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Physical activity during school-time and fundamental movement skills: a study among pre-schoolers with and without Physical Education classes

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Purpose: To analyze associations between physical activity (PA) during school hours and fundamental movement skills (FMS) of young children with and without PE classes. Methods: This cross-sectional study examined 201 children of both sexes (102 girls, 50.7 %), aged 3 to 5 years old (4.51 ± 0.79), who were engaged (n=129) or not (n=72) in physical education (PE) classes weekly. Light (LPA) and moderate-to-vigorous physical activity (MVPA) were assessed by accelerometer during school hours over five consecutive days, and FMS was assessed using the TGMD-2. To verify the association between PA (LPA and MVPA) and FMS (locomotor and object control scores) in both PE and NPE groups, multiple linear regression analysis was used. Results: MVPA during school hours was significantly associated with object control performance in the PE group ($\beta = .14$ $p = .025$). A model with LPA and MVPA explained 4% of the object control performance variability. Conclusion: The positive association observed between MVPA and object control skills on those preschoolers involved in PE classes highlight that opportunities in structured PE classes should be used as a central strategy to promote motor development in preschool settings.

Keywords: physical activity; motor skills; motor development; preschool setting, physical education; preschoolers

Subject classification codes: include these here if the journal requires them

Introduction

The benefits of physical activity (PA) for healthy growth and development have been extensively documented (Carson et al., 2017; Lobstein et al., 2015), though a large number of young children do not engage in sufficient levels of PA (Beets et al., 2011; Berglind & Tynelius, 2018). At young ages, children´s routines are characterized by little time in moderate-to-vigorous physical activity (MVPA), and a greater time in light activities (Pate & O'Neill, 2012) or sedentary behavior (SB) (Pereira et al., 2019). This fact may be, at least partially, attributed to the lack of opportunities to be active in unstructured activities, such as in outdoor free-play (Palmer, Matsuyama, & Robinson, 2017; True et al., 2017), or in structured activities, such as Physical Education (PE) classes.

Prior studies suggest that PA should be promoted from early childhood, as healthy behaviors are established during this period of life (Paes, Marins, & Andreazzi, 2015; Schmutz et al., 2018). Moreover, both unstructured and structured PA engagement in early childhood, may be an opportunity to develop children´s fundamental movement skills (FMS)(Robinson et al., 2015; Stodden et al., 2008). A recent study involving more than one thousand Norwegian preschoolers showed a positive association between PA and locomotor and object control skills, being the strongest associations found for more vigorous activities (Nilsen et al., 2020). Conversely, in middle-late childhood, low proficiency in FMS may prevent children from successfully participating in various types of PA (Robinson et al., 2015; Stodden et al., 2008), as children may be discouraged to move and participate in activities in which they will not succeed. Moreover, from a longitudinal perspective, different studies corroborate that those with greater FMS mastery are those with higher PA levels (De Meester et al., 2016), and this competence may also influence PA levels during

adulthood (Loprinzi, Davis, & Fu, 2015). Consequently, understanding how PA associates with FMS during early childhood may be important to maximize child´s current and future health.

While the emphasis during early childhood should be on adequate amounts of active free play (Council on Sports Medicine and Fitness and Council on School Health, 2006), it is also suggested that preschool-aged children accumulate 60 minutes of structured PA each day (NASPE, 2011). True et al., (2017) have previously reported that in preschoolers, structured activities in Physical Education (PE) classes might promote FMS development. PE classes may also provide children´s knowledge about movement possibilities and offer PA opportunities (Logan et al., 2015). Even when classes do not offer sufficient PA levels to achieve the recommend level of PA for health (Eveline et al., 2012), a systematic review study reinforces that PE classes positively contribute to total daily PA through other mechanisms, such as increased awareness of the importance of PA (Pate et al., 2011).

Though the school period is recognized as an important and feasible time to promote health-related behaviors among children especially for those in full-time attendance (Barnekow et al., 2006), O'Neill et al., (2016) suggests that the school environment constrains children´s PA levels, considering children are more active outside of school. In the context of preschoolers in Brazil, children from low-income families, living in deprived areas, spend more than 60% of their waking time in a preschool setting. Therefore, preschools may be one of the few opportunities for these children to be engaged in structured PA, as the lack of neighborhood PA facilities, combined with the violent social context, may discourage their outdoor free-play. Even considering this environmental context, PE classes are not mandatory in Brazilian preschools. Moreover, though the importance and frequency of daily activities is

recognized by Brazilian teachers, sedentary activities are more frequent and considered to be of great importance in the preschoolers' daily life (Lorås, 2020), which may negatively impact on children´s PA opportunities, and consequently, on their healthy behaviors throughout life.

Given that PE classes have potential to positively influence preschooler's PA levels , and also to increase opportunities for FMS development (True et al., 2017), this study compared PA levels and FMS; and analyzed the association between PA and FMS in preschoolers who were, or were not, engaged in PE classes. Understanding this topic is important in relation to guiding and structuring teaching strategies for effective development in preschoolers. By examining if the association between school-based PA and FMS differs between those children who are engaged in PE and those that are not, it enables teachers and researchers to understand the contribution that PE makes to these two key aspects related to child development and health. Secondly, by determining the nature of this association it will better enable targeted strategies to enhance PA and/or FMS either directly through PE or at other points within the school day, dependent on the strength of associations uncovered. This information may provide a useful contribution to PE teachers and educators to redirect the contents covered in their classes, and may support relevant public health policies for preschools, reinforcing the urgent need for PE classes among Brazilian preschoolers.

Materials and Methods

This cross-sectional study comprises a secondary analysis of the data collected in the Movement´s Cool project (Martins et al., 2021), which aimed to analyze the possible cross-sectional and longitudinal associations between movement behaviors and health outcomes in preschool children. The Research Ethics Committee from the Health

Sciences Center of [removed for blind review] (protocol 2.727.698) approved the current study.

Context

At the preschool level, the public-school system is distributed in nine educational zones where 86 preschools are located. These preschools are spaces for full-time education for children from zero to 5 years old, with similar physical structures. In general, preschools have an outdoor playground, administration rooms, teachers' room, five classes, baby changing room, indoor yard, children's changing rooms, laundry, pantry, and kitchen. A PE teacher's presence as a member of the staff is not mandatory, so some preschools have PE teachers, and others do not. For those preschoolers without PE classes, there is no period dedicated to structured PA in their preschool provision, and children are enrolled in a daily 20min indoor free-play period, supervised by the teacher, who has no specific training to offer PA. For those with a PE teacher, PE classes happen twice per week, lasting approximately 40 minutes and take place during the morning or the afternoon, according to the school's schedule. In preschool settings, classes are organized by age in two levels: i) very young children (3 years and 11 months); and ii) young children (4 years to 5 years and 11 months). Each class comprises approximately 20 children, who attend preschools for 35 hours/week (90 min/day are dedicated for rest). For those children enrolled in PE classes, the curricula are structured to offer two 40 min-PE classes per week, conducted by a PE teacher, with 3 years of experience in preschools, and who are enrolled in pedagogical training periodically.

The current study was conducted with preschool children, enrolled in public preschools from [removed for blind review]. From the 86 existing preschools, 50 of them have registered children aged 3-to-5 years and 10 months. From those 50

preschools, 26 have adequate space for the application of motor tests (a linear distance of at least 18.5m; cemented floor), and from those, 10 preschools have PE teachers as members of the staff. In three educational zones, none of the preschools located had 3-to-5 years old children or adequate space. Six preschools (three from the 10 preschools with PE classes, and 3 from the 16 preschools without PE classes), each preschool from a specific educational zone, was randomly selected and considered for the current study.

Population and sample

In the six selected preschools, 573 children aged 3 to 5 were regularly registered in 2018. For the purpose of this study, 308 children who were attending the preschool, and who were between 3 and 5 years old at the assessment period, were eligible. From those, 13 did not return the informed consent form, 14 children were absent on assessment days, 30 refused to participate or gave up during the Test of Gross Motor Development (TGMD)-2 assessment, 14 refused to wear the accelerometer, and 36 do not validate accelerometer data. Thus, the final sample of the study consisted of 201 children (102 girls) aged 4.51 years (± 0.79), comprising 129 children who were registered in preschools with PE classes (PE) (engaged in PE class for almost one year), and 72 children whose preschools did not offer PE classes (NPE).

Variables and protocols

Measurements were carried out between October and November 2018, by the specialized and trained project staff (physical education teachers and graduate students).

Physical activity

PA was objectively assessed using accelerometers (Actigraph, model WGT3-X, Florida), a valid instrument for measuring PA in preschoolers (Bornstein et al., 2011).

The preschool teachers received verbal and written instructions for the correct use of the accelerometer, including placement, and the correct positioning. The device initialization, data reduction, and analysis were performed using the ActiLife software (Version 6.13.3).

The participants were instructed to wear the accelerometer on the right hip for five consecutive days (Monday to Friday) during school hours (from 7:00 am to 5:00 pm). Children who had at least 360 minutes of daily use during two days were included in the analyses (Dolinsky, Brouwer, Evenson, Siega-Riz, & Østbye, 2011). Periods ≥20 min of consecutive zero counts were defined as non-wear time and removed from the analysis (Esliger et al., 2005). Two hundred and thirty-seven preschoolers used the device, but 36 preschoolers did not provide valid accelerometer data assessments, according to the established criteria.

Accelerometers were set up to measure acceleration at a 100 Hz sampling rate, using a 15-s epoch length (Cliff et al., 2009). Data were reintegrated to 60-s epoch, and analyzed as ActiGraph counts, using the vector magnitude. The wear time ranged from six to 10 hours between subjects, and the mean wear time was 8.5 hours (SD± 2h of wear time between children).

Time spent in the commonly defined intensity domains of light, moderate, and vigorous PA were estimated and described using the cut-points proposed by Butte et al., (2014). Habitual PA for a preschool time was estimated as the average count per minute between 7am and 5pm.

Fundamental Movement Skills

Fundamental movement skills were measured using the Test of Gross Motor Development - Second Edition (TGMD-2). The TGMD-2 is valid and reliable for use in Brazilian children (Valentini, 2012). This test evaluates gross motor performance in

children aged 3 to 10 years, and consists of two domains: locomotor skills (run, gallop, hop, leap, jump and slide) and object control skills (strike, dribble, catch, kick, throw and underhand roll).

The TGMD-2 was administered according to the guidelines recommended by Ulrich & Sanford (2000). Before testing each skill, participants were given a visual demonstration of the researcher's skill using the correct technique. However, they were not told what components of the skill were being assessed. Participants were then called individually to perform the skill twice. General encouragement but no verbal feedback on performance was given during or after the tests. All skills were video-recorded and later assessed by one trained assessor who does not administer the tests. After viewing each trial, the trained assessor analyzed each skill component. A “1” indicated that the component was present in the performance of the skill for that trial or a “0” indicated the component was not present. The video analysis was performed by two expert evaluators, obtaining high intra and interrater reliability (ICC: 0.93-0.98).

Activities in PE and NPE groups

The PE lessons consisted of games, rhythmic and expressive activities, two times per week, lasting approximately 40 minutes per session. The curriculum planning was implemented according to National Guidelines for Common Curriculum (Ministério da Educação, 2017). The classes took place in a playground and a covered recreation area in day care centers. The playground contained slides, ladders, swings, ropes, rocking chair, tunnels, and rubber mats. In general, PE teachers used hula-hoops, flexible cones, field markers, ropes, and plastic bottles. The activities were predominantly manipulative in nature due to the limited spaces for locomotor activities. The NPE children also utilized these same spaces and materials in their free play activities (non-structured

activities, twice per week, during approximately 40 minutes per session), although any facilitated instruction or guidance were not provided by teachers.

PE classes were focused on developing children ability to displace their body in space, guiding by notions such as in front, behind, at the top, below, inside, outside etc., while engaging in games and activities of different natures (Ministério da Educação, 2017). PE classes were structured to offer different learning and developmental opportunities in the preschool´s playground (or in the indoor yard, for those preschools without the playground structure). For very young children, activities such as reproducing and creating movements, exploring how to pass through, around, over and under objects were key aspects of PE classes. For the younger children, manipulative activities, such as building toys from popular recyclable materials and experiencing/exploring activities with their built toys were explored. For NPE group, the schedule time was destined to free-play.

Data analysis

The normality of data distribution was assessed by skewness (SK) and kurtosis (KU) uni and multivariate. Values above 3 for SK and above 7 for KU were considered as a cut-off for distribution violation. Descriptive analysis procedures (mean, standard deviation) were performed for all the studied variables. The Student`s t-test for independent samples was used to compare LPA, MVPA, locomotor, object control, and total scores between PE and NPE groups. Correlations among all variables was tested using Pearson correlation coefficient (r). Cut-off values of r between 0.1 and 0.3(weak); 0.31 and 0.70 (moderate); 0.71 and 0.90 (very strong), were adopted. To verify the associations between PA (LPA and MVPA) and FMS (locomotor and object control scores) in both PE and NPE groups, multiple linear regression analyzes were used, considering a maximum likelihood parameter estimation. The multivariate outliers were

assessed through Mahalanobis distance (D^2). The Variance Inflation Factor (VIF) was used to verify possible multicollinearity. Values above 5 were considered as a cut-off for multicollinearity. Analyses were performed in R (http://cran.r-project.org). The significant level adopted was < .05.

Results

Data were normally distributed (KU<3 and SK<7). Uni and multivariate outliers were not found and no multicollineatity has been seen for the variables used in the regression models (VIF<5).

The descriptive analysis for PE and NPE is presented in Table 1. Similar expended time in LPA (t (199) = -1.061, p = .290) and MVPA (t (199) = .954, p = .341) was observed in both PE and NPE groups. Significant higher locomotor (t (199) = 3.45, p = .001), object control (t (199) = 3.98, p < 001) and total motor skill performance (t (199) = 4.42, p < .001) were observed for PE compared to NPE children.

insert table 1

Weak and non-significant correlations were observed between PA and FMS in PE (r values between -.166 and .042) and NPE (r values between -.117 and .042). In both groups, significant, positive, and moderate to strong correlations were observed between LPA and MVPA (r values = .493 and .553 respectively) and between locomotor, object control skills scores (r values = .337 and .569 respectively) (Table 2).

insert table 2

The results concerning the uni and multivariate skewness (SK) and kurtosis (KUu) (KUm) confirmed the normality of data distribution in both PE and NPE groups (SK values between -.178 and 1.699; KU values between -.800 and .651; KUm values -1.217 and 2.321). In addition, errors between observed and predicted values (i.e., the

residuals of the regression) were checked by Q-Q-Plot and were normally distributed. Results of the Shapiro Wilk test supported the normality of the residuals (values between .306 and .622). Additionally, results for the Variance Inflation Factor (VIF) demonstrated no evidence of possible multicollinearity in the four regression models assessed (values between 1.32 and 1.44).

The path diagram of the relationship between PA (LPA and MVPA) and FMS (locomotor, object control, and total score) in PE (Figure 1) and NPE (figure 2) groups showed a significant trajectory between MVPA and object control score ($\beta = .14$, $p = .025$) in the PE group. This model with LPA and MVPA explained 4% of the variability of object control performance of the PE group (Figure 1).

insert figure 1

insert figure 2

Discussion

This study compared PA levels and FMS in preschoolers with and without PE classes; and explored the associations between PA and FMS during school hours among those children. Similar levels of LPA, and MVPA between PE and NPE groups were observed, although children in the PE group showed higher FMS scores. The assessed children also presented PA values above the recommended for total PA (above 150 min), as previously observed in similar population (Hnatiuk et al. 2014; Pate et al., 2011; Reilly, 2010). Moreover, and corroborating with Temple et al. (2016), higher locomotor, object control and total scores were observed for children engaged in structured PA, through PE classes.

The main results of the current study demonstrate that MVPA was associated with object control scores in the PE group. The association between PA and FMS in children and adolescents has been previously investigated, reporting inconsistent

findings (Barnett et al., 2016; Figueroa & An, 2017; Holfelder & Schott, 2014; Logan, Kipling Webster, Getchell, Pfeiffer, & Robinson, 2015; Robinson, Wadsworth, & Peoples, 2012). In early childhood, systematic reviews of RCTs, longitudinal and cross-sectional studies observed a positive association between PA, specially the structured moderate-to-vigorous one, and child´s motor development (Carson et al. 2017; Jones et al. 2020; Van Capelle et al. 2017), though the limited number of evidence from longitudinal designs, and the low quality of the provided evidence requires caution in results extrapolation. Moreover, Lorås (2020) explored the effects of PE on children and adolescent´s motor competence (3 to 13 years-old) through a meta-analytic review, and observed that participation in a PE class has a positive effect on the development of motor competence. The results of the aforementioned reviews with preschoolers are consistent with the current study, when showing a positive association between PA (specially the structured and /or moderate-to-vigorous one), and motor development (motor competence, FMS, coordination). Nonetheless, it is important to state that differences in studies´ design, the conceptual terminologies, and the protocols used make direct comparisons difficult to establish.

Indeed, object control skills require a greater cognitive demand to learn and perform, and also take longer to develop, when comparing to locomotor skills (Morgan et al., 2013). One could hypothesize that object control skills are more difficult to improve than locomotor skills. This may be due to the greater skill component complexity and perceptual demand of object control skills, which may require more intensive skill instruction and practice (Morgan et al., 2013). Also, it is plausible to suggest that to undertake many of the object control skills in a proficient manner, the child needs at least adequate locomotor skills, as for throw, strike, kick, for example, have a locomotor element in the behavioral components that are used to score them. It is

313 also important to highlight that children may be further along their developmental
314 pathway and nearer to mastery locomotor than with object control skills (Gallahue,
315 Ozmun, & Goodway, 2013), as they have less space to get better in locomotor, but
316 sufficient space and opportunities in object control skills. Therefore, the participation in
317 PE classes may be a plausible explanation for the current results (Robinson &
318 Goodway, 2009).
319 Moreover, previous studies have reported inconsistent findings regarding PA
320 as a correlate of object control or locomotor skills (Barnett et al., 2016). Barnett et al.
321 (2013) have reported a moderate relationship between object control skills and MVPA
322 in preschoolers. Conversely, Webster et al., (2019) observed that locomotor and total
323 score were associated with vigorous PA, but not with total PA or MVPA. In contrast,
324 Foweather et al., (2015) reported that object control skills were positively associated
325 with LPA on weekdays and with both LPA and MVPA during weekends, highlighting
326 that the type of activity children are engaged may be determinant in these relationships.
327 Additionally, prior work has demonstrated children who attended day care
328 centers with more larger playgrounds, better-educated teachers had a better motor
329 competence when compared to children attending day care centers without the same
330 conditions (True et al., 2017). In regard to the restricted structural spaces in the
331 investigated preschools for PE classes in the current study, it is essential to highlight
332 that these relationships may be dependent on opportunities for motor experiences in day
333 care centers, where preschoolers spend more than 60% of their awake time.
334 Likewise, it is well-known that different factors influence motor skill learning:
335 the presence of feedback; adequate environment; and the variance in the stimuli (Magill,
336 1990). Considering that all the assessed children were in similar spaces, the presence of
337 structured PA (PE classes) could be considered essential to provide feedback on motor

skills learning, to offer planning activities, with skills variance to promote new experiences and, consequently, better motor competence. The type of activity offered is also another matter of concern. In the assessed day cares, PE classes were predominantly based on manipulative activities, such as making their own toys, and games and plays, due to the limited spaces for locomotor activities, and in general, using balls, flexible cones, ropes, and PET bottles. Indeed, challenging tasks, with clear objectives and effectiveness on the activities proposed, besides feedback frequency during the performance (Sidaway et al. 2012) are important aspects in PE classes. Thus, it is plausible to consider that these structured activities offered during PE classes may provide children engagement, and be a potential factor for increasing MVPA (Duncan et al. 2019), and consequently, to develop object control skills. Indeed, young children need specific and systematic opportunities to learn FMS, that will contribute to a lifetime of PA, as in PE classes, and it cannot be left to chance (Stork & Sanders, 2008).

Moreover, although the preschool setting may have a meaningful influence on children's motor and movement development, one should not expect preschool to be the only daily available setting to allow children to be active. Despite this, concerning FMS as a product of preschooler´s engagement in PA opportunities (Stodden et al., 2008), the contribution of preschool settings to PA engagement is even more important for those children who were assessed, who have less chance to participate in structured activities outside preschools (only 4.4% of the evaluated children are involved in outside school structured PA – data not shown).

Finally, the NPE children also used the same spaces and materials as the PE children in free play activities. Consequently, these factors did not influence the relationship between MVPA and locomotor or object control performance. Concerning the restricted structural spaces in the investigated preschools for PE classes, it is

363 essential to highlight that the relationship between PA and FMS may be dependent on
364 opportunities of motor experiences in day care centers, where preschoolers spend more
365 than 60% of their awake time. However, provision of space and material alone does not
366 appear to be sufficient to impact on PA and FMS. For example, children who attended
367 day care centers with larger playgrounds, but also with better-educated teachers had a
368 better motor competence when compared to children attending day care centers without
369 the same conditions (True et al., (2017). The results of the current study reinforces the
370 critical role of a mediator (i.e., teacher) to help the children to increase their PA and
371 FMS at childcare centers (Lander et al., 2017). Moreover, one could argue that
372 provision of adequately trained staff to guide PA for this specific age group may be
373 crucial in maximizing the use of the preschool environment to benefit children's health
374 enhancing behaviors.
375 In the assessed context of the present study, sedentary activities are more
376 frequent and considered to be of great importance in the preschoolers' daily life. From a
377 public health and educational point of view, a broader discussion on how a focus on
378 having young children demonstrate better numeracy and literate earlier may impact on
379 their free and structured play time in preschools is important, as an increase in PE time,
380 will likely mean a loss of other 'learning' time. Nonetheless, from a dynamical systems
381 approach, improvements in the motor domain are necessarily linked to improvements in
382 other developmental domains, as the cognitive, and the socioemotional ones,
383 considering it occurs in the same organism, over the same period (Corbin, 1980).
384 Moreover, the use of different strategies in preschool settings should be encouraged. For
385 example, the incorporation of a physically active learning, to mitigate the impact of
386 sedentary daily time should be considered. Incorporating PE classes in the delivery of
387 transdisciplinary content is also another strategy to consider.

The strengths of this study include the assessment of a robust sample in terms of delimitation, which allows the generalization of results; the assessment of FMS through TGMD-2, which is widely used instrument worldwide, and which comprehensively assesses a wide range of motor skills; and the exploration of relevant information for professional´s daily routines. Though there was a substantial sample loss in relation to those children who wore the accelerometers, this was due to the teachers´ forgetting to replace the device after children´s bath. However, the number of children who meet the minimum wear-time criteria for accelerometer measurement inclusion (84%) must be acknowledged. This value is above the average observed in similar studies (Hislop et al., 2014). Considering the specificity of the evaluated population (attending preschools for 10 hours per day, many absences at preschool), and the challenges of ensuring appropriate accelerometer wear time in this population, it could be seen as a strength of the present study. The absence of information relating to the quality of PE classes is another concern for future research, as there is no information regarding the type of activity children are involved in, or even the period of time children are effectively active, that could positively affect FMS scores. Regarding future research perspectives, the study of different social and built correlates of preschool´s environment, such as the pedagogical approach concerning PA promotion, the quantity and quality of PA facilities, the teacher´s engagement in the offered activities, as well as a critical evaluation of applied PE classes, might be essential points of investigation. Future studies should also test the bidirectional relationship between PA and FMS, and how it associates with the engagement on structured PA (ie. PE) in early childhood. Furthermore, intervention studies must be conducted to confirm these shreds of evidence, presented in the current study, regarding the potential association of PE classes on the relationship between PA and FMS.

Overall, the key practical implications of the current study are that the level of preschool-based activity is not the defining factor for FMS, but the nature of the learning opportunities provided. A recent systematic review showed that active-movement-based programs introduce substantial effects above what might be general motor-development effects observed for control group. Therefore, specific curricula with PE practices targeted at different aspects of motor competence could be effective for motor development (Lorås, 2020). In a meta-analytic review of fifty-six trials covering 48,185 youths aged 3 to 13, García-Hermoso et al. (2020) reported that quality-based PE are associated with small increases in FMS, regardless of frequency or duration of PE lessons. The authors also suggested that high levels of active learning time may need to be balanced with opportunities for instruction, feedback, and reflection. Indeed, preschools need to ensure there is sufficient space for preschoolers to move and practice motor skills. This needs to be coupled with appropriate equipment, such as balls, bats, beanbags, climbing frames, and with training for preschool teachers. Without this, children will be unlikely to reach their motor potential at an early age, likely leading to a negative trajectory of PA and unhealthy weight throughout life. Thus, preschools should be restructured to include PE classes, based on a public policy for PE in young ages, in which opportunities for motor skill development should be included in the day-to-day preschool activities.

Thus, considering the current study identified significant differences in FMS between preschoolers with and without PE classes, and that for those who had PE classes, MVPA is positively associated with object control skills, useful propositions for policy, teacher training and for PE lessons specifically are suggested. Concerning policy, the present study may reinforce the importance of statutory PE. For the PE curricula, it should be important to concentrate on motor development during the

preschool period, with an explicit focus on development of object control skills. For teacher training, strategies may be needed to upskill trainee teachers in: a) how best FMS can be developed through PE; b) how they are linked to PA; and c) why this is particularly important. For PE lessons, strategies, interventions, guidance and other initiatives could be put in place which position the development of object control skills as a central tenant of schemes of work, or blocks of lessons in preschool PE.

Conclusion

This study provides new evidence for PE professional who works with preschool children, when highlighting the association between MVPA and object control skills on those involved in PE classes, indicating the need for future studies to assess the quality of PE classes in preschool settings. The development of good motor competence should be a priority focus for both public health and education. Opportunities in structured PE classes should be used as an important strategy to promote motor development in preschoolers, coupled with specific training in motor skill development for those working in preschools.

Declaration of interest statement: The Authors declares that there is no conflict of interest.

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Table 1. Descriptive statistics for PE and NPE groups.

	PE (n=128) Mean (SD)	**NPE (N=71)** Mean (SD)	**Total** Mean (SD)
(1) LPA	135.1 (32.7)	129.4 (29)	133.1 (31.5)
(2) MVPA	30.6 (15.3)	31.5 (14.9)	30.9 (15.1)
(3) Locomotor	19.5 (6.5)[1**]	16.2 (6.5)[1**]	18.3 (6.7)
(4) Object control	20.6 (7)[2**]	16.5 (5.8)[2**]	19.1 (6.8)
(5) Total MS	40.2 (11)[3**]	33 (11.1) [3**]	37.6 (11.5)

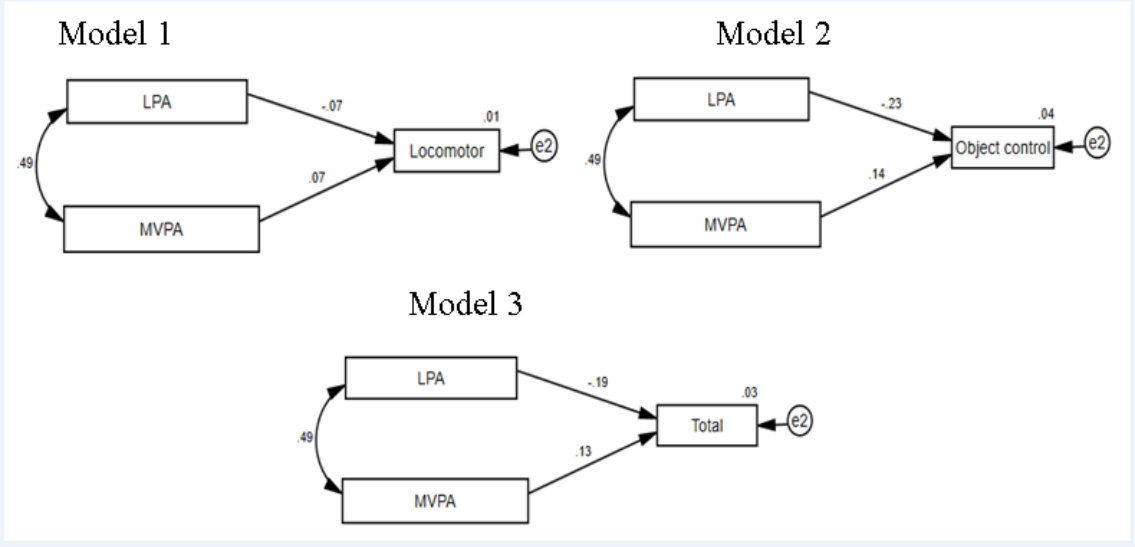
Note: PE: physical education group; NPE: non-physical education group; Total MS: total motor skills; [1,2,3] significant difference between PE and NPE groups. ** significant at $p < .001$

Table 2. Pearson correlations for PE group (n = 128), and NPE group (n = 70).

	PE			**NPE**		
	(1)	(2)	(3)	(1)	(2)	(3)
(1) LPA	-			-		
(2) MVPA	.493**	-		553**	-	
(3) Locomotor	-.030	.042	-	-.117	-.079	-
(4) Object control	-.166	.023	337**	.086	.042	.569**

Note: PE: physical education group; NPE: non-physical education group;
LPA: light physical activity; MVPA: moderate-to-vigorous physical activity.
** Significant at $p < .001$

667 Figure 1



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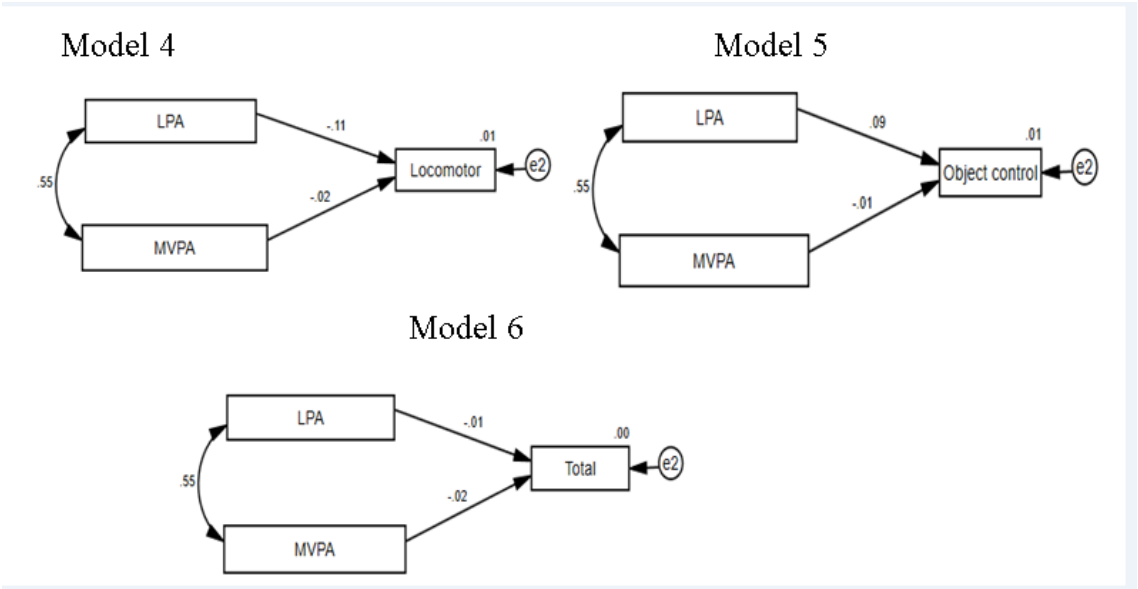
669

Figure 2.


Model 4
LPA
MVPA
Locomotor
e2
.55
-.11
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Model 5
LPA
MVPA
Object control
e2
.55
.09
-.01
.01
Model 6
LPA
MVPA
Total
e2
.55
-.01
-.02
.00

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