the non-randomized design of the study, these disparities suggested the presence of selection bias (Sterne et al., 2019). For example, teachers with prior co-teaching experience or schools with the necessary resources to support co-teaching may have been more likely to participate in the PD+CT group.

To address potential bias, propensity score matching was performed (Bergstra et al., 2019; Spreeuwenberg et al., 2010). A regression analysis using the MOBAK score as the dependent variable identified pre-intervention covariates ($p < 0.05$), which were included in the logistic regression model to estimate propensity scores (baseline MOBAK, sex, and perceived physical activity level). Following the guidelines (Bergstra et al., 2019; Rassen et al., 2013) and recent practice (Shurrab et al., 2023), pairwise nearest-neighbor matching without replacement was conducted. Each student in the PD+CT group was matched with a corresponding student from the PD group based on their propensity score. Students in the resulting PD+CT and PD groups were matched with students from the control group. An initial caliper tolerance of 0.2 was adjusted to 0.1 to achieve absolute standardized differences of <10% for all covariates (Austin, 2011). The propensity score matching process was conducted using SPSS version 30.

Descriptive statistics, including means, standard deviations, and frequencies, were calculated for all variables. Baseline comparisons of student characteristics across the three groups were conducted using Chi-square tests for categorical variables and one-way ANOVA for continuous variables. To assess the intervention's effects on students' basic motor competencies and evaluate within-group changes over time, a repeated measures ANOVA was conducted, including sex and perceived physical activity level as covariates, consistent with their use in the cohort construction process. All statistical analyses were conducted using SPSS version 30, with a significance level set at $p < 0.05$.

Results

The initial sample consisted of 26 teachers (control: 15; PD: 7; PD+CT: 4) and 220 students (control: n = 104; PD: n = 64; PD+CT: n = 52). Preliminary analysis identified significant baseline differences across groups in MOBAK scores ($p < 0.001$), age ($p < 0.001$), grade ($p < 0.001$), and participation in extracurricular physical activity ($p = 0.006$). To improve group comparability, propensity score matching was applied as described in the method section. This resulted in a final matched sample of 96 students (control: n = 48; PD: n = 24; PD+CT: n = 24) while retaining all 26 teachers (control: 15; PD: 7; PD+CT: 4). Matching significantly reduced absolute standardized differences in baseline MOBAK scores: PD+CT vs. PD decreased from 78% to 8%; PD+CT vs. control from 104% to 7%; and PD vs. control from 26% to 9%.

Table 1 summarizes the baseline characteristics of students across the control, PD, and PD+CT groups. Students in the PD+CT group were, on average, 0.56 years younger than those in the control group (95% CI [-1.17, -0.10], $p < 0.05$). Significant differences were also observed in physical activity variables. The PD+CT group reported, on average, 1.75 more days per week with over 1 hour of physical activity compared to the PD group (95% CI [0.94, 2.56], $p < 0.001$) and 0.74 more days compared to the control group (95% CI [0.03, 1.46], $p = 0.041$). The PD group reported 1 day fewer, on average, than the control group (95% CI [-1.72, -0.29], $p = 0.006$). Additionally, the PD+CT group had significantly higher participation in extracurricular physical activity compared to both the PD and control groups ($p = 0.01$).

Table 1. Baseline characteristics of students across groups

	Overall (n = 96)	PD+CT (n = 24)	PD (n = 24)	Control (n = 48)	p-value
Age (years)	7.07 ± 1.18	6.63 ± 0.65	7.26 ± 1.63	7.21 ± 1.10	.096
Grade					<.001
First	41 (41.7%)	9 (37.5%)	13 (54.2%)	19 (39.6%)	
Second	24 (25.0%)	15 (62.5%)	0 (0.0%)	9 (18.8%)	
Third	19 (19.8%)	0 (0.0%)	4 (16.7%)	15 (31.3%)	
Fourth	12 (12.5%)	7 (29.2%)	7 (29.2%)	5 (10.4%)	
Sex					.715
Girls	52 (54.2%)	12 (50%)	12 (50%)	28 (58.3%)	
Boys	44 (45.8%)	12 (50%)	12 (50%)	20 (41.7%)	
Weight status					.248
Underweight	1 (1.1%)	1 (4.2%)	0 (0.0%)	0 (0.0%)	
Normal weight	57 (60.6%)	12 (50%)	13 (56.5%)	32 (68.1%)	
Overweight	25 (26.6%)	7 (29.2%)	9 (39.1%)	9 (19.1%)	
Obesity	11 (11,7%)	4 (16.7%)	1 (4.3%)	6 (12.8%)	
Total organized physical activity (min/week)	191.95 ± 136.39	159.65 ± 89.56	245.88 ± 228.61	187.49 ± 97.87	.136
Perceived physical activity level					.910
Inactive	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	
Insufficiently active	10 (10.4%)	3 (12.5%)	2 (8.3%)	5 (10.4%)	
Sufficiently active	49 (51.0%)	12 (50%)	15 (62.5%)	22 (45.8%)	
Active	27 (28.1%)	15 (62.5)	5 (20.8%)	15 (31.3%)	
Very active	10 (10.4%)	2 (8.3%)	2 (8.3%)	6 (12.5%)	
Physical education classes [a]	64 (78.0%)	17 (81.0%)	17 (85.0%)	30 (73.2%)	.539
Extracurricular physical activity [a]	41 (44.1%)	16 (69.6%)	8 (33.3%)	17 (37.0%)	.017

Note: Continuous data were analyzed with ANOVA and are presented as mean value with standard deviation; categorical data were analyzed with Chi-square and are presented as number (%); [a] reflects the number and percentage of participants answering "yes" to this question.

As anticipated from the regression analysis conducted before propensity score matching, baseline MOBAK scores differed significantly by sex and perceived physical activity levels (Table 2). Boys scored, on average, 2.397 points higher than girls (95% CI [1.62, 3.17], $p < 0.001$). Higher perceived levels of physical activity were consistently associated with better motor competence in both boys and girls. Students classified as very active, active, or sufficiently active outperformed those in the insufficiently active category ($p = 0.003$, $p = 0.004$, and $p = 0.013$, respectively).

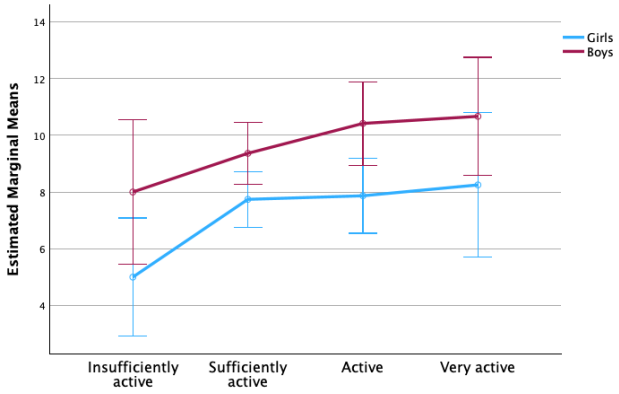
Table 2. Baseline MOBAK scores across sex and physical activity levels

	Overall (n = 96)	Boys (n = 44)	Girls (n = 52)	*p*-value	*Post hoc* LSD test
Baseline MOBAK Score	8.51 ± 2.84	9.70 ± 2.66	7.50 ± 2.59	<.001	Boys > girls
Perceived physical activity level				<.001	
Insufficiently active	6.20 ± 2.70	8.00 ± 2.16	5.00 ± 2.45		
Sufficiently active	8.47 ± 2.48	9.36 ± 2.32	7.74 ± 2.39		Boys > girls
Active	9.00 ± 3.21	10.42 ± 3.40	7.87 ± 2.64		Boys > girls
Very active	9.70 ± 2.63	10.67 ± 2.25	8.25 ± 2.75		

Note: Data were analyzed with ANOVA and are presented as mean values with standard deviation.

Within specific physical activity levels, boys consistently outperformed girls: significant differences were observed in the sufficiently active (95% CI [0.16, 3.09], $p = 0.030$) and active (95% CI [0.57, 4.52], $p = 0.012$) categories. Figure 1 provides a visual representation of these patterns across sex and activity levels.

Figure 1. Baseline MOBAK scores by sex across perceived physical activity level



Note. Data were analyzed with ANOVA; Error bars: 95% CI.

A repeated measures ANOVA was performed to evaluate the effects of the intervention on students' basic motor competencies across the three groups (control, PD, and PD+CT). Results indicated a significant improvement in MOBAK scores over time across all groups ($F(1,91) = 11.529$, $p = 0.001$), with an average increase of 2.69 points (95% CI [2.17, 3.19], $p < 0.001$) (Table 3). However, there were no significant effects of group ($F(2,91) = 0.285$, $p = 0.752$), sex ($F(1,91) = 0.52$, $p = 0.820$), or perceived physical activity level ($F(1,91) = 1.599$, $p = 0.209$) on intervention outcomes. No significant interaction effects were observed between time and group, suggesting that the magnitude of improvement over time was similar across all groups. Similarly, no interaction effects were identified between time and sex, or time and perceived physical activity level.

Table 3. Pre- and Post-Intervention MOBAK scores

	n	MOBAK Pre-	MOBAK Post-	Mean difference [CI 95%]	*p*-value
Overall	96	8.51 ± 2.83	11.19 ± 2.96	-2.69 [-3.19, -2.17]	<.001
PD+CT	24	8.71 ± 2.98	11.67 ± 2.66	-2.94 [-3.91, -1.99]	<.001
PD	24	8.45 ± 2.57	10.92 ± 2.90	-2.48 [-3.39, -1.46]	<.001
Control	48	8.46 ± 2.93	11.31 ± 3.15	-2.67 [-3.35, -1.99]	<.001

Note. Data were analyzed with Repeated Measures ANOVA and are presented as mean value with standard deviation.

Discussion

Motor competence is a critical factor in children's development, influencing future physical activity participation and health trajectories (Goodway et al., 2021) and is a key feature of quality physical education (European Commission, 2015; UNESCO, 2015). Professional development for generalist primary school teachers has been proposed as a strategy to enhance physical education (Jess et al., 2017). Co-teaching models, where generalist and specialist teachers collaborate, have demonstrated success in improving academic achievements across various domains (Helding Vembye et al., 2023). However, evidence on the effectiveness of these approaches in Portugal is limited, and their impact on promoting motor competence in primary school students remains unclear. This study aimed to address this gap by examining the impact of a professional development program, implemented with and without a co-teaching component, on the motor competence of primary school students. While all groups showed significant improvements in motor competence over the school year, no significant differences were observed between the intervention groups (PD and PD+CT) and the control group. These results align with the understanding that motor competence naturally improves with time, but they also raise important questions about the effectiveness of the implemented intervention. To better interpret these findings, this discussion explores the key correlates of motor competence observed in this study, examines potential explanations for the lack of differential intervention effects, and outlines important study limitations, future research directions, and practical implications.

Correlates of basic motor competencies

Basic motor competencies were assessed using the MOBAK test battery 1-2 and 3-4 (Herrmann et al., 2015; Herrmann & Seelig, 2016). The theoretical model proposed by Stodden et al. (2008) suggests an interrelationship between motor skills, physical fitness, and physical activity levels, with motor skill development as a critical mechanism for promoting engagement in physical activity. Numerous studies employing the MOBAK battery confirm these relationships, highlighting associations between basic motor competencies and factors such as physical fitness (Legarra-Gorgoñon et al., 2023), physical activity levels (Mücke et al., 2021), participation in extracurricular activities (Carvalho et al., 2024; Wälti et al., 2022), physical activity frequency and type (Herrmann & Seelig, 2017), and weight status (Carvalho et al., 2024; Herrmann, Heim, et al., 2019; Monacis et al., 2024).

Consistent with prior research, our study found that higher perceived levels of physical activity were associated with higher motor competence. However, contrary to expectations, physical activity variables, such as total organized physical activity and extracurricular physical activity, did not show significant correlations with MOBAK scores. These discrepancies warrant closer examination. One potential explanation lies in the reliance on parent-reported data for physical activity variables. The extensive questionnaire used in the "Sintra Grows Healthy" project included numerous detailed questions spanning health, behavior, and quality-of-life domains. This complexity may have increased the cognitive burden on respondents (Rolstad et al., 2011), reducing the precision of reported physical activity details. In contrast, the perceived physical activity measure—a more straightforward categorical question—may have been easier for parents or legal guardians to answer accurately, aligning more closely with their intuitive assessments of their child's overall engagement in physical activities. Nevertheless, while the measure has been employed in previous local studies (Carreiro da Costa & Marques, 2011; C. Lopes et al., 2017), there is insufficient evidence to establish its validity.

Another factor to consider is whether the reported physical activities specifically targeted the skills assessed by MOBAK, such as throwing or balancing. While general physical activity is broadly linked to motor competence, skill-specific practices may have a more direct impact on MOBAK scores. Additional analyses could further explore potential correlations between specific MOBAK domains and physical activity variables. For instance, one study indicated that children who engage in physical activity for at least 30 minutes on four or more days per week perform significantly better in self-movement tasks but not necessarily in object-movement tasks (Walter et al., 2024). Similarly, in another study, the frequency of team sports participation was more strongly correlated with object movement, while individual sports showed a closer relationship to self-movement (Strotmeyer et al., 2020).

Context also appears to play a significant role. An international study covering ten European countries found that movement competency levels vary depending on location and are strongly influenced by participation in extracurricular physical activity, although not all samples showed significant correlations (Wälti et al., 2022). These findings highlight the importance of considering local contexts and suggest a need for further region-specific research to validate and expand upon the present study's results.

Intervention effects

The significant improvement in MOBAK scores across all groups over the school year aligns with existing literature, which suggests that children's motor competence naturally evolves through growth, maturation, and regular exposure to physical activity opportunities (Berk, 2006). Studies have demonstrated that even without targeted interventions, children experience notable improvements in motor skills as they develop (Legarra-Gorgoñon et al., 2024). However, the absence of significant differences between the intervention groups and the control group raises critical questions about the effectiveness of the implemented professional development program and co-teaching arrangements. The lack of group effects suggests that the intervention did not add measurable value beyond the natural developmental trajectory of the children.

The most plausible explanation for these findings is likely rooted in logistical challenges, particularly the delayed and shortened duration of the intervention. Due to the COVID-19 lockdown from January to March 2021, teachers had only April and May to implement the strategies learned during the professional development program. While evidence suggests that even short-term motor skill interventions (4–8 weeks) can effectively improve fundamental movement skills (L. Lopes et al., 2021),

the 4–5 month gap between the baseline MOBAK assessments and the start of the intervention in this study likely diluted its measurable effects. During this period, natural developmental progression, combined with the relatively short two-month intervention, may have led to improvements in motor competence that were indistinguishable from those arising purely from maturation. Furthermore, the gap between the professional development program and its practical application may have weakened its impact, as teachers lacked opportunities to apply the material directly after completing the training (Villegas-Reimers, 2003).

Co-teaching, hypothesized to amplify the effects of the professional development program, faced additional challenges. The research underscores that the success of co-teaching in physical education depends on sustained collaboration, clearly defined roles, and the consistent implementation of shared strategies (Flintoff, 2003)—conditions that are difficult to achieve within a short timeframe. Some researchers argue that co-teaching requires at least a year to be effective, as it is a developmental approach demanding time for co-teachers to adapt, establish trust, and refine their practices (Friend, cited in Helding Vembye, 2024).

Beyond time constraints, variability in co-teaching implementation likely influenced outcomes, as not all co-teaching arrangements fostered the intended active exchange of instructional strategies. Reports from participating teachers indicated diverse approaches to collaboration, ranging from fully integrated lesson planning and delivery to more sporadic involvement of the specialist physical education teacher. The Escola Ativa e Literacia Física para a Vida guide (Martins et al., 2022), developed as part of the "Sintra Grows Healthy" project, outlines several structured co-teaching models that can inform future implementations. These models range from highly interactive methods, such as interactive teaching, where both teachers actively lead instruction, to supportive models, such as one teaching, one assisting, where one teacher manages the lesson while the other provides individualized support. Other models, such as parallel teaching and alternative teaching, allow for differentiated instruction by dividing responsibilities in ways that maximize student engagement and individualized feedback. However, in the current study, co-teaching implementation was not systematically controlled, and the lack of process monitoring prevents a clear assessment of which models were adopted. Future research should address this limitation by incorporating structured implementation protocols and monitoring procedures.

Implementation fidelity—the extent to which an intervention is delivered as intended—is recognized as a critical factor in determining program success (H. C. Hill & Erickson, 2019). Ensuring structural fidelity (the consistent delivery of planned intervention components) and process fidelity (accurate execution of the intervention in practice) in future studies is essential for maximizing intervention reliability. Future research should incorporate case studies to examine how different co-teaching models function in real-world school settings. Identifying the most effective strategies and the conditions under which they succeed can provide valuable insights for refining professional development initiatives and optimizing co-teaching practices in primary physical education.

The limited impact of the intervention may also be understood in the broader context of the COVID-19 pandemic, which severely disrupted educational routines and physical activity patterns among children in Portugal. Studies conducted during this period highlight deprioritization of physical education, reduced instructional time, and difficulties in maintaining a pedagogical continuity (Resende et al., 2020). The closure of schools and cancellation of extracurricular sports, combined with restrictions on outdoor mobility, not only reduced opportunities for structured movement but also negatively affected children's motivation and psychosocial well-being (Mendes et al., 2023). These factors likely influenced students' engagement and their motor competence development. In this light, the pandemic may have exacerbated pre-existing challenges in primary physical education, limiting the potential for short-term interventions to yield measurable gains.

Implications for practice and policy in Portugal

Low and declining physical activity levels among Portuguese youth continue to be a persistent public health concern (Pizarro et al., 2023). The transition from primary to middle school marks a particularly vulnerable period, with significant drops in activity levels often observed during this stage (Martins et al., 2019). These trends emphasize the vital need for early, consistent, and high-quality physical education in primary schools to foster lifelong participation in physical activity.

Although physical education is mandatory across all grade levels in Portugal, its implementation in primary schools is inconsistent, and it is typically led by generalist teachers with minimal and varying preparation in the subject (Neves, 2019). Research and teacher training in physical education in Portugal have traditionally focused on the post-primary level (Onofre et al., 2023). In response, recent efforts have produced resource manuals and pedagogical guidelines to support these teachers (Maia et al., 2023; Martins et al., 2022). However, these initiatives have not been systematically evaluated, and their practical impact remains unclear. The disconnect between curriculum intentions and classroom realities has been documented for nearly two decades (Neves, 2007, 2019, 2024), with persistent concerns that primary physical education practice does not meet student needs or expectations.

This study provides an initial empirical examination of a co-teaching model in Portuguese primary physical education, embedded in a real-world municipal initiative. It demonstrates that co-teaching between generalist and specialist teachers is practical and logistically feasible when supported by local partnerships. This finding strengthens the case for co-teaching as a scalable and context-sensitive strategy to enhance instructional quality, particularly in settings where specialist availability is limited.

From a policy perspective, these findings underscore the urgent need for sustained structural support. Investing in evidence-based strategies could help bridge the gap between legislative intent and school practices. In Portugal's context, co-teaching appears to be a viable interim strategy, warranting further investigation, systematic improvement, and targeted funding to facilitate its implementation and research.

Limitations and future directions

This study has several limitations that warrant acknowledgment. First, as a non-randomized design, this research was susceptible to biases that could compromise the validity of the results (Sterne et al., 2019). Selection bias may have occurred, as teachers with prior co-teaching experience were more likely to be included in the co-teaching group due to existing school arrangements. Without random allocation, confounding variables—unrelated to the intervention—could influence the observed motor competence outcomes. While propensity score matching was employed to mitigate baseline differences between groups, this method cannot eliminate selection bias and confounding entirely. It is a practical alternative when randomized controlled trials are not feasible or ethical (Liau et al., 2024); however, it has inherent limitations. Its success depends on the accurate identification and inclusion of relevant covariates, and it only accounts for measured confounders—variables for which data is available and included in the analysis (Inacio et al., 2015). In this study, covariates identified through regression analysis were used to calculate propensity scores, but unmeasured confounders may still have influenced the results. Furthermore, the reduction in sample size due to matching likely diminished the statistical power of the analysis.

Second, the COVID-19 pandemic significantly disrupted the study timeline, leading to delays and a shortened intervention period. As discussed earlier, these logistical challenges likely affected the implementation and potential impact of the intervention.

Third, the absence of a follow-up assessment limits the ability to detect potential delayed effects of the intervention. While no significant differences were observed between groups immediately after the intervention, changes in students' motor competency may have emerged over time due to continued exposure to improved instructional practices. Teachers in the intervention groups might have continued to refine and integrate the strategies learned during the professional development program into their physical education instruction, potentially leading to cumulative improvements in teaching quality. Additionally, for those in the co-teaching group, the collaborative dynamics between generalist and specialist teachers could have evolved with time. As trust and role clarity increased, the effectiveness of co-teaching partnerships may have improved. Without a follow-up assessment, it is unclear whether these potential long-term effects materialized. Future research should incorporate longitudinal designs to assess delayed outcomes, tracking both student motor competence and changes in instructional practices over an extended period.

Fourth, the study lacked comprehensive process control mechanisms. Monitoring implementation fidelity was limited, particularly in the co-teaching component. Variability in how co-teaching was operationalized may have diluted its effects, emphasizing the importance of structural and process fidelity in future studies.

While this study focused on professional development and co-teaching as strategies to enhance physical education instruction, research consistently indicates that physical education specialists tend to produce superior outcomes compared to generalist teachers. Studies have shown that physical education specialists create more opportunities for motor skill practice (Constantinides et al., 2013) and facilitate higher levels of physical activity during lessons (Telford et al., 2016). Their instruction has also been linked to physiological benefits, such as improved bone strength (Daly et al., 2016). Moreover, specialists employ more effective teaching strategies (Davis et al., 2013), leading to greater student engagement and enhanced learning outcomes. Schools with specialist physical education teachers have also reported higher student participation rates in intramural sports programs, reinforcing the broader impact of their role in promoting active lifestyles beyond formal instruction (Faulkner et al., 2008). Given these findings, future intervention studies should compare different instructional models, led by physical education specialists, generalist teachers, and co-teaching teams, to identify the most effective approach for primary school students. Given the logistical and financial constraints that often limit the widespread adoption of specialist-led physical education, it is essential to evaluate whether co-teaching or targeted professional development can serve as sustainable alternatives while ensuring that all students receive meaningful opportunities for motor competence development.

Future studies could explore qualitative analyses of teachers' experiences and instructional practices to gain insights into the mechanisms driving the effectiveness of professional development programs and co-teaching. Finally, further investigation into moderators and mediators of intervention outcomes, as suggested by a recent systematic review (Helding Vembye et al., 2023), could inform strategies to optimize these educational approaches.

Conclusions

This study evaluated the impact of a 25-hour professional development program for generalist primary school teachers, with and without an eight-week co-teaching component involving specialist physical education teachers, on the motor competence of primary school students. The program aimed to improve physical education instruction by equipping teachers with skills to assess students and implement evidence-based teaching strategies. While all groups showed significant improvements in basic motor competencies over the school year, no additional benefits were observed in the intervention groups compared to the control group. This suggests that natural developmental progression and regular exposure to physical activity opportunities were the primary drivers of improvement rather than the intervention itself.

Despite its limitations, this study contributes to the growing body of literature on motor competence development and provides critical considerations for designing and implementing school-based interventions through physical education. In contexts like Portugal, where primary physical education is implemented inconsistently, identifying cost-effective and scalable models for high-quality instruction is particularly relevant. Although co-teaching is legally recognized as a potential strategy for improving physical education in primary schools, empirical evidence on its effectiveness remains limited. This study provides pioneering insights into its practical implementation and potential impact.

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