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The effectiveness of the HIPPA intervention in the sociocultural environment of ECEC physical activity

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ABSTRACT: Studies have shown that, on average, children's physical activity (PA) levels in early childhood education and care (ECEC) environments are low, thus opening up the possibility of interventions. We examined the effect of the teacher-implemented one-year long 'home-and-childcare-based intervention to promote physical activity' (HIPPA) study on children's PA in ECEC settings in Finland. Participating four-year-old children (N = 128) were cluster-randomised into two groups, intervention (seven childcare centres) and control (seven childcare centres), in autumn 2011. The children were observed directly during their ECEC times. Multilevel linear analysis was used to test the PA differences between the intervention conditions. Post-intervention results showed that the HIPPA intervention increased the children's PA. To enhance the real-life effectiveness of the present multicomponent intervention, we examined methods based on the intervention's success and found areas of development for future studies. Overall,

promoting active play by ECEC personnel offers an effective way to enhance children's PA. Furthermore, to ensure the sustainability of the intervention effects, specific changes in practice have been identified that should be transferred into the policies intended for ECEC settings.

Keywords: *children, physical activity, early childhood education and care, multicomponent intervention research*

Introduction

Current studies suggest that young children's physical activity (PA) behaviours have changed over the decades. The prevalence of early childhood overweight and obesity has increased rapidly worldwide (de Onis et al., 2010; Di Cesare et al., 2019; NCD-RisC, 2017). Environmental, behavioural, biological, and genetic factors all impact on weight gain (Di Cesare et al., 2019), and it seems very likely that changes in PA and sedentary behaviour have promoted this unfavourable development (de Onis et al., 2010; Di Cesare et al., 2019; NCD-RisC, 2017). Not only does living in a modern society require less physical effort than before (Hill et al., 2003; Wiklund, 2016), but it also offers a wide variety of sedentary activities (Gray et al., 2015). Opportunities for physical activities requiring a wide range of motor skills may have diminished. This can impair performance in tasks that require good coordinative skills, such as balancing and throwing (Roth et al., 2010). Therefore, attention should be paid to children's PA, and time and space should be organised so that children have the opportunity to achieve sufficiently diverse PA on a daily basis. The World Health Organization (WHO) recommends PA for a total of 180 min per day, including at least one hour of moderate-to-vigorous PA (MVPA) for children three- to four-year-olds (WHO, 2019). These evidence-based guidelines aim to enhance the growth and development of children and are consistent in several countries across continents, such as Australia, Canada, the United Kingdom, and the United States of America. In Finland, corresponding recommendations apply for children under eight years old (Ministry of Education and Culture, 2016).

Studies have shown an increasing interest in children's PA behaviour in early childhood education and care (ECEC) settings, with results pointing out that children's PA in various ECEC environments is generally low, thus opening up the possibility of an intervention (Jones et al., 2019). ECEC environments can potentially impact children's PA because most children aged 3–5 years engage in ECEC (OECD, 2022). Review articles addressing the efficiency of health behaviour (i.e., PA and diet) interventions in childcare-age children have been published in recent years (Stacey et al., 2017). It is also worth noting that successfully implemented PA and fundamental motor skills interventions in ECEC may enhance children's overall well-being and support their cognitive and learning skills

(Jylänki et al., 2022). The most recent meta-analysis of 21 published ECEC-setting intervention studies found a small but significant impact on children's MVPA but no significant effect on light PA (LPA). A more substantial overall impact on MVPA than LPA may reflect the contents of the intervention programmes, which focused mainly on enhancing MVPA by promoting, for example, active play outdoors or structured gross movement sessions in ECEC settings (Hnatiuk et al., 2018.)

Reducing playground density and providing portable play equipment have proven to be effective intervention methods for increasing children's outdoor PA (Stacey et al., 2017). Although there is significant variation in the frequency and intensity of outdoor PA, children spend more than half of their outdoor time engaged in sedentary activities (Truelove et al., 2018). This suggests that free play alone may not be sufficient to promote PA (Alhassan et al., 2007; Cardon et al., 2009) or to develop gross motor skills in all children, which is vital for lifelong PA (Brian et al., 2017; Stodden et al., 2008). ECEC personnel involvement (e.g., prompts to PA, trips to a forest to play or learn through play) or structured PA (e.g., obstacle courses, rule games) during recess periods is needed alongside free play. Nevertheless, outdoor play is an important form of children's PA. Outdoors, children have space to move and play, giving them opportunities to develop their creativity and social skills (Aras et al., 2016; Truelove et al., 2017, 2018). Children have been observed in childcare settings to be up to two times more physically active outdoors as indoors (Tandon et al., 2018).

The provision of structured PA (e.g., integrated into the preschool curriculum) was one of the potentially effective methods that can facilitate children's PA, as observed in two recent reviews and meta-analyses listing several childcare centres' policies and practices (Hnatiuk et al., 2018; Stacey et al., 2017). Studies have reported that the most promising effects result from methods that target the improved knowledge and qualifications of ECEC personnel through training, and physical environments, such as modifications of playground space (e.g., by reducing its density) and providing portable equipment (Stacey et al., 2017). ECEC personnel should have knowledge of children's motor skills development and the ability to support development in an age-appropriate way. Another approach is to tailor an intervention to the distinct cultural and societal needs of the target group. Tailoring can mean providing ongoing support to address context-specific barriers or modifying materials to suit the local community (Hnatiuk et al., 2018). This is an important factor to consider in today's standards because ECEC personnel already face challenges, such as time-consuming administrational duties, when performing their basic routines (Aras, 2016). It is essential to ensure that ECEC personnel can change their practices to help promote children's PA under their supervision (Hnatiuk et al., 2018). From the perspective of long-term health behaviour effects, the following factors should be considered: children enjoy the offered activities, interventions are easy to implement

and are embedded into ECEC environments without demanding extra time, there are enough resources (money or personnel), and parents and children are consistently informed (Finch et al., 2014; Zhou et al., 2014).

Despite the growing interest in promoting PA in ECEC settings, little is known about the characteristics of the interventions facilitating children's PA. Furthermore, it has been suggested that a more comprehensive approach should be used, rather than simply focusing on a single determinant when considering the effectiveness of an intervention (Gubbels et al., 2014). Thus, the first purpose of the current study is to examine the effects of the teacher-implemented, one-year-long 'home-and-childcare-based intervention to promote physical activity' (HIPPA) intervention on children's directly observed PA in ECEC settings. Second, this study explores the moderating factors in the observed physical (outdoors and indoors) and social environments (adult initiation of PA or adult involvement or presence in PA), wherein children's PA occurs at childcare centres using the observational system for recording physical activity in preschool children (OSRAC-P). Observed social-environmental factors were the specifically primary location of the child in the ECEC centre, time of day, group composition (e.g., child group, adult group), and activity initiator (child or adult). Observed outdoor and indoor factors included activity contexts, for example playing in open space, with fixed equipment, or in the sandbox; participation in group time; and teacher-arranged gross motor activity or sociodramatic play (see Appendix 1). Differences in the cross-sectional and longitudinal associations of children's PA between the intervention (HIPPA) and control groups were assessed. Finally, the sensitivity of the intervention was examined by separately assessing the associations amongst and between boys and girls.

Methods

This cluster-randomised HIPPA intervention study is part of a more extensive study on Dutch and Finnish two- to six-year-old children's PA in childcare and home settings (see Mehtälä et al., 2017; Soini, 2015). A follow-up study (2010–2013) was developed to estimate children's PA behaviours and those of their parents using several different methods. Direct observation (OSRAC-P; Brown et al., 2006), accelerometers (Actigraph GT3X) and proxy reports were used to assess the children's PA. In the present study, only data collected by the OSRAC-P were used.

In Finland, the study consisted of two phases. The first phase of the study (Phase I, autumn 2010 to winter 2011) identified the level and characteristics of children's PA at different times of the year (Figure 1). The purpose of the second phase (Phase II, spring 2011 to winter 2013) was to plan and implement an intervention appropriate to the environment

to increase the PA of childcare-age children based on the current best knowledge and the evaluation of the study results of the first phase (Soini, 2015). Ethical approval for the study was obtained from the local ethical committee and the social affairs and health officer of the city where the study was conducted.

Study design and participants

In spring 2010, 60 public childcare centres located throughout a city in central Finland were invited to participate in the study (Figure 1). Fourteen childcare centres accepted the invitation after a regional administrative meeting and distributed the information letters and consent forms to eligible families. The sole inclusion criterion was that the children enrolled in the participating childcare centres must be born in 2007. The 14 participating childcare centres were representative of the typical Finnish ECEC system. Most childcare centres in Finland are municipal (Finnish National Agency for Education, 2022). In this study, 13 were municipal childcare centres, and 1 was private.

In the present study, we examined the intervention data (Phase II) from autumn 2011 to winter 2013. The time included four data collection points: initiation, midway, post-intervention, and follow-up of the HIPPA intervention (Mehtälä et al., 2017). There were 220 children born in 2007 at the participating childcare centres in autumn 2011. The families of 128 eligible children provided informed consent. Eleven children had missing intervention initiation data because of sickness or other reasons for their absence during the measurement days, thus leading to a final sample of 117 children (53%). The participating children were cluster-randomised into two groups: intervention (seven childcare centres) and control (seven childcare centres). Paired and random allocations were used, and the childcare centres were matched based on their locations. The participants in the intervention centres were exposed to the HIPPA, whereas those in the control centres received their usual daily programmes (Mehtälä et al., 2017).

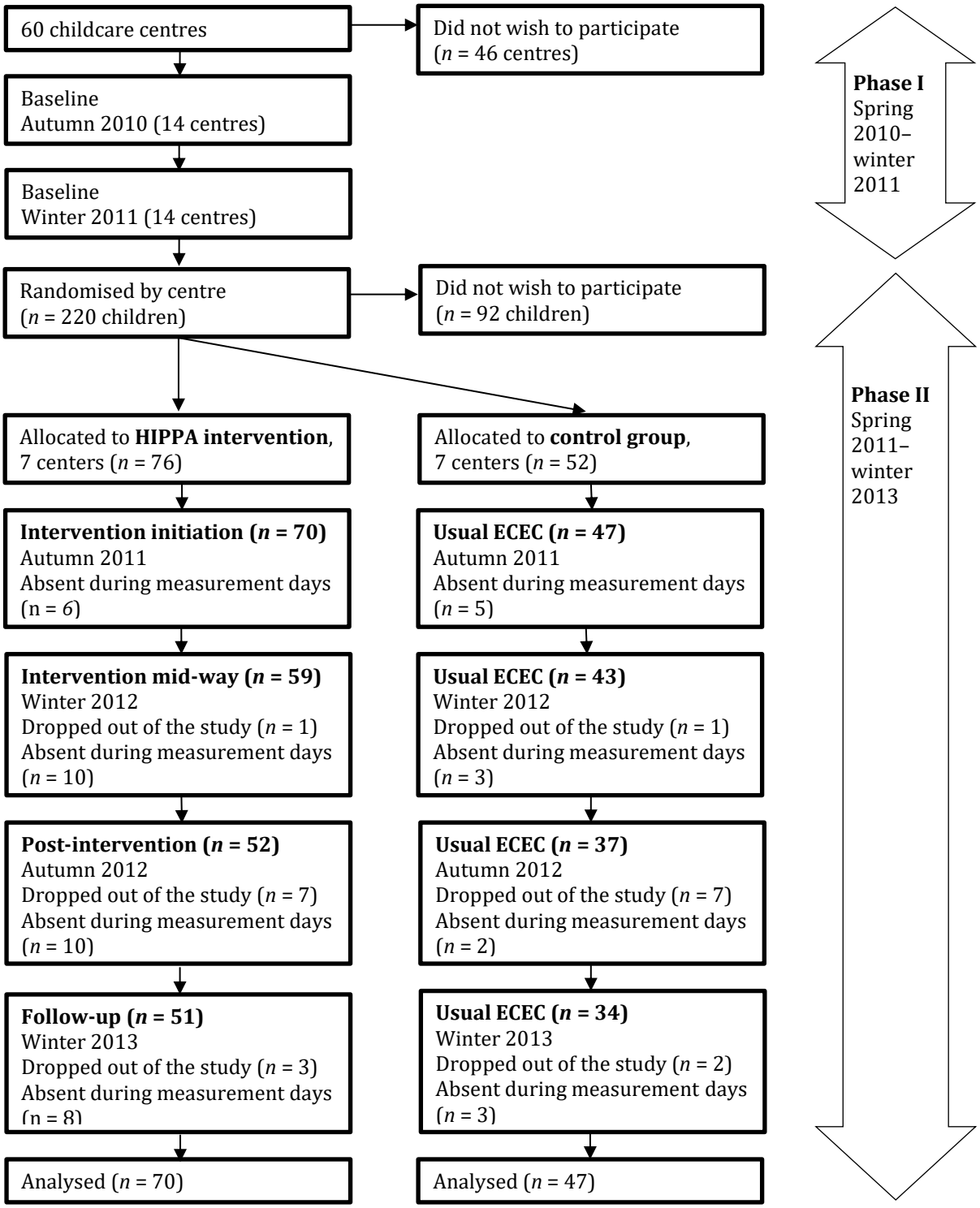

FIGURE 1 Flowchart of study participants. The present study analysed only the data collected during Phase II.

In each data collection period, each child's height was measured by two researchers to the nearest 0.1 cm and their weight to the nearest 0.1 kg using a portable stadiometer (Charder HM 200P) and a digital scale (Seca 877), respectively. The body mass index (BMI) was calculated for each child as weight (kg) divided by the squared height (m^2). The descriptive data of the participating children at the start of the intervention are presented in Table 1. In general, the children in the HIPPA group were younger, shorter, and weighed less than those in the control group. Notably, age differences appeared between girls, while a difference in mean weight was recorded between boys. Amongst the HIPPA group, girls had lower observed mean PA than boys.

TABLE 1 Participants' characteristics at the start of the HIPPA intervention

CHARACTERISTIC	*CONTROL GROUP*						*HIPPA INTERVENTION GROUP*					
	Boys		Girls		Total		Boys		Girls		Total	
	n	Mean (*SD*)	*n*	Mean (*SD*)	*N*	Mean (*SD*)	*n*	Mean (*SD*)	*n*	Mean (*SD*)	*N*	Mean (*SD*)
Age, year	23	4.24 (0.24)	24	**4.31 (0.26)***	47	**4.28 (0.25)***	34	4.13 (0.28)	36	**4.09 (0.29)***	70	**4.11 (0.28)***
Height, cm	23	**108.1 (4.9)***	23	**106.3 (3.9)***	46	**107.2 (4.4)***	31	**104.9 (6.2)***	36	**103.3 (3.6)***	67	**103.6 (5.0)***
Weight, kg	23	**18.7 (2.6)***	23	17.8 (2.1)	46	**18.2 (2.4)***	31	**17.3 (2.6)***	36	17.3 (2.1)	67	**17.3 (2.3)***
BMI, kg/m^2	23	15.9 (1.5)	23	15.7 (1.2)	46	15.8 (1.3)	31	15.9 (1.1)	36	16.2 (1.4)	67	16.1 (1.3)
Mean PA	23	2.57 (0.40)	24	2.44 (0.29)	47	2.51 (0.35)	34	**2.50 (0.15)****	36	**2.37 (0.20)****	70	2.43 (0.19)

Note. *Statistically significant difference ($p < .05$) between intervention conditions and **genders.

Intervention

The socio-ecological model was applied as a framework in the HIPPA intervention. This approach is commonly used to guide the selection of strategies and methods for intervention studies because it considers the dynamic and complex interplay between an individual and the environmental factors that can affect one's health behaviours (McLeroy et al., 1988). One of the leading ideas was to plan the intervention collaboratively with ECEC personnel. The tailored intervention based on each centre's own needs would be primarily implemented by the ECEC personnel and must be able to overcome real-life challenges, such as lack of resources. The intervention was planned with the ECEC personnel based on the data collected in autumn 2010 and winter 2011 and it utilised the former Finnish early childhood PA recommendations (Ministry of Social Affairs and Health, 2005). The main targets to be modified were outdoor playtime, indoor facilities of

the centres, the PA knowledge and skills of the principals, ECEC personnel's competence and support for PA, and the children's motivation and self-efficacy for PA.

In the intervention planning meetings held in the spring of 2011 between researchers and ECEC personnel, the targets were considered, and various methods were presented to promote children's PA in childcare centres' typical daily life situations. Children's guardians had the opportunity to record their ideas to anonymously promote children's PA. Several methods were identified: modifying outdoor time and space, that is by an implementation of adult-led or adult-initiated physical activities or by staggering outdoor time of different child groups; parental activation, for example at a parents' evening; in-service education of ECEC personnel; making indoor spaces more stimulating for PA; more effective use of existing PA programmes; and colleagues' support. The discussions also raised issues that were potential barriers to the implementation of these methods in the intervention. They were related to children's safety, for example increased risk of injuries, size of the indoor facilities and child groups, and concerns about personnel as well as equipment adequacy. The attitudes of the personnel and guardians towards PA were highlighted as both a barrier and an enabler to increase children's opportunities for PA.

Various intervention materials were used to increase children's PA and to promote children's as well as ECEC personnel's and guardians' motivation, knowledge, and self-reliance: the 'moving bead box' to increase children's MVPA, especially; family PA tip cards and PA monitoring cards to enhance joint activity in the family; the 'best practices' poster with 20 tips on how to promote PA among children in ECEC; and intervention folders to families where to collect their monthly letters considering issues related to overall well-being. As much as possible, the intervention utilised existing materials to promote children's PA of in ECEC settings (i.e., materials of the Young Finland association Varpaat Vauhtiin! and Pihaseikkailu).

The personnel were encouraged to discuss PA with parents during daily encounters and upon finalization of the individual ECEC plan. The emphasis of the plan is on the objectives set for the pedagogical activities. The ECEC partnership combines the knowledge and experience of parents and personnel, whose relationship plays an essential role in ensuring a child's well-being (Heikkilä et al., 2004). The researchers participated in parents' evenings, where they discussed the baseline results (Phase I; Soini et al., 2012) on the importance of PA for health and well-being and how guardians can enhance it through their own actions. Monthly letters related to health and well-being were also distributed to families through the ECEC. In addition, families, as important role models for children, were offered the opportunity to borrow and use pedometers during the measurement period.

Amongst the methods discussed in the planning meetings, the personnel chose the most suitable ones to be implemented in their childcare centres. In each of the intervention ECEC centres, the personnel themselves tested the functionality of these different methods monthly. The research team provided support, such as in-service education, produced materials, or offered information on where to get relevant materials. For ECEC personnel, two training sessions about observing children's motor skills were organised, monthly PA tips were given, and a follow-up planning meeting for the intervention was conducted. Monthly PA tips aimed at increasing personnel's social support for PA of children.

In spring 2012, the researcher and responsible ECEC personnel attended the intervention follow-up meeting. There was a free discussion among the participants on topics related to the implementation of the intervention. Notes were taken of the discussion. The aim was to assess which methods of the intervention had been in use in the centre, which had been proven to be suitable for everyday life in the ECEC, which had remained only experimental, and what would be done in the future. The design and content of the HIPPA intervention have also been described by Mehtälä and colleagues (2017).

For one year starting in August 2011, the HIPPA was implemented step-by-step by ECEC personnel in childcare centres. As the HIPPA was integrated into the daily routines of the centres (Table 2), the intervention was implemented and realised with the whole child group. However, only the children who provided written research consent were assessed.

TABLE 2 A typical daily programme of a childcare centre in Finland is illustrated by Soini et al. (2016) work who also examined the daily programme at the same time period as the data collection in this paper

TIME	*ACTIVITY*
6:30 a.m. – 8:00 a.m.	Childcare centre opens, unstructured play indoors
8:00 a.m. – 9:00 a.m.	Breakfast
9:00 a.m. – 11:00 a.m.	Structured activity time indoors, free play indoors and/or outdoors
11:00 a.m. – 12:00 a.m.	Warm lunch
12:00 a.m. – 2:00 p.m.	Rest, unhurried activities
2:00 p.m. – 2:30 p.m.	Snack
2:30 p.m. – 3:00 p.m.	Free play indoors
3:00 p.m. – 5:00 p.m.	Free play outdoors
5:00 p.m.	Childcare centre closes

Data collection and PA measures

The OSRAC-P was developed to assess children's PA behaviours in preschool settings (Brown et al., 2006). This direct observation instrument has been used to evaluate children's PA intensity, PA types, location, and social interactions (group composition, PA initiator, prompts) at childcare centres. In the present study, the observers (N = 9) were trained using the method suggested by Brown and colleagues (2009). Prior to data collection, they studied the necessary background information of the method, memorised the instrument, and practiced observing by watching videos or monitoring the live actions of children in ECEC settings or playgrounds.

Observations were performed simultaneously by two observers. One pair of observers was assigned to the intervention and the other to the control childcare centre. Each childcare centre was visited on three consecutive days per data collection period to conduct direct observations. Data were collected from randomly selected participants to distribute observations evenly across the morning (8 a.m. to 12 noon) and afternoon schedules (2 p.m. to 5 p.m.) inside and outside ECEC premises. The children were not observed during meals or during rest times. The observers used a focal-child momentary time-sampling procedure with 15-s observe and 30-s record intervals eight times, yielding 6-minute observation blocks (Gubbels et al., 2011). Some of the blocks included fewer than eight observations, such as when a child left for home before the observation ended. Altogether, 47,024 single observations were recorded (2 observers x 4 data collection periods x (85–117) children x mean 7.6 blocks x 8 observations/block (Appendix 1).

PA intensity level was measured on a five-point scale (1 = stationary or motionless, 2 = stationary with limb or trunk movements, 3 = slow or easy movements, 4 = moderate movements, and 5 = fast movements), and the highest intensity level reached by the child during each 15-s observation was recorded. For this study, three dichotomous PA level variables were formed: PA level 1 (stationary or motionless) and level 2 (stationary with limb or trunk movements) were recoded to indicate sedentary behaviours, level 3 (slow or easy movements) characterised light PA, and levels 4 (moderate movements) and 5 (fast movements) were combined to represent MVPA (see Brown et al., 2009; Gubbels et al., 2011; Soini et al., 2016).

Inter-rater reliability measures

The reliability of the OSRAC-P in the Finnish ECEC context was tested in the spring of 2010 (Seppälä, 2011). Previously, a Dutch research group used this protocol with few differences (Gubbels et al., 2011). For the current study, the inter-rater reliability (IRR)

was evaluated using both Cohen's Kappa statistic and interval-by-interval agreement (IOA). Cohen's Kappa coefficient estimates and their 95% confidence intervals (CI) using Light's (1971) extension were calculated to determine the IRR of the two observers for the single observations of the OSRAC-P variables (Hallgren, 2012). Light's Kappa equals the average of Kappa values calculated for all observer pairs. Light's Kappa values showed substantial to almost perfect agreement in the observations of two observer groups in all other OSRAC-P categories (sedentary PA, MVPA, type of PA, group composition, indoor context, outdoor context, and initiator of activity) but moderate agreement in LPA and prompts (Mean κ = .705 (95% CI, .617–.793; Landis and Koch, 1977). IOA scores exceeded 85% in all other categories except in LPA, in which agreement was 78.9% (Mean IOA = 95.8% (95% CI, 94.3–97.3) (See Appendix 2).

Statistical analysis

The preliminary analyses consisted of chi-squared tests to determine differences in the prevalence of OSRAC-P variables between the two groups (intervention and control) at different time points. Our previous analysis with PA, measured by accelerometers (Mehtälä et al., 2017) and the other flexible ecological study in childcare-age children, revealed differences in PA intervention responses between genders (Pate et al., 2016); hence, analyses were conducted separately for boys and girls.

The mean PA was calculated by obtaining the average value of the eight single observations of the six-minute blocks and recordings of the two observers. The dichotomous OSRAC-P variables (e.g., group time) were stated as 'present' when both or the other observer recorded it as present (1) and stated as 'absent' when both observers recorded it as absent (0) (Soini et al., 2016). The primary observer's marking was chosen when only one option had to be selected.

The effectiveness of the HIPPA intervention in increasing the children's mean PA was analysed using a linear mixed effect model (LMM), in which group (intervention/control), time, gender, and season were entered as fixed effects. The season was included as a random slope, and a child's centre and nested effects of a child were included in the model as random effects. All models were adjusted for the children's age and BMI. The restricted maximum likelihood method was used in the parameter estimation. Numerous models were conducted to evaluate the necessity of including the random intercept and to determine the best-fitting covariance structure using Akaike's information criterion (AIC) and the Bayesian information criterion (BIC). The best-fitting variance-covariance structure was the scaled identity. We also checked the significance of the interactions between the fixed effects. The data included missing values, but these were assumed to be completely random.

The moderation effects of covariates were analysed using the LMM, and only the data from the initiation of the HIPPA intervention and post-intervention measurement points were included. In all the models, group, time, gender, and selected covariates were introduced as fixed effects; time and group were included as random slopes; and centre and nested effects of a child were included as random effects. The models were adjusted for the children's age and BMI. The dependent variable was cube root transformed for the general socio-environmental models and indoor activity models. The best-fitting variance-covariance structure was the scaled identity.

In the general socio-environmental model, the covariates (i.e., primary location (in or out), time of day (morning or afternoon), group composition (with adult(s) or only child(ren)) and activity initiator (adult or child)) were introduced as fixed effects. The indoor activity models included the seven most often observed indoor activities: playing with toys (yes/no), other activities not listed in the OSRAC-P (yes/no), group time (yes/no), art (yes/no), sociodramatic play (yes/no), teacher-arranged activity (yes/no), and transition between different locations inside (yes/no). The outdoor activity models also included the seven most observed outdoor activities: playing in open space (yes/no), playing with fixed equipment (yes/no), playing in the sandbox (yes/no), playing with portable equipment (yes/no), sociodramatic play (yes/no), other activity not listed in the OSRAC-P (yes/no), and riding or using push toys with wheels (yes/no).

To identify the interaction effects of the intervention and their covariates, we forced the model interactions between time and all covariates, between group and covariates, and finally, three-way interactions between time, group, and covariates.

Multilevel logistic regression was conducted to examine the nature of the differences between the intervention and control groups in the associations between moderate-to-vigorous (MVPA) and light-to-vigorous (LMVPA) intensity levels and the selected covariates. In the models, we included group, time, and the interaction of time and group as fixed effects, which were adjusted for gender and age. A child's centre and nested effects of a child were assigned as random effects, and time was assigned as a random slope. All analyses were performed using SPSS Statistics for Windows, version 25.0 (IBM Corp., Armonk, NY, USA). p-values < .05 were considered statistically significant.

Results

Intervention effects on PA levels

The interaction effect between time and group was significant ($F(3, 97) = 7.117$, $p < .001$). There were smaller increments in PA amongst the control group than in the intervention group post-intervention compared to PA at the start of the intervention ($b = –0.21$, $t(257) = –3.56$, $p < .001$). According to post-hoc tests, children in the HIPPA group had higher PA levels compared with those in the control group post-intervention (estimated mean difference = 0.162, 95% CI [0.038–0.286], $p = .012$). Correspondingly, the PA levels of the control group were higher than of the HIPPA group at follow-up (estimated mean difference = 0.150, 95% CI [0.024–0.276], $p = .021$).

Amongst boys, the interaction effect between time and group was significant ($F(3,133) = 4.331$, $p = .006$). There was a smaller increment in PA amongst control boys than amongst boys in the HIPPA group post-intervention compared with their PA at the start of the intervention ($b = –0.28$, $t(99) = –2.86$, $p = .005$). Pairwise comparisons revealed that boys in the HIPPA group had higher PA levels compared to those in the control group post-intervention (estimated mean difference = 0.203, $p = .015$), whilst at the follow-up, the PA of boys in both the HIPPA and control groups were no longer different ($F(1, 165) = 2.947$, $p = .088$).

Amongst girls, the interaction effect between time and group was also significant ($F(3,92) = 5.065$, $p = .003$). There were smaller increments in PA amongst control girls than amongst those in the HIPPA group post-intervention compared with their PA at the start of the intervention ($b = –0.16$, $t(125) = –2.38$, $p = .019$). Girls in the HIPPA group had higher PA levels than those in the control group post-intervention (estimated mean difference = 0.180, $p = .010$). At follow-up, the PA of girls in both the HIPPA and control groups did not differ significantly ($F(1,42) = 3.217$, $p = .08$).

Table 3 presents the longitudinal percentual changes in activity levels based on the primary locations of the observed children during the observations. The percentages demonstrate that in the HIPPA childcare centres, PA time increased and sedentary time decreased; the percentual increase is evident, especially in the children's MVPA proportions. The percentage of intervals at the post-intervention and the percentage changes in all observed categories are presented in Appendix 3.

TABLE 3 Percentage of intervals at post-intervention (T2) and percentage changes in observed primary locations between the start of the HIPPA (T1) and post-intervention (T2) by PA levels and intervention conditions

INTERVENTION CONDITION	*OBSERVED CODES*	*OBSERVED INTERVALS (T2 % OF TOTAL)*	*PERCENTAGE OF INTERVALS AT T2 BY ACTIVITY LEVELS (T2% - T1%)*		
CONTROL (n = 36)			Sedentary (Levels 1–2)	Light (Level 3)	MVPA (Levels 4–5)
	Inside	2,468 (51)	64 (–1)	28 (2)	9 (–1)
	Outside	2,304 (51)	26 (–9)	45 (10)	29 (–1)
	Transition	20 (80)	50 (0)	44 (19)	6 (–19)
HIPPA (n = 52)					
	Inside	3,182 (51)	51 (–19)	34 (8)	16 (11)
	Outside	2,829 (51)	19 (–19)	47 (4)	34 (15)
	Transition	44 (52)	35 (–18)	48 (0)	17 (17)

Note. *The observed children are the same at T1 and T2 (N = 88)

Moderating effects of the socio-environmental contexts on the relation between intervention condition and children's PA

All children

As the Table 4 shows, the difference in children's PA between intervention conditions was enhanced indoors compared to the outdoor environment post-intervention (b = 0.025, t(12045) = 3.719, p < .001). Furthermore, the effect was weaker in the mornings compared to afternoon activities (b = –0.037, t(12072) = –5.745, p < .001) and in adult-initiated activities compared to child-initiated activities (b = –0.056, t(12075) = –4.783, p <.001). The model-building process for the general socio-environmental context is presented in Appendix 4.

TABLE 4 The moderating effects of the general socio-environmental context covariates on the relationship between the intervention condition and the children's observed PA from the start of the intervention up to post-intervention

EFFECT	*ESTIMATE*	*SE*	*95% CI*		*p**
			LL	UL	
Gender	−0.013	0.007	−0.028	0.001	.066
Primary location	0.025	0.007	0.012	0.038	<.001
Time of day	−0.037	0.006	−0.049	−0.024	<.001
Group composition	0.005	0.010	−0.015	0.025	.621
Initiator	−0.056	0.011	−0.078	−0.033	<.001

Note. Children's PA = mean of the highest observed PA level at each observation interval (1–8). The variable was cube root transformed. Level 1 Observed intervals Control *N* = 5,360, HIPPA *N* = 6,935; Level 2 Children control *N* = 47, HIPPA *N* = 70, Level 3 Childcare centre *N* = 14; CI = confidence interval; *LL* = lower limit; *UL* = upper limit. **p*-values from the cross-level interaction test. Gender: girl = 0, boy = 1; Primary location: indoors = 0, outdoors = 1; Time of day: morning = 0, afternoon = 1; Group composition: adult = 0, child = 1; Initiator: adult = 0, child = 1.

The stratified subgroup analysis showed that the OR values of MVPA and LMVPA increased in favour of the HIPPA group indoors (OR = 4.65, 95% CI [2.45, 8.82]; OR = 2.95, 95% CI [1.46, 5.97], respectively) and in the afternoons (OR = 3.18, 95% CI [1.81, 5.58]; OR = 3.08, 95% CI [1.61, 5.90], respectively). The odds of MVPA, but not LMVPA were higher in the HIPPA group compared to the control group outdoors (OR = 2.33, 95% CI [1.41, 3.85]; OR = 1.51, 95% CI [0.93, 2.46], respectively) and in the mornings OR = 2.25, 95% CI [1.39, 3.63]; OR = 1.46, 95% CI [0.80, 2.66], respectively). The OR values of MVPA and LMVPA also increased in child-initiated (OR = 2.58, 95% CI [1.77, 3.77]; OR = 2.33, 95% CI [1.30, 4.18], respectively) but not in adult-initiated activities (OR = 1.51, 95% CI [0.58, 3.94]; OR = 0.61, 95% CI [0.17, 2.21], respectively).

Figure 2 demonstrates the interaction effect between time and intervention condition based on the observed primary locations.

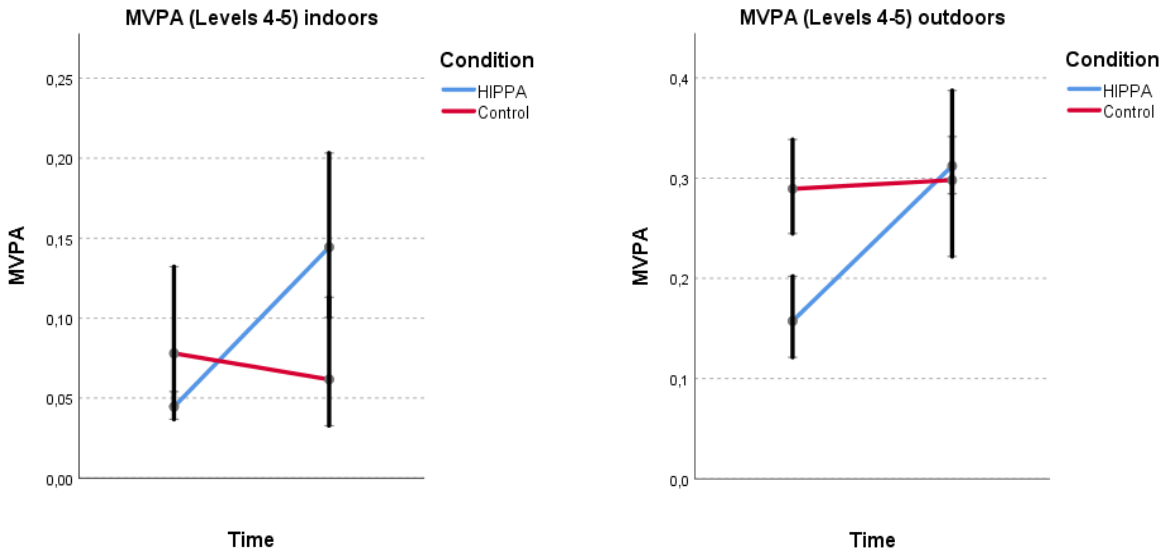

FIGURE 2 Interaction effects between time and intervention condition on children's MVPA indoors and outdoors. Multilevel logistic linear regression models were adjusted with a grand mean centred children's age.

Indoor activities

Significant interaction effects were observed in all indoor activities except transition (Table 5). Differences in the children's average interval PA levels between intervention conditions were reduced due to the effects of these indoor factors.

TABLE 5 The moderating effects of indoor activities on the relationship between the intervention condition and children's observed PA from the start of the intervention to post-intervention

EFFECT	*ESTIMATE*	*SE*	*95% CI*		*p**
			LL	UL	
Toys	−0.047	0.011	−0.068	−0.026	<.001
Other	−0.051	0.011	−0.073	−0.030	<.001
Art	−0.167	0.016	−0.199	−0.136	<.001
Group time	−0.046	0.014	−0.073	−0.020	.001
Sociodramatic	−0.036	0.016	−0.067	−0.004	.026
Teacher arranged	−0.050	0.018	−0.085	−0.015	.005
Transition	−0.005	0.017	−0.039	0.029	.776

Note. Children's PA = mean of the highest observed PA level at each observation interval (1–8). The variable was cube root transformed. Control Level 1 Observed intervals *N* = 2,488, HIPPA *N* = 3,234, Level 2 Children control *N* = 47, HIPPA *N* = 70, Level 3 Childcare centre *N* = 14; CI = confidence interval; *LL* = lower limit; *UL* =

upper limit. *p-values from the cross-level interaction test. Toys = playing with toys, dolls, dollhouses, Lego, puzzles etc.; Other = being in some other indoor context or engaging in some activity other than the options listed in the OSRAC-P; Art = engaging in art activities or being in an art centre or activity area; Group time = participating in a group activity that is teacher organised or led; Sociodramatic = engaging in sociodramatic or pretend to play activities or being in a sociodramatic play centre; Teacher arranged = engaging in teacher planned, arranged, and led gross motor physical activities with or without equipment; Transition = moving from one classroom activity context to another area without engaging in materials.

However, the stratified subgroup analysis showed that the odds of MVPA and LMVPA were higher when children played with toys (OR = 24.36, 95% CI [4.95, 119.78]; OR = 4.53, 95% CI [1.63, 12.56], respectively) in the HIPPA group compared to the control group. The odds of MVPA were higher in sociodramatic play and in other activities than listed in the OSRAC-P in the HIPPA group compared to the control group (OR = 44.50, 95% CI [8.42, 235.27]; OR = 4.50, 95% CI [1.57, 12.94], respectively].

Outdoor activities

Significant interaction effects were observed in almost all outdoor activities (Table 6). The effects of these outdoor factors increased the differences in the children's average interval PA levels between intervention conditions.

TABLE 6 The moderating effects of outdoor activities on the relationship between the intervention condition and children's observed PA from the start of the intervention up to the post-intervention

EFFECT	*ESTIMATE*	*SE*	*95% CI*		*p**
			LL	UL	
Fixed	0.325	0.065	0.198	0.451	<.001
Open space	0.418	0.064	0.294	0.543	<.001
Portable	0.393	0.109	0.179	0.608	<.001
Sandbox	0.395	0.067	0.264	0.526	<.001
Sociodramatic	0.441	0.094	0.256	0.626	<.001
Wheel	0.454	0.087	0.282	0.625	<.001
Other	0.154	0.100	0.041	0.349	.123

Note. Children's PA = mean of the highest observed PA level at each observation interval (1–8). Control Level 1 Observed intervals N = 2,304, HIPPA N = 2,829, Level 2 Children control N = 47, HIPPA N = 70, Level 3 Childcare centre N = 14; CI = confidence interval; *LL* = lower limit; *UL* = upper limit. *p-values from the cross-level interaction test. Fixed = Engaging in activity on fixed playground equipment or being on the fixed playground equipment; Open space = Being in an open outdoor area that is not one of the other outdoor activity contexts; Portable = Engaging in activity with equipment brought to the playground other than balls or wheel toys; Sandbox = Engaging in activities using sandbox materials or being in a sandbox; Sociodramatic = Engaging in activity with sociodramatic play props or similar materials; Wheel = Touching, riding, or pushing wheel toys that are not fixed equipment (e.g., tricycles, scooters, wagons); Other = Outdoor activity context other than the options listed in the OSRAC-P.

The stratified subgroup analysis showed that the odds of MVPA were higher in the HIPPA group compared to the control group while playing in open spaces (OR = 2.49, 95% CI [1.30, 4.77]), playing with portable equipment (OR = 5.93, 95% CI [2.18, 16.12]), and playing in sandboxes (OR = 9.02, 95% CI [3.75, 21.74]). The odds of LMVPA were higher in riding or pulling/pushing toys with wheels in the HIPPA group compared to the control group (OR = 17.39, 95% CI [1.99, 151.84]).

Girls

The odds of MVPA and LMVPA indoors (OR = 3.22, 95% CI [1.36, 7.64]; OR = 2.21, 95% CI [1.07, 4.59], respectively) and in the afternoons (OR = 5.12, 95% CI [2.38, 11.02]; OR = 2.18, 95% CI [1.09, 4.34], respectively) were higher in the HIPPA girls compared to the girls in the control group.

The odds of MVPA, but not LMVPA outdoors (OR = 2.73, 95% CI [1.49, 4.99]; OR = 0.92, 95% CI [0.50, 1.69], respectively), in the mornings (OR = 1.92, 95% CI [1.04, 3.57]; OR = 0.93, 95% CI [0.49, 1.78], respectively); and in child-initiated activities (OR = 2.67, 95% CI [1.81, 3.93]; OR = 1.45, 95% CI [0.88, 2.45], respectively), were higher in the HIPPA girls compared to those in the control group. Furthermore, the odds of MVPA outdoors were higher in HIPPA girls when playing in open spaces (OR = 2.46, 95% CI [1.07, 5.64]) compared to the control girls.

Boys

The odds of MVPA and LMVPA indoors (OR = 7.21, 95% CI [3.88, 13.39]; OR = 2.72, 95% CI [1.16, 6.36]), in the afternoons (OR = 2.43, 95% CI [1.04, 5.67]; OR = 4.91, 95% CI [1.76, 13.73]), and in child-initiated activities (OR = 2.53, 95% CI [1.18, 5.42]; OR = 3.74, 95% CI [1.36, 10.76]) were higher in the HIPPA boys compared to the control boys. Furthermore, the odds of MVPA indoors were higher in the HIPPA boys in playing with toys (OR = 8.91, 95% CI [1.15, 69.30]), and in other activities apart from those listed in OSRAC-P (OR = 15.31, 95% CI [4.10, 57.24]), compared to the control boys.

The odds of LMVPA indoors were higher in playing with toys (OR = 5.41, 95% CI [1.56, 18.77]), and in sociodramatic play (OR = 23.47, 95% CI [2.01, 274.77]), but lower in transition (OR = 2.48 x 10^{-7}, 95% CI [6,97 x 10^{-8}, 1.74 x 10^{-6}]), compared to the control boys.

The odds of LMVPA, but not MVPA outdoors, were higher in the HIPPA boys compared to those in the control group (OR = 3.43, 95% CI [1.06, 11.08]; OR = 2.10, 95% CI [0.83, 5.30], respectively), whilst the odds of MVPA, but not LMVPA in the mornings, were higher in the HIPPA boys compared to those in the control group (OR = 2.56, 95% CI [1.18, 5.56];

OR = 1.89, 95% CI [0.87, 4.13], respectively). The OR values of MVPA increased in favour of the HIPPA group in sandbox activities (OR = 21.90, 95% CI [9.75, 49.17]), and decreased in activities apart from those listed in the OSRAC-P (OR = 0.19, 95% CI [0.04, 0.84]). Furthermore, the odds of LMVPA outdoors were higher in the HIPPA boys in sandbox activities (OR = 12.01, 95% CI [4.98, 28.98]), in sociodramatic play (OR = 3.66, 95% CI [1.58, 8.5]), and in riding or pulling or pushing with wheel (OR = 3.29 x 10^8, 95% CI [1.68 x 10^7, 6.43 x 10^9]), compared to the control boys.

Discussion

This research focused on examining the effects of the HIPPA intervention on children in ECEC settings. A real-life HIPPA intervention was implemented by ECEC personnel to promote the PA of children aged four to five years. The intervention proved to be successful, based on the increased PA post-intervention amongst HIPPA children in ECEC settings. This study adds information to the scarce research on the long-term promotion of childcare-aged children's PA (Jones et al., 2019).

In the present study, children's PA increased in the afternoons and during child-initiated activities, indicating that the intervention especially affected the more sedentary time of day (Soini et al., 2016) and unstructured time of ECEC. The increase in PA indoors suggests that the HIPPA intervention affected the practices of the childcare centres. Discussions with ECEC personnel highlighted the presence of restrictions and rules that were more likely to inhibit children's PA indoors than outdoors. The safety of the children justified the existence of the rules, but some of the rules could be removed by thinking about the practices in a new way. Interestingly, gross motor activities were observed more frequently in the HIPPA centres post-intervention than at the start of the intervention (82% of the observed intervals were at post-intervention) and more frequently than in the control childcare centres (Table S3). In other words, HIPPA children were more likely than usual to engage in gross motor activities without adult initiation or immediate presence. The results also indicate that sociodramatic play and transition indoors were more often at physically higher intensive levels than at the start of the intervention. The findings support the notion that ECEC practices have changed to a more permissive and supportive direction in terms of PA indoors. Findings regarding gross motor activities and sociodramatic play are promising, although they do not seem to enhance the intervention effect on the observed mean PA. These activities can be considered as active play—an unstructured form of PA with or without equipment where, more importantly, children have fun (Truelove et al., 2017). Overall, the results support the hypothesis of Truelove and colleagues (2017) that active play may be easier to

promote amongst young children than PA from the perspective of ECEC personnel and that educators' perceptions of PA for childcare-age children being only structured activities or simply involving running or jumping (Jones et al., 2019) may have changed.

The intervention was supported by researchers; however, the ECEC personnel implemented the methods in accordance with the context of their respective centres. At the follow-up, the participating ECEC personnel were asked to fill in a questionnaire regarding the extent and quality of the implementation of the HIPPA intervention in their centres, and almost 60% answered the questionnaire. The results showed that the most frequently implemented intervention method was the modification of indoor facilities to promote PA. They used floor tapes and figures and built obstacle courses to encourage the children to move in various ways (balancing, jumping) but to do so safely in specific areas of the centre. Four out of five (81%) intended to keep PA equipment available to children during free play in the future (Mehtälä et al., 2017).

Considering that children in ECEC are more sedentary in afternoons than in mornings (Soini et al., 2016) and indoors than outdoors (Tandon et al., 2018), it is logical that the HIPPA intervention affected more children's PA in those contexts. Due to the lower PA indoors, there was more room to increase children's PA compared to the outdoor setting, along with a variety of targets that the intervention could influence. The ECEC programme is structured indoors, especially in the mornings, but children's spontaneous, free play is a highly cherished part of the ECEC setting (Arash, 2016, see also Table 2). The adult-led group sessions (i.e., group times) are also held in the mornings. Group time was the third most common indoor activity and proved to be very sedentary in both intervention conditions in the present study (Table S3). The level of group-time activity in the HIPPA intervention group even decreased slightly during the intervention. Regarding the relative contribution of group time to the total ECEC time in the mornings, teaching ECEC personnel how to activate those learning sessions physically could increase children's PA whilst also providing opportunities to enhance their academic skills and fundamental motor skills (Jylänki et al., 2022; Trost et al., 2008; Van der Fels et al., 2015). Good motor skills enable children to enjoy various physical activities and may help them maintain a life-long active lifestyle (Stodden et al., 2008).

The HIPPA intervention included methods to facilitate outdoor play time (i.e., stressing the importance of outdoor time and encouraging ECECs to modify the environment to make it more inspiring to PA with equipment or playground markings, with organised/adult-led or adult-initiated PA, or by using existing PA campaign materials) because of the unquestionable evidence of the importance of outdoor time in providing PA opportunities for children (Sääkslahti & Niemistö, 2021; Truelove et al., 2018). The level of intervention implementation was lower outdoors than indoors (59% vs. 86%),

but the outdoor time provided increased by 45 minutes per day in the HIPPA childcare centres (Mehtälä et al., 2017). In contrast to indoor conditions, outdoor facilities are usually suitable and safe for every kind of PA, which is why children are also allowed to be more physically active outdoors. Outdoor time is considered free time for children (Iivonen et al., 2021), which is also evident in the results of the present study and may be reflected in the implementation levels of the intervention. Adult-initiated activities and prompts for PA occurred very rarely. Teacher-arranged activities were not observed outdoors in the HIPPA centres and only in 1% of all outdoor intervals in the control centres.

After half a year of intervention, children's PA was slightly higher in the control group compared to the HIPPA group. In Finland, pre-primary school education is provided for six-year-old children. Thus, at the follow-up time, the participating children were already enrolled in pre-primary school education, so the adults around them, and even the group and the facility where they were during ECEC time, may have already changed. Previous studies have reported that increasing children's outdoor play opportunities and the availability of PA equipment promote children's PA, but these methods alone are insufficient to maintain such an increase over a more extended period (Alhassan et al., 2007; Cardon et al., 2009). This may be why children's PA in the HIPPA group decreased after half a year of intervention. Specifically, changes in practice may not have gone to a policy level. Anticipating staff turnover in general, the entire ECEC unit must be committed to changing its patterns to promote children's PA (Repo et al., 2020).

The primary strength of the present study is that it is a long-term PA intervention with a follow-up, which is still scarce in this research area (Jones et al., 2019). The HIPPA intervention was part of the usual ECEC time, so the whole child group, and not only the children participating in the research, were influenced.

This work also has limitations that should be recognised. First, PA was measured by observing randomly selected children amongst the participants. As a method, observation is valuable when searching for detailed information about the social, physical, and pedagogical environments associated with PA (Brown et al., 2006; Loprinzi & Cardinal, 2011). However, it should be noted that activities during the observation recordings were not observed and, therefore, not recorded. The intervals were also not recorded if the next child participating in the study was not immediately found for observation. Thus, only parts of their ECEC times were recorded.

Second, the highest PA level achieved by an observed child during the observation interval was recorded. At the same time, all the activities in which they participated during this time frame were recorded. This might have slightly increased the mean PA of typically

very sedentary activities. However, the amount of the increase is expected to be the same for both the intervention and control groups.

Third, the number of participating children was relatively low, which may have affected the precision of our results. Thus, the effects of a small sample size should be kept in mind when interpreting the results. Finally, the PA knowledge and skills of the ECEC managers, the personnel's competence in supporting children's PA, and the children's own motivations and self-efficacies were not assessed; however, they were objects in the HIPPA intervention. Hence, the impacts of these factors on the children's PA remain unresolved.

Conclusions

The results of the present study show that the real-life PA intervention, implemented over one year by ECEC personnel with the support of researchers, increased PA in four-year-old children. To the best of our knowledge, this study is the first attempt to determine from the child's level where the intervention effects lie and what the methods are like amidst the background of the impact of a multi-component intervention in ECEC settings.

Our results indicate that children's PA could be promoted by allowing them to be physically active indoors during unstructured time. Creating small indoor areas suitable for active play is a cost-effective and easy-to-implement strategy (Hendersson et al., 2015). Keeping PA equipment, such as balls, jumping ropes, and trampolines, available for children, along with indoor facilities, can inspire children to engage in active play more effectively. Implementing these methods may require changes in the practices of the ECEC settings and personnel's attitudes towards children's physically active play, especially indoors. Furthermore, influencing personnel's perceptions of their competence in supporting children's active play through ECE teacher education could also be a long-term strategy that can be translated into a policy-level strategy (Soini et al., 2021).

Current evidence suggests that increasing childcare-aged children's PA requires multicomponent interventions (Jones et al., 2019; Mehtälä et al., 2014) and that the ECEC setting is ideal for implementing an effective intervention; this is also supported by the present study. However, the ECEC setting *per se* is a complex environment, with various interactions among personnel, children, and their environment (Jones et al., 2019; Mehtälä et al., 2014). To improve the effectiveness of an intervention on a larger scale in real-life scenarios, it is essential to evaluate the effective methods in multi-component interventions and why they are effective.

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APPENDIX 1 Descriptions of the moderators. Number of observed intervals and percentage of intervals in the intensity levels of all measurements by intervention condition from the Anonymized initiation up to the follow-up (modified by Brown et al., 2006).

		Control				HIPPA			
Observed categories	Observed codes	Observed intervals	Percent of intervals by activity levels			Observed intervals	Percent of intervals by activity levels		
			Sedentary (Levels 1-2)	Light (Level 3)	MVPA (Levels 4-5)		Sedentary (Levels 1-2)	Light (Level 3)	MVPA (Levels 4-5)
Primary locations	Inside	5,725	64	25	11	7,337	65	26	8
	Outside	4,584	30	38	33	5,766	32	44	24
	Transition*	48	50	46	4	59	41	53	7
Total observed intervals		10,350				13.162			
Physical activity types	Sit or squat	5,539	67	26	7	7,389	71	24	5
	Stand	3,556	44	41	15	4,569	40	48	12
	Walk	2,404	8	60	32	3,747	6	68	26
	Run	877	3	15	82	1,013	2	19	79
	Climb	659	7	40	54	617	4	54	42
	Pull or push	641	6	47	48	545	4	44	52
	Jump or skip	385	3	30	67	277	2	40	59
	Crawl	312	9	62	29	268	11	68	21
	Lie down	244	50	36	14	276	55	33	12
	Swing	299	12	40	48	199	11	44	45
	Slide	157	4	33	63	258	18	54	28
	Ride	146	11	33	56	169	15	35	50
	Throw	141	4	45	52	141	1	55	44
	Balance	161	13	42	45	91	6	73	22
	Rough and tumble	144	5	45	50	88	0	67	33
	Dance	85	7	52	41	52	10	48	42
	Other	119	7	33	61	17	47	29	24
	Ski	69	20	25	55	53	23	49	28
	Skate	68	9	31	60	46	28	61	11
	Swim	49	35	25	41	65	0	40	60
	Roll	44	7	46	48	38	5	79	16
	Rock	28	7	39	54	50	26	54	20
Total observed intervals		16,127				19,968			

Appendix 1 Continues

		Control				HIPPA			
Observed categories	Observed codes	Observed intervals	Percent of intervals by activity levels			Observed intervals	Percent of intervals by activity levels		
			Sedentary (Levels 1-2)	Light (Level 3)	MVPA (Levels 4-5)		Sedentary (Levels 1-2)	Light (Level 3)	MVPA (Levels 4-5)
Indoor activities	Toys	1,693	69	25	6	2,823	75	22	4
	Other	1,386	54	34	12	1,580	47	43	10
	Group time	939	84	13	3	837	87	11	2
	Art	590	86	13	1	901	88	10	2
	Sociodramatic	567	49	38	13	520	38	48	14
	Teacher arranged	411	29	31	40	372	37	37	27
	Transition	336	19	57	24	299	7	61	32
	Music	260	75	18	7	201	64	21	15
	Gross motor	192	16	33	52	226	11	50	39
	Selfcare	119	62	28	10	179	64	32	3
	Video	86	95	5	0	111	98	2	0
	Housework	60	45	37	18	88	52	39	9
	Manipulative	39	95	5	0	78	97	3	0
	Pool activity	48	40	19	42	69	15	30	55
	Large block	52	17	54	29	31	19	55	26
	Snack	22	73	23	5	48	56	42	2
	Preacademic	17	77	24	0	19	74	26	0
	Tantrum	3	33	67	0	10	1	80	20
	Time Out	2	100	0	0	4	100	0	0
Total observed intervals		7,048				8,707			

Appendix 1 Continues

		Control				HIPPA			
Observed categories	Observed codes	Observed intervals	Percent of intervals by activity levels			Observed intervals	Percent of intervals by activity levels		
			Sedentary (Levels 1-2)	Light (Level 3)	MVPA (Levels 4-5)		Sedentary (Levels 1-2)	Light (Level 3)	MVPA (Levels 4-5)
Outdoor activities	Open space	970	28	40	31	1,999	26	44	30
	Fixed equipment	1,113	25	39	36	1,020	26	49	25
	Sandbox	754	37	46	17	1,183	46	43	11
	Portable equipment	539	26	38	36	1,097	28	44	29
	Sociodramatic	451	40	35	25	722	37	43	20
	Other	674	37	37	25	330	47	40	13
	Wheel	411	20	35	46	432	20	33	48
	Games	274	25	26	49	99	13	31	56
	Transition	257	20	41	40	93	27	60	13
	Forest	142	33	37	30	124	19	65	15
	Sports field	148	23	30	47	109	26	55	19
	Ball and object	92	22	36	42	48	25	38	38
	Teacher arranged	31	32	39	29	13	15	54	31
	Tantrum	18	67	33	0	20	60	30	10
	Snacks	3	67	33	0	11	9	91	0
	Pool	0	NA	NA	NA	7	0	43	57
	Time out	1	0	100	0	1	0	0	100
Total observed intervals		5,878				7,786			
Activity initiators	Adult Initiated	2,514	62	22	16	2,665	64	26	10
	Child Initiated	7,843	44	34	22	10,497	47	36	17
Total observed intervals		10,357				13,162			
Group composition	Group child only	3,862	44	34	22	5,188	44	38	18
	One-to-one peer	3,062	42	35	23	3,809	47	36	17
	Group with adult	3,127	60	24	16	3,498	64	26	10
	Solitary	1,748	42	35	23	2,492	43	40	17
	One-to-one adult	385	51	33	16	452	56	36	8
Total observed intervals		12,184				15,439			

Note. Prompts to PA were also observed, but they were not included in any of the analyses because there were too few of them. *Observed transition intervals were integrated into the indoor intervals in the moderation analysis.

APPENDIX 2 Kappa coefficients and interval-by-interval agreement for observed categories in Observational System for Recording Physical Activity in Children – Preschool (OSRAC-P; Brown et al., 2006) (n = 76,800 observations).

OBSERVED CATEGORY		*M*	*SD*	*95%CI*
Physical activity levels, all	Kappa coefficient	.497	.128	.407 – .587
	Interval-by-interval agreement (%)	87.6	8.3	80.3 – 94.9
Sedentary	Kappa coefficient	.695	.065	.653 – .738
	Interval-by-interval agreement (%)	85.5	N/A	N/A
Light	Kappa coefficient	.483	.098	.425 – .537
	Interval-by-interval agreement (%)	78.4	N/A	N/A
MVPA	Kappa coefficient	.611	.122	.530 – .691
	Interval-by-interval agreement (%)	90.8	N/A	N/A
Physical activity types	Kappa coefficient	.667	.200	.539 – .795
	Interval-by-interval agreement (%)	97.4	4.2	95.6 – 99.2
Group compositions, all	Kappa coefficient	.732	.122	.663 – .802
	Interval-by-interval agreement (%)	92.9	3.4	90.0 – 95.9
Adult involved or present	Kappa coefficient	.803	.170	.752 – .853
	Interval-by-interval agreement (%)	93.7	N/A	N/A
Child/ren only involved or present	Kappa coefficient	.793	.199	.746 – .840
	Interval-by-interval agreement (%)	93.6	N/A	N/A
Primary locations	Kappa coefficient	.836	.105	.761 – 911
	Interval-by-interval agreement (%)	99.7	0.1	99.6 – 99.8
Indoor activities	Kappa coefficient	.779	.181	.698 – .859
	Interval-by-interval agreement (%)	99.1	1.5	98.4 – 99.7
Outdoor activities	Kappa coefficient	.721	.181	.630 – .812
	Interval-by-interval agreement (%)	98.7	1.7	97.9 – 99.6
Initiator of activities	Kappa coefficient	.874	.077	.846 – .902
	Interval-by-interval agreement (%)	94.8	0.0	94.8 – 94.8
Prompts for PA, all	Kappa coefficient	.499	.218	.296 – .701
	Interval-by-interval agreement (%)	99.7	0.4	99.3 – 100.0
No prompts	Kappa coefficient	0.491	.231	.282 – .700
	Interval-by-interval agreement (%)	99.2	N/A	N/A
All categories	Kappa coefficient	.705	.155	.617 – .793
	Interval-by-interval agreement (%)	95.8	2.0	94.3 – 97.3

APPENDIX 3 Percentage of intervals at the post-intervention (T2) and percentage changes in observed categories between the start of the intervention (T1) and the post-intervention (T2) by PA levels and by intervention condition.

		*CONTROL (n = 36)**				*INTERVENTION (n = 52)**			
OBSERVED CATEGORIES	*OBSERVED CODES*	*OBSERVED INTERVALS (T2 % OF TOTAL)*	*PERCENTAGE OF INTERVALS AT T2 BY ACTIVITY LEVELS (T2% - T1%)*			*OBSERVED INTERVALS (T2 % OF TOTAL)*	*PERCENTAGE OF INTERVALS AT T2 BY ACTIVITY LEVELS (T2% - T1%)*		
			Sedentary (Levels 1-2)	Light (Level 3)	MVPA (Levels 4-5)		Sedentary (Levels 1-2)	Light (Level 3)	MVPA (Levels 4-5)
Primary locations	Inside	2,468 (51)	64 (-1)	28 (2)	9 (-1)	3,182 (51)	51 (-19)	34 (8)	16 (11)
	Outside	2,304 (51)	26 (-9)	45 (10)	29 (-1)	2,829 (51)	19 (-19)	47 (4)	34 (15)
	Transition	20 (80)	50 (0)	44 (19)	6 (-19)	44 (52)	35 (-18)	48 (0)	17 (17)
Total observed intervals		4,792 (51)				6,055 (53)			
Physical activity types	Sit or squat	2,568 (50)	64 (-1)	32 (5)	4 (-4)	3,286 (56)	51 (-28)	38 (19)	11 (9)
	Stand	1,805 (49)	39 (-5)	46 (6)	15 (-1)	2,267 (50)	24 (-21)	56 (9)	20 (12)
	Walk	1,022 (49)	5 (-7)	66 (5)	29 (3)	1,827 (47)	1 (-10)	56 (-18)	42 (28)
	Run	414 (53)	1 (-3)	15 (-7)	84 (10)	532 (61)	1 (-5)	11 (-14)	88 (19)
	Climb	326 (56)	5 (-5)	37 (-10)	59 (16)	287 (62)	0 (-7)	42 (-19)	58 (27)
	Pull or push	339 (50)	6 (-2)	68 (22)	27 (-20)	280 (46)	2 (-2)	50 (9)	48 (-7)
	Swing	222 (38)	16 (-10)	32 (8)	52 (2)	152 (36)	17 (-17)	56 (-35)	27 (53)
	Jump or skip	206 (47)	1 (-4)	44 (14)	55 (-11)	134 (69)	0 (-2)	27 (-27)	73 (29)
	Ride	132 (44)	10 (4)	31 (-3)	59 (-1)	125 (52)	0 (-28)	29 (-11)	71 (39)
	Crawl	107 (42)	2 (-8)	71 (11)	27 (-4)	75 (35)	0 (-22)	50 (-11)	50 (34)
	Lie down	97 (40)	41 (-6)	51 (13)	8 (-8)	94 (43)	37 (-50)	40 (30)	24 (21)
	Balance	83 (25)	10 (0)	52 (4)	38 (-4)	60 (58)	3 (-1)	60 (-20)	37 (21)
	Throw	46 (52)	8 (4)	50 (0)	42 (-4)	56 (71)	0 (-6)	40 (-41)	60 (48)
	Rough and tumble	50 (44)	5 (-6)	55 (22)	41 (-16)	35 (71)	0 (0)	36 (-34)	64 (34)
	Slide	29 (55)	6 (-1)	69 (15)	25 (-14)	37 (54)	0 (0)	25 (-52)	75 (52)
	Swim	6 (50)	0 (0)	100 (67)	0 (-67)	46 (85)	0 (0)	44 (15)	56 (-15)
	Rock	9 (0)	0 (NA)	0 (NA)	0 (NA)	27 (52)	7 (-15)	63 (-12)	30 (28)
	Roll	18 (67)	8 (-8)	42 (8)	50 (0)	11 (55)	0 (0)	83 (43)	17 (-43)
	Dance	21 (86)	0 (0)	61 (-39)	39 (39)	2 (100)	0 (NA)	50 (NA)	50 (NA)
	Other	11 (64)	29 (29)	29 (-21)	43 (-7)	12 (8)	0 (-55)	0 (-18)	100 (73)
Total observed intervals		7,511 (49)				9,345 (53)			

Appendix 3 Continues

OBSERVED CATEGORIES	*OBSERVED CODES*	*CONTROL (n = 36)**				*INTERVENTION (n = 52)**			
		OBSERVED INTERVALS (T2 % OF TOTAL)	*PERCENTAGE OF INTERVALS AT T2 BY ACTIVITY LEVELS (T2% - T1%)*			*OBSERVED INTERVALS (T2 % OF TOTAL)*	*PERCENTAGE OF INTERVALS AT T2 BY ACTIVITY LEVELS (T2% - T1%)*		
			Sedentary (Levels 1-2)	Light (Level 3)	MVPA (Levels 4-5)		Sedentary (Levels 1-2)	Light (Level 3)	MVPA (Levels 4-5)
Indoor activities	Toys	706 (50)	64 (-4)	35 (9)	2 (-5)	1,141 (48)	50 (-31)	42 (24)	8 (7)
	Other	494 (57)	51 (-12)	38 (12)	11 (0)	771 (57)	45 (-9)	45 (1)	11 (9)
	Group time	539 (48)	87 (6)	11 (-4)	2 (-2)	418 (59)	90 (2)	9 (1)	1 (-3)
	Art	245 (81)	84 (-11)	14 (10)	2 (2)	310 (49)	78 (-16)	17 (10)	6 (6)
	Sociodramatic	255 (25)	32 (-25)	62 (27)	6 (-2)	194 (61)	19 (-15)	50 (-12)	31 (27)
	Teacher arranged	197 (71)	26 (-7)	31 (-8)	43 (15)	153 (38)	24 (-12)	35 (-10)	41 (21)
	Transition	143 (36)	14 (-18)	60 (7)	27 (12)	151 (63)	6 (3)	33 (-48)	61 (45)
	Music	107 (69)	81 (11)	14 (-17)	5 (15)	70 (51)	97 (15)	0 (-18)	3 (3)
	Selfcare	56 (38)	38 (-28)	33 (5)	29 (23)	89 (49)	59 (-5)	36 (5)	5 (0)
	Gross motor	14 (43)	0 (-13)	17 (-8)	83 (21)	105 (82)	1 (1)	43 (6)	56 (-7)
	Housework	37 (11)	0 (-42)	75 (36)	25 (7)	48 (90)	63 (63)	28 (-72)	9 (9)
	Manipulative	13 (62)	88 (-13)	13 (13)	0 (0)	53 (28)	94 (-7)	7 (7)	0 (0)
	Videos	48 (58)	96 (1)	4 (-1)	0 (0)	7 (14)	0 (-100)	100 (100)	0 (0)
	Pool activity	8 (0)	0 (NA)	0 (NA)	0 (NA)	47 (83)	0 (-13)	44 (19)	56 (-6)
	Large block	37 (0)	0 (NA)	0 (NA)	0 (NA)	12 (67)	0 (-75)	25 (0)	75 (75)
	Snack	13 (46)	83 (-2)	17 (2)	0 (0)	21 (100)	38 (NA)	57 (NA)	5 (NA)
	Preacademic	16 (100)	75 (NA)	25 (NA)	0 (NA)	3 (100)	0 (0)	100 (0)	0 (0)
	Tantrum	2 (0)	0 (NA)	0 (NA)	0 (NA)	5 (80)	0 (0)	0 (0)	0 (0)
	Time out	2 (0)	0 (NA)	0 (NA)	0 (NA)	3 (0)	0 (NA)	0 (NA)	0 (NA)
Total observed intervals		2,902 (52)				3,601 (54)			

Appendix 3 Continues

		*CONTROL (n = 36)**				*INTERVENTION (n = 52)**			
OBSERVED CATEGORIES	*OBSERVED CODES*	*OBSERVED INTERVALS (T2 % OF TOTAL)*	*PERCENTAGE OF INTERVALS AT T2 BY ACTIVITY LEVELS (T2% - T1%)*			*OBSERVED INTERVALS (T2 % OF TOTAL)*	*PERCENTAGE OF INTERVALS AT T2 BY ACTIVITY LEVELS (T2% - T1%)*		
			Sedentary (Levels 1-2)	Light (Level 3)	MVPA (Levels 4-5)		Sedentary (Levels 1-2)	Light (Level 3)	MVPA (Levels 4-5)
Outdoor activities	Fixed equipment	688 (50)	19 (-10)	47 (8)	37 (2)	673 (65)	19 (-11)	46 (3)	35 (8)
	Open space	376 (56)	27 (1)	45 (-2)	28 (1)	958 (58)	16 (-13)	41 (-9)	44 (21)
	Sandbox	526 (54)	32 (-13)	58 (19)	10 (-6)	724 (52)	30 (-27)	53 (16)	17 (11)
	Wheel	264 (48)	24 (8)	35 (2)	40 (-10)	310 (40)	4 (-23)	38 (6)	58 (17)
	Sociodramatic	178 (34)	47 (-15)	31 (20)	22 (-4)	299 (41)	34 (-30)	43 (8)	23 (22)
	Other	265 (66)	40 (-17)	41 (6)	19 (11)	125 (38)	29 (-21)	58 (21)	13 (1)
	Portable equipment	131 (31)	15 (-10)	65 (23)	20 (-13)	162 (55)	20 (-30)	53 (8)	37 (22)
	Games	199 (71)	18 (-14)	29 (10)	53 (4)	65 (51)	6 (-6)	46 (11)	49 (-5)
	Forest	126 (18)	17 (-19)	70 (37)	13 (-18)	100 (38)	0 (-19)	79 (14)	21 (5)
	Transition	114 (32)	27 (17)	49 (-2)	24 (-15)	67 (7)	0 (-26)	60 (-6)	40 (32)
	Ball and object	35 (89)	19 (-56)	45 (45)	36 (-11)	6 (100)	0 (NA)	50 (NA)	50 (NA)
	Teacher arranged	31 (74)	26 (-24)	35 (-15)	39 (39)	0 (0)	0 (NA)	0 (NA)	0 (NA)
	Tantrum	5 (80)	75 (-25)	25 (25)	0 (0)	19 (47)	11 (-89)	67 (67)	22 (22)
	Snacks	0 (0)	NA	NA	NA	11 (0)	0 (NA)	0 (NA)	0 (NA)
	Pool	0 (0)	NA	NA	NA	7 (100)	0 (NA)	43 (NA)	57 (NA)
	Time out	0 (0)	NA	NA	NA	1 (0)	0 (NA)	0 (NA)	100 (NA)
Total observed intervals		2,938 (51)				3,527 (53)			

Appendix 3 Continues

OBSERVED CATEGORIES	*OBSERVED CODES*	*CONTROL (n = 36)**				*INTERVENTION (n = 52)**			
		OBSERVED INTERVALS (T2 % OF TOTAL)	*PERCENTAGE OF INTERVALS AT T2 BY ACTIVITY LEVELS (T2% - T1%)*			*OBSERVED INTERVALS (T2 % OF TOTAL)*	*PERCENTAGE OF INTERVALS AT T2 BY ACTIVITY LEVELS (T2% - T1%)*		
			Sedentary (Levels 1-2)	Light (Level 3)	MVPA (Levels 4-5)		Sedentary (Levels 1-2)	Light (Level 3)	MVPA (Levels 4-5)
Activity initiators	Child Initiated	3,617 (50)	39 (-6)	41 (8)	20 (-2)	4,956 (53)	30 (-23)	44 (10)	26 (13)
	Adult Initiated	1,175 (53)	62 (-3)	24 (0)	14 (3)	1,099 (53)	66 (7)	20 (-14)	14 (7)
Total observed intervals		4,792 (51)				6,055 (53)			
Group composition	Group child only	1556 (56)	42 (-3)	40 (7)	18 (-4)	2082 (54)	25 (-23)	46 (9)	30 (15)
	One-to-one peer	1,577 (49)	36 (-9)	42 (8)	22 (1)	1,861 (50)	29 (-24)	44 (9)	28 (16)
	Group with adult	1417 (56)	59 (-6)	26 (3)	15 (3)	1523 (50)	62 (1)	24 (-8)	14 (7)
	Solitary	894 (42)	33 (-15)	45 (13)	22 (2)	1,430 (55)	31 (-17)	45 (6)	24 (11)
	One-to-one adult	187 (48)	47 (-10)	39 (8)	14 (2)	223 (46)	29 (-40)	52 (26)	19 (15)
Total observed intervals		5,631 (52)				7,119 (52)			
Prompts	None	4,736 (51)	48 (-5)	33 (6)	19 (0)	6,038 (53)	45 (-18)	37 (6)	18 (12)
	Teacher increase	48 (19)	11 (-7)	78 (34)	11 (-27)	18 (0)	0(NA)	0(NA)	0(NA)
	Teacher decrease	5 (60)	33 (33)	33 (-17)	33 (-17)	2 (50)	100 (100)	0 (0)	50 (-100)
	Peer increase	4 (75)	0 (0)	0 (-100)	100 (100)	2 (50)	0 (0)	0 (0)	100 (0)
	Peer decrease	0 (0)	0 (NA)	0 (NA)	0 (NA)	1 (0)	0 (NA)	0 (NA)	0 (NA)
Total observed intervals		4796 (51)				6061 (53)			

Note. *The observed children are the same at T1 and T2 (N = 88); Green color = percentual increase in the observed PA level between T1 and T2, Yellow color = no change in the observed PA level between T1 and T2, Red color = percentual decrease in the observed PA level between T1 and T2.

APPENDIX 4 Results of multilevel modeling

	Null model			*Random Intercept and Fixed Slope*			*Two-way interactions*			*Random Intercept and Random Slope*			*Cross-Level Interactions*		
Effect	Estimate	95% CI (LL, UL)	*p*	Estimate	95% CI (LL, UL)	*p*	Estimate	95% CI (LL, UL)	*p*	Estimate	95% CI (LL, UL)	*p*	Estimate	95% CI (LL, UL)	*p*
Intercept	1.357	1.344, 1.370	<.001	1.396	1.379, 1.414	<.001	1.421	1.402, 1.439	<.001	1.424	1.403, 1.445	<.001	1.430	1.409, 1.452	<.001
Time				0.038	0.035, 0.042	<.001	0.012	0.005, 0.020	0.002	0.008	-0.007, 0.023	0.285	-0.007	-0.024, 0.009	.375
Condition				0.008	-0.015, 0.031	.444	-0.032	-0.057, -0.006	0.018	-0.037	-0.066, -0.009	0.011	-0.049	-0.079, -0.020	.002
Age				0.034	0.014, 0.055	.001	0.029	0.009, 0.049	0.005	0.019	0.001, 0.039	0.062	0.020	$8.4X10^{-5}$, 0.040	.049
BMI				0.008	0.005, 0.011	<.001	0.008	0.005, 0.011	<.001	0.006	0.003, 0.010	<.001	0.006	0.003, 0.009	<.001
Gender				-0.023	-0.036, -0.011	<.001	-0.024	-0.043, -0.005	0.013	-0.027	-0.045, -0.009	0.004	-0.030	-0.048, -0.011	.002
Primary location				-0.083	-0.086, -0.080	<.001	-0.101	-0.106, -0.095	<.001	-0.101	-0.107, -0.095	<.001	-0.095	-0.101, -0.088	<.001
Time of day				0.006	0.003, 0.009	<.001	-0.004	-0.010, 0.001	0.117	-0.004	-0.009, 0.002	0.159	-0.014	-0.020, -0.007	<.001
Group composition				-0.013	-0.018, -0.008	<.001	0.001	-0.010, 0.009	0.884	-0.002	-0.012, 0.007	0.653	0.001	-0.010, 0.013	.835
Initiator				-0.014	-0.020, -0.009	<.001	-0.025	-0.035, -0.014	<.001	-0.024	-0.035, -0.014	<.001	-0.040	-0.053, -0.028	<.001
Time Condition							0.038	0.032, 0.045	<.001	0.043	0.024, 0.063	<.001	0.071	0.048, 0.094	<.001
Time Gender							0.005	-0.001, 0.012	0.115	0.011	0.004, 0.018	0.002	0.018	0.008, 0.029	.001
Time Primary location							0.005	-0.001, 0.012	0.112	0.005	-0.001, 0.012	0.108	-0.010	-0.019, $3.1X10^{-4}$	.058
Time Time of day							0.005	-0.002, 0.011	0.145	0.004	-0.002, 0.010	0.218	0.025	0.016, 0.034	<.001
Time Croup composition							-0.011	-0.021, -0.001	0.026	-0.009	-0.019, 0.001	0.064	-0.013	-0.028, 0.003	.011
Time Initiator							-0.006	-0.017, 0.006	0.326	-0.007	-0.019, 0.004	0.213	0.024	0.007, 0.041	.006
Condition Gender							0.001	-0.026, 0.024	0.932	0.001	-0.023, 0.025	0.938	0.006	-0.019, 0.030	.638
Condition Primary location							0.026	0.020, 0.033	<.001	0.026	0.020, 0.033	<.001	0.017	0.008, 0.025	<.001
Condition Time of day							0.012	0.006, 0.019	<.001	0.013	0.006, 0.019	<.001	0.029	0.021, 0.038	<.001
Condition Croup composition							-0.009	-0.020, 0.001	0.07	-0.009	-0.019, 0.002	0.101	-0.012	-0.026, 0.002	.095
Condition Initiator							0.026	0.014, 0.037	<.001	0.026	0.015, 0.038	<.001	0.052	0.036, 0.068	<.001
Time Condition Gender													-0.013	-0.028, 0.001	.066
Time Condition Primary location													0.025	0.012, 0.038	<.001
Time Condition Time of day													-0.037	-0.049, -0.024	<.001
Time Condition Croup composition													0.005	-0.015, 0.025	.621
Time Condition Initiator													-0.056	-0.078, -0.033	<.001
Variance components															
Within child variance	$9.3x10^{-3}$	$9.1x10^{-3}$, $9.5x10^{-3}$	<.001	$6.9x10^{-3}$	$6.7x10^{-3}$, $7.0x10^{-3}$	<.001	$6.7x10^{-3}$	$6.5x10^{-3}$, $6.9x10^{-3}$	<.001	$6.7x10^{-3}$	$6.5x10^{-3}$, $6.8x10^{-3}$	<.001	$6.6x10^{-3}$	$6.4x10^{-3}$, $6.8x10^{-3}$	<.001
Variance of intercepts across children	$1.2x10^{-3}$	$8.5x10^{-4}$, $1.6x10^{-3}$	<.001	$9.7x10^{-3}$	$7.1x10^{-4}$, $1.3x10^{-3}$	<.001	$9.0x10^{-4}$	$6.5x10^{-4}$, $1.2x10^{-3}$	<.001	$8.2x10^{-4}$	$6.0x10^{-4}$, $1.1x10^{-3}$	<.001	$8.1x10^{-4}$	$5.9x10^{-4}$, $1.1x10^{-3}$	<.001
Variance of intercepts and slopes across centres	$3.2x10^{-4}$	$9.0x10^{-5}$, $1.1x10^{-3}$	.119	$2.2x10^{-4}$	$5.0x10^{-5}$, $9.7x10^{-4}$	.187	$2.1x10^{-4}$	$5.0x10^{-5}$, $9.0x10^{-4}$	.175	$1.3x10^{-4}$	$6.2x10^{-5}$, $2.6x10^{-4}$	.007	$1.4x10^{-4}$	$6.9x10^{-5}$, $2.9x10^{-4}$	.006
Additional information															
ICC	0.029														
AIC	-22310			-25645			-25858			-25923			-25980		
BIC	-22288			-25623			-25836			-25901			-25958		
Number of estimated parameters	4			13			24			24			29		