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The effect of the cluster randomized HIPPA intervention on childcare children's overall physical activity

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abstract

Background The effect of the cluster randomized Home- and childcare-based Intervention to Promote Physical Activity (HIPPA) intervention on the everyday physical activity (PA) of children between the ages of 4 to 5 years was evaluated.

Material/Methods Fourteen childcare centers with 102 children born in 2007 and their families participated in the study. HIPPA was implemented over a single preschool year in seven childcare centers while seven other centers continued their normal care (control group, CG). The PA levels of children were assessed by accelerometers six times every six months during two and a half years of research. Valid PA data were obtained from 69 children at baseline and analyzed with a linear mixed model.

Results Children in HIPPA engaged in more MVPA (moderate-to-vigorous PA) at post-intervention and more LMVPA (light-to-vigorous PA) at the six-month follow-up on weekdays than the CG did (estimated net effect: 13 min/day and 15 min/day, respectively). Sex-specific analyses indicated that the differences in weekday MVPA and LMVPA between groups were significant at follow-up among girls (estimated net effect: 15 min/day and 20 min/day, respectively), but not among boys.

Conclusions Overall, HIPPA was effective in increasing PA in childcare-aged children, especially in girls.

Key words physical activity, children, childcare, intervention, sex

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INTRODUCTION

Physical activity (PA), especially total PA and moderate-to-vigorous PA (MVPA), appears to be associated with cardiometabolic risk factors independently of sedentary time or body composition [1, 2]. However, it is commonly known that children's PA levels are low, and most children do not meet the current PA guidelines [3]. Participation in organized sport has increased over the decades [4], but unstructured, spontaneous everyday PA is decreasing among even the youngest children in developed countries [5, 6]. Nowadays, various indoor sedentary activities (e.g., watching TV/videos, playing electronic games while sitting, reading) compete for the interest of children against physically more active outdoor playtime [7–10]. Along with the observed low levels of PA, some children's motor skills have declined, a trend that is possibly a reflection of the sedentary lifestyle [11, 12]. During early childhood, there is a constant need to promote PA in order to ensure that children obtain adequate motor skills and become physically active adults [13, 14]. The increase in PA, even slight, may have beneficial effects on the development of fundamental motor skills [15, 16] and executive functioning in children [17].

Most children between the ages of 2 and 6 attend childcare, so the childcare environment is of great importance to these children's PA [6, 18]. Children's MVPA levels have been associated with the environment and the policy of childcare centers [19] even more than they have with children's demographic factors [20]. However, these studies have reported low levels of PA among children attending childcare, concluding that the childcare environment offers a major intervention opportunity.

The importance of childcare in children's lifelong PA has been recognized. During the past decade, interventions to promote childcare children's PA have been implemented to an increasing extent [21, 22], but the results have been modest. Most of the studies have been short term (less than 14 weeks), and follow-up has been rare or non-existent. There have been attempts to transfer the associations shown in cross-sectional studies between children's PA levels and outdoor time [23] to intervention programs, but these have met with mixed results [24–29]. In addition to the policies and practices of the childcare centers, the influence of teachers on children's PA levels has been recognized [19, 30], and so teachers are often essential targets for the intervention. On the other hand, interventions have rarely been implemented by teachers themselves and the intervention program commonly comes in a top-down manner.

It has been pointed out that interventions concentrating on changing the specific context to promote activity in childhood have not been sufficiently effective [31]. In attempts to change health behaviors such as PA, a wider approach may potentially be more effective [32]. Children's families are in constant contact with their local childcare centers, a situation that provides an opportunity to intervene in the home environment as well [33]. There is currently no evidence about the effect of involving parents in childcare center interventions, but research on this topic is limited [21].

In the current study, the socio-ecological model was used as an intervention framework [34]. The Home- and childcare-based Intervention to Promote Physical Activity (HIPPA) used a three-level socio-ecological model to better target and increase the effectiveness of the intervention and to find potential

PA promotional strategies. We identified modifiable personal (preferences), behavioral (sedentary and active time) and socio-environmental (family, peers, teachers, availability of PA equipment and facilities) factors associated with children's PA levels. The model allowed us to address the factors that affect children's PA in childcare centers and homes, that is, in those settings where children spend a substantial part of their day [6].

The aim of this study was to evaluate the effect of the 12-month cluster randomized Home- and childcare-based Intervention to Promote Physical Activity (HIPPA) intervention designed to increase 4- to 5-year-old children's everyday PA on weekdays and at weekends both at the childcare center and at home. Six measurements of PA were conducted every six months during two and a half years of research. However, this study reports only mid-way (6 months), post-intervention (12 months) and follow-up (18 months) intervention effects.

MATERIAL AND METHODS

SETTING

This cluster-randomized trial was part of a larger research project, "Dutch and Finnish 2–6-year-old children's physical activity both at childcare and at home". As presented in Figure 1, in spring 2010, 60 public childcare centers in the area of a city located in Central Finland were invited to participate in the HIPPA intervention. The invitation was given via a presentation to the principals of the childcare centers during a regional administrative meeting. Eleven childcare centers accepted the invitation. These childcare centers distributed the information letters and consent forms to the eligible families, who had to have a child enrolled in the participating childcare centers. The only inclusion criterion was that the child had been born in 2007. When the data collection had already begun, it was decided to expand the sample by asking four new childcare centers to participate in the study. Three of them accepted this invitation. All 14 childcare centers were located around the city and they were representative of the typical Finnish childcare system. The University of Jyväskylä Ethical Committee, along with the Social Affairs and Health officer in the city, approved the study.

RANDOMIZATION

Clusters were formed naturally from the childcare centers and they were randomized to either the intervention or the control arm. The 14 voluntary childcare centers were stratified into pairs by their districts because we hypothesized that a childcare center's location may reflect opportunities for PA as well as indicate the socioeconomic status of families. The paired centers were randomly assigned to the intervention group (seven childcare centers) or to the control group (seven childcare centers). There were no statistically significant differences in mean indoor size, mean play area outside and availability of PA equipment between the intervention and control childcare centers. The effects of weather on the results were minimized by conducting the measurements in the paired intervention and control childcare centers at the same time. The study participants, researchers, and statisticians were blinded to the group assignment at baseline but not at the follow-up assessments.

PARTICIPANTS

In fall 2010, there were 179 children born in 2007 at the 14 childcare centers. Informed consent was provided by 102 families (57%; Fig. 1). Ninety-six children participated in the baseline measurement, with six children sick or in homecare during the measurement.

PA was measured objectively by accelerometers (Actigraph GT3X) and the required amount of at least eight hours of recorded accelerometer data per day on at least two weekdays and one weekend day [35] was obtained from 81 children. The missing data were due to ten children being in homecare or sick during the measurement, and five children refused to use accelerometers at some point of the measurement.

Lastly, the data of 12 children were excluded from the final analysis due to sickness or absences on two weekdays during the measurement. The final valid full baseline data were obtained from 69 children (68%; 33 boys and 36 girls; Fig. 1).

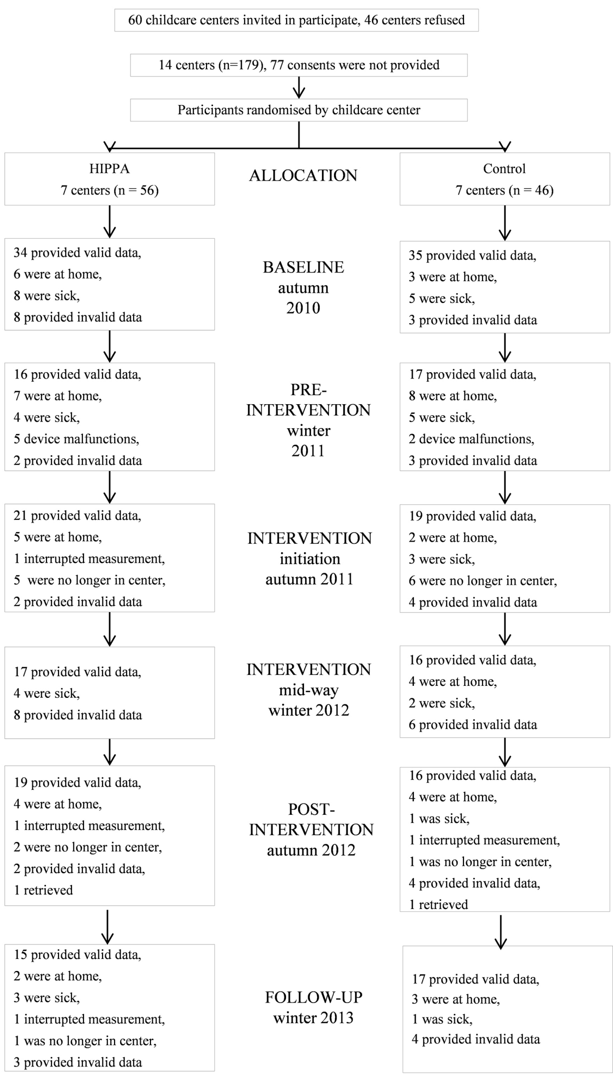

Fig. 1. Flow chart of study participants

INTERVENTION

The HIPPA intervention was implemented during a single preschool year in childcare centers starting in August 2011. The socio-ecological model was used as a theoretical framework. To ensure the sustainability of the intervention, the program was planned to be low intensity (i.e., the intervention should create as little burden as possible for teachers and families) and easily implementable primarily by teachers. In other words, HIPPA should be able to overcome real-life demands, particularly at childcare centers. The intervention program plan was made on the basis of the baseline measurements and discussions with the teachers. On average, four teachers were present at every planning meeting in each childcare center. In these discussions, possible methods to promote, in particular, children's spontaneous PA were presented to the teachers. It was assumed that the intervention would be implemented more intensively if the teachers decided which methods they wanted to use among the various proposals (Table 1).

Table 1. HIPPA intervention strategies to promote physical activity (PA) of children in childcare centers

	Childcare center environment	
Target	Methods	Implementation
PA knowledge and skills of principals of childcare centers	interview monthly letters	all seven principals were interviewed distribution 100%
The Early Childhood Education and Care (ECEC) partnership	monthly letters and themes* extending to the homes meetings meetings PA week calendar	distribution 100% at least the content of the meetings was known by 74% of teachers used in 2/7 of the centers (29%) 62% of teachers felt that they had more tools to support parents
Facilities at childcare centers	facilities more inspiring for PA to children (e.g. PA equipment available for children, floor tapes and figures, obstacle courses) participating in two existing PA campaigns#	86% indoors / 59% outdoors 6/7 and 4/7 of the centers participated
Outdoor playtime	stressing the importance of outdoor playtime via training sessions and letters/tips organized/adult-led or adult initiated outdoor physical activities participating in two existing PA campaigns#	provided average outdoor time increased 45min/day 64% of teachers carried out at least once 6/7 and 4/7 centers participated in campaigns
Teachers' knowledge of factors that influence children's well-being and social support	meetings with the researchers two motor skill observation training sessions monthly PA tips best practices guidelines step counters	at least the content of the meetings was known by 74% of teachers 47% participated in at least one of the training sessions 55% used at least one person used in 3/7 centers 48% read and 62% felt that their knowledge increased not recorded
Children's motivation and self-efficacy	Moving Pearl Box	10% of teachers tried to use
	Home environment	
Target	Methods	Implementation
Parents' knowledge of factors that influence children's well-being	monthly letters parents' evenings	distribution 100% researchers participated at least one evening/center
Parents' social support	home PA tips step counters	distribution 100% 13% used
Family PA	home PA tip cards monthly letters	distribution 100% distribution 100 %
Parents' interest in the children's childcare PA time	monthly letters parents' evenings weekly calendar of PA	distribution 100% researchers participated in at least one evening/center on the wall of 2/7 centers (29%)
Children's motivation and self-efficacy	PA/Screen-Free-Day cards home PA tip cards monthly letters	30% / 4% distribution 100% distribution 100%

Note. *See Table 2. # VarpaatVauhtiin!andPihaseikkailu (Young Finland association "Nuori Suomi"). Correspondingly, 3/7 and 3/7 of control centers participated in these campaigns.

Discussions with the collectively agreed intervention methods were transcribed and sent back to the childcare center so that the absent teachers would also be aware of the intervention content in the childcare centers. The intervention was to be applied throughout the whole child group. However, only the children with written research consent participated in the measurements.

The teachers were encouraged to modify the childcare physical environment to be more inspiring for children's PA. We also encouraged teachers to discuss children's PA with the parents during the everyday encounters in the vestibule of the childcare center as well as during the child's individual Early Childhood Education and Care (ECEC) plan discussions (see [36]). Every month (from August to May),a single health-related behavior theme was provided to the childcare centers and to homes (Fig. 2). Teachers received monthly PA tips and participated in two training sessions that focused on the motor skills of children. The control childcare centers continued their daily routines and usual care.

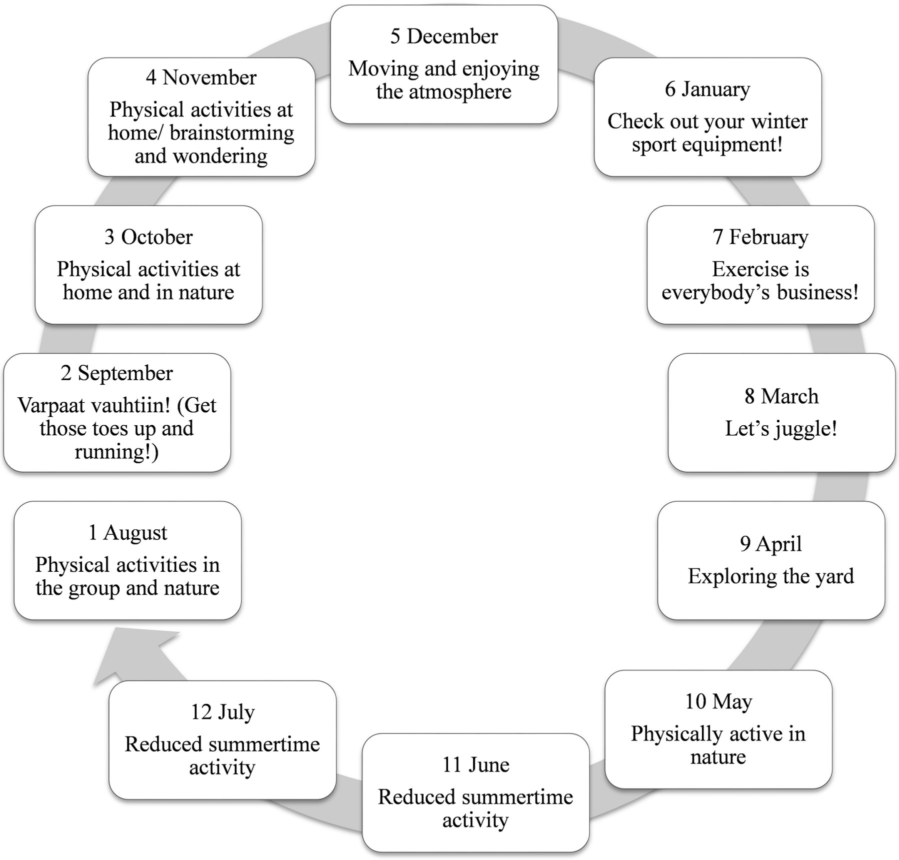

Fig. 2. Monthly themes of HIPPA-intervention extending to the childcare centers and homes

In Finland, childcare centers usually open at 6:30 a.m. and close at 5 p.m. Breakfast, a warm lunch and a snack are served every day for every child. After breakfast, there is usually structured activity time indoors and unstructured playtime outdoors. After lunch, children rest and at around 2 p.m. the snack is served. In the afternoon, children play freely indoors and/or outdoors. One indoor physical activity session and another outdoor session once a week were suggested in the Finnish early childhood physical activity recommendations [37], which were available during the implementation of this study.

We tried to strengthen the shared educational and care partnership between homes and childcare (see Table 1). Distribution of all materials, information and communication in the context of the intervention happened in the childcare center. Every month (from August to May), the same health-related behavior theme was promoted at home as well as at the childcare centers (see Fig. 2). The aim was to increase parents' interest and awareness of the physical activities their children were participating in during childcare time so that the parents would be able to extend these activities to the home as well. To support this aim, families were offered materials that promoted a healthy lifestyle. Families received monthly letters with extra PA materials. A schedule for a sufficiently physically active day was offered to help parents make their daily routines more active. To increase their awareness of how much time they spent on physical activities as a family and how often they use it in front of the TV or computer, they were advised to complete PA and "Screen-Free Day" cards. Families also had the opportunity to borrow pedometers to motivate parents (or siblings) to be more active themselves and therefore to be more active role models for their child. Cards and pedometers were self-assessment materials and not assessed by researchers. Families also received PA tip packet, which contained the family PA tip card for every month.

INTERVENTION EXPOSURE

In March 2013, 105 teachers in the childcare centers participated in the HIPPA intervention. Of these, 58 (55%) responded to the questionnaire considering the extent and quality of the implementation of the HIPPA intervention (Table 1). The response rate varied from 38 percent to 100 percent between centers. Most questions, such as *Did you participate in the intervention planning meeting?*, had the response options of *yes* or *no*. The survey also included questions, such as *Did the intervention inspire you to try to organize outdoor physical activities so that children could participate spontaneously if they wanted?,* to which the response options were *weekly, monthly, less often*, or *never*.

Of the respondents, 95% were going to use some of the methods of the HIPPA intervention in the future as well. The most often mentioned methods were making indoor facilities more inspiring for children to be physically active (85%) and keeping PA equipment available during free play for children (81%).

MEASURES

PRIMARY OUTCOMES

Accelerometers (Actigraph GT3X) were used to assess children's overall daily PA. The outcomes of interest were light PA, moderate-to-vigorous PA (MVPA), light-to-vigorous PA (LMVPA), and counts per minute of accelerometer wear time (cpm). The cut-points established by Van Cauwenberghe et al. [38] and a five-second epoch duration was used to count the amounts of the time children spent at the light (> 1492 counts/min), moderate (> 2340 counts/min), and vigorous (> 3524 counts/min) intensity levels. The amounts of the time spent at different intensity levels were expressed as minutes per day. Total PA was calculated by dividing the cumulative counts by minutes of accelerometer worn, and it was expressed as mean counts per minutes (cpm).

Accelerometer data were collected for five consecutive days, three weekdays and two weekend days, per childcare center. Complete data were defined as at least eight hours of recorded accelerometer data per day for at least three days including one weekend day [35]. Parents were asked to put the accelerometers on their children's right hip immediately after waking up and to remove them before going to bed. They were also asked to record when accelerometers were fitted and removed and why they were removed.

Accelerometer data were reduced with the commonly used methods from previous PA studies among childcare-aged children [39]. Non-wearing time of accelerometers was identified as 20 minutes of consecutive zeros in the recorded data, biological implausible as 15,000 counts per minutes (cpm), and nighttime between 9 p.m. and 7 a.m. [40]. Non-wearing time, biologically implausible measurements, and nighttime were removed from the data with the self-customized software.

SECONDARY OUTCOMES

The time offered by teachers to children to be outdoors during childcare was calculated based on the measurers' observations. The time spent outdoors was observed for at least one child group of each childcare center during the three measurement days at every measurement period. The observed child group had to contain at least one study participant. The morning outdoor time began when the children were allowed to go play outside (transition or waiting time was not included) and stopped when the whole group went back indoors. Afternoon outdoor time began in the same way as in the morning, but it mostly ended at the official closing time of the center because child groups usually play outdoors for the rest of the day. There were a few clear exceptions, such as when bad weather forced the child group to go back inside before the parents came. Morning and afternoon outdoor times during the three days were averaged separately and then summed to the total outdoor time per day.

Two researchers measured children's height and weight to the nearest 0.1 cm and 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 squared height (m^2).

STATISTICAL ANALYSIS

In this paper we analyze the effect of the intervention (HIPPA vs. control) on the change in children's PA (minutes of MVPA, light PA, LMVPA per day or cpm per day) over time by using a linear mixed model (LMM). We report here the results at the mid-way (6 months), post-intervention (12 months) and follow-up (18 months) stages of the study. LMM produces an appropriate analysis of correlated (clustered and repeated measures) data. In our case, the children are first clustered within centers, meaning that the outcomes of children within a center are potentially correlated (intraclass correlation ICC). Second, each child has data on several measurement occasions, which raises the need to model the correlations between the measurements. LMM allows the analysis of repeated measures even when the data are incomplete, if the missing observations can be considered missing at random [41].

The main interest lies in the effects of group and time and their interaction, which represents the effect of the intervention over time. Thus, group and time were introduced as fixed effects in the LMM. The time effect was modeled through orthogonal polynomials, which split the development of children's PA into meaningful trend components: linear, quadratic, cubic and so on.

In addition, we had children's sex, children's age, and BMI (centered to the grand mean at the baseline) at each measurement occasion, and the measurement season as fixed covariates in the model. Covariates were chosen *a priori* because these have been previously found to correlate with child's physical activity [42].

To account for the clustering effect of childcare centers, a random intercept was introduced for each center, but random coefficient regression models (a special case of LMM) were also employed to check if there was any random variation between centers in the effect of time (i.e., if the average trend components of children's PA differed significantly between centers). After some experimentation with different covariance structures, we modeled the covariances of repeated measurements with the first-order autoregressive [AR(1)] structure [41].

The model parameters were estimated with the restricted maximum likelihood (REML) method. The statistical significances of the fixed effects were tested with Wald Type III *F* tests. Interaction effects between time and group or covariates were retained if significant. If the main effect of a covariate was significant, possible interaction effect with the group was checked and retained if significant. The estimated outcome means at the considered time points were calculated from the fixed effect estimates. Pairwise comparisons of these means were performed using Bonferroni adjustments.

The need for random effects (i.e., random intercept and random regression coefficients of the trend components for the centers) in the model, as well as the goodness-of-fit of the AR(1) structure compared to other covariance structures, were evaluated by well-known information criteria, the Akaike information criterion (AIC) and the Bayesian information criterion (BIC). The smaller the criterion value is, the better the model fit.

The normality of the outcome variables was assessed by the Shapiro-Wilks test. Weekday and weekend-day MVPA and cpm and weekend-day LMVPA were log-transformed and weekend-day light PA was two-step transformed to address the observed skewness [43]. In the sex-specific analyses, girls' weekend-day light PA and cpm and boys' weekday cpm were log-transformed, and boys' weekend-day light PA was transformed by the two-step approach.

Differences in the provided outdoor time for children between HIPPA and control childcare centers were examined by Mann-Whitney *U* test and average changes in the time spent outdoors within the HIPPA and control centers by a Wilcoxon Signed-Ranks Test.

Independent groups' *t*-tests for continuous outcomes and chi-squared tests for categorical outcomes were used to compare baseline differences between the HIPPA and control groups and also to compare completers and non-completers. In this context, completers refer to those who completed all measurements and non-completers to those who did not complete the measurements at mid-way, post-intervention, or follow-up (n = 32 vs. 37; n = 35 vs. 34; n = 33 vs. 36, respectively).

The alpha level 0.05 was set as the criterion of statistical significance. In multiple pairwise comparisons, the Bonferroni correction was used to decrease the risk of familywise Type I error [44]. Statistical analysis followed the intention-to-treat principle. The consistency of the HIPPA intervention effect on gender was assessed by conducting additional separate analyses for boys and for girls. All data were analyzed using the software IBM SPSS Statistics for Windows 24.0.

RESULTS

BACKGROUND RESULTS

Table 2 presents the baseline characteristics of children by groups. At the baseline, statistically significant differences were observed in height and weight between the intervention group and the control group (p = .040, p = .039, respectively). Children in the control group were taller and heavier than the children in the intervention group. When adjusted for age, the group differences in height and weight were no longer significant, (ANOVA, p = .099, p = .079, respectively).

Table 2. Baseline unadjusted descriptive statistics

	HIPPA-intervention group (n = 34)	Control group (n = 35)	Total (n = 69)
	Mean (SD)	Mean (SD)	Mean (SD)
Age, months	38 (4)	39 (3)	39 (4)
Sex, % boys	53	43	48
Height, cm	97.3 (5.4)	99.6 (3.1)*	98.5 (4.5)
Weight, kg	15.4 (1.8)	16.2 (1.5)*	15.8 (1.7)
BMI, kg/m2	16.2 (1.1)	16.3 (1.1)	16.3 (1.1)
Weekdays PA			
Light PA, min/d	40.7 (8.0)	39.6 (7.1)	40.1 (7.5)
Moderate PA, min/d	31.3 (7.3)	30.4 (7.4)	30.9 (7.3)
Vigorous PA, min/d	31.2 (10.6)	29.8 (11.5)	30.4 (11.0)
MVPA, min/d	62.4 (17.3)	60.2 (17.5)	61.3 (17.3)
LMVPA, min/d	103.1 (24.0	99.8 (23.0)	101.4 (23.4)
Counts/min (cpm)	654 (125)	645 (165)	649 (146)
Weekend days PA			
Light, min/d	38.7 (9.2)	39.8 (9.3)	39.2 (9.2)
Moderate, min/d	28.7 (8.3)	30.9 (9.2)	29.8 (8.8)
Vigorous, min/d	29.0 (14.7)	30.7 (14.0)	29.8 (14.3)
MVPA, min/d	57.7 (21.3)	61.6 (22.6)	59.7 (21.9)
LMVPA, min/d	96.3 (29.0	101.4 (31.1)	98.9 (30.0)
Counts/min (cpm)	633 (190)	646 (174)	640 (181)

Note. * T-test for the difference between groups, p< .050.

The drop-off analyses showed no significant differences with regard to demographics or PA parameters at baseline between completers and non-completers.

RESULTS FOR THE MODEL FITTING

Surprisingly, in the analyses of the whole sample (both sexes) the REML estimate of the variance component of the childcare centers (random intercepts) appeared to be zero for all primary outcomes. This suggests that the between-center variation is negligible, which also means that the centers did not have any clustering effect on the children as regards the considered outcome variables (the outcomes of the children can be considered uncorrelated with each other regardless of the center). The result for the random regression coefficients of the trend components of the children's PA was the same: their between-center variation was negligible. Thus, any random effects were not retained in the model, and a child was the only actual unit of analysis in the whole sample analysis. Even more surprisingly, it appeared that the correlation parameters of the AR(1) structure did not differ from zero, suggesting that the repeated measurements were uncorrelated for all primary outcomes. This result was confirmed when the model fit was assessed by AIC and BIC.

In contrast to the models of the whole sample, in the sex-specific models for girls the random intercept of centers appeared significant. The estimated intraclass correlation coefficient (ICC) ranged between 0.073 and 0.096, depending on the outcome variable. This indicates mild dependency of the outcomes for the girls within a center. In the boys' models, the variance between the centers again appeared to be zero, so that in terms of PA the boys within a center can be considered independent. Random coefficient models did not fit better than random intercept models for either boys or girls.

For girls, the AR(1) autocorrelation structure fitted best for the MVPA, LMVPA, and cpm models and the uncorrelated structure for the model of light PA. For boys, uncorrelated structure fitted best for all primary outcomes.

Table 3. Adjusted means and differences with their CIs in children's weekday PA between the HIPPA intervention group and control group at mid-way, post-intervention and follow-up (six months after intervention)

	HIPPA (n = 34) Mean (95% CI)	Control (n = 35) Mean (95% CI)	HIPPA-Control Adjusted difference (95% CI) #	p
MVPAa min/day				
Baseline	58.6 (53.3–64.4)	56.6 (51.6–62.2)	2,0 (-4.7–11.0)	0.602
Mid-way	72.4 (66.0–79.5)	66.8 (60.8–73.5)	5.6 (-3.2–17.6)	0.240
Post	80.4 (72.8–88.8)	67.5 (61.0–74.6)	12.9 (2.0–27.9)*	0.016
Follow-up	75.7 (66.8–85.9)	67.4 (59.7–76.2)	8.3 (-3.0–25.1)	0.174
Lightb min/day				
Baseline	40.1 (37.8–42.3)	39.2 (37.0–41.4)	0.9 (-2.2–4.0)	0.582
Mid-way	42.4 (40.4–44.4)	39.2 (37.3–41.3)	3.1 (0.3–6.0)	0.031
Post	43.2 (40.9–45.4)	39.3 (37.0–41.5)	3.9 (0.8–7.1)	0.016
Follow-up	43.9 (41.3–46.5)	39.3 (36.7–41.9)	4.7 (1.0–8.3)	0.012
LMVPA min/day				
Baseline	99.7 (91.0–106.4)	99.3 (91.7–106.9)	-0.5 (-11.2–10.2)	0.922
Mid-way	115.6 (108.6–122.6)	106.7 (99.7–113.6)	9.0 (-1.0–18.9)	0.077
Post	121.3 (113.5–129.0)	109.1 (101.4–116.8)	12.1 (1.2–23.1)	0.030
Follow-up	126.9 (118.0–135.8)	111.6 (102.7–120.4)	15.3 (3.0–27.7)*	0.016
cpma				
Baseline	608 (570–650)	618 (579–659)	-9 (-59–52)	0.741
Mid-way	711 (670–755)	674 (635–715)	37 (-19–106)	0.211
Post	749 (701–801)	694 (650–741)	55 (-11–137)	0.107
Follow-up	789 (732–852)	715 (662–771)	75 (-4–176)	0.066

Note. #Adjusted mean difference between HIPPA and control groups (HIPPA-control) at selected time. Adjusted for sex, centered age, centered BMI and season; *Significant after Bonferroni adjustment; CI, confidence interval; MVPA, moderate-to-vigorous physical activity; LMVPA, light-to-vigorous physical activity; cpm, counts per minute ;aThe natural log--transformed and then back-transformed; bGroup*time interaction was non-significant.

MAIN RESULTS

The mixed model results for the fixed effects of weekday MVPA, LMVPA, light PA and cpm are presented in the appendix tables A1–A4. No significant interactions between time and group for weekend day PA outcomes were observed.

There was a significant main effect of sex for all weekday PA outcomes so that boys were more physically active than girls. Significant sex and time interaction for weekday light PA was also observed, suggesting that the mean change over time was different between boys and girls. When taking into account the nonlinearity of light PA over sex, boys' light PA seems to decrease at follow-up whereas girls' light PA continue to increase. BMI influenced weekday MVPA and season weekday LMVPA and cpm. Children who were heavier at the baseline spent on average more time at the MVPA level. Overall, children were more active in the fall than in winter. No main effect of age was observed for primary outcomes.

There were significant interaction effects between time and group in weekday MVPA, LMVPA and cpm, and also the significant main effect of the group for weekday light PA. Results indicate that the intervention had some effects on children's weekday PA. These results are presented and analyzed more closely in Table 3, which presents the means of children's weekday PA adjusted for the other fixed effects in the LMM as well as the confidence intervals of their difference between the treatment groups.

A post hoc test with Bonferroni correction showed that the HIPPA group spent significantly more time at the MVPA intensity level than the control group at the post-intervention, $F(1, 146.4) = 5.92, p = 0.016$, but not at mid-way or follow-up. For LMVPA, the post hoc pairwise comparisons showed a significant difference between groups at the six-month follow-up, $F(1, 137.6) = 6.00$, $p = 0.016$. For cpm, the post hoc pairwise comparisons showed no significant differences between the groups at the measurement points after the Bonferroni correction.

SEX-SPECIFIC RESULTS

Sex-specific results of the linear mixed models for the fixed effects of weekday MVPA, LMVPA, light PA, and cpm are presented in appendix tables A5–A12.

Among girls, there were significant main effects of BMI and season for weekday PA outcomes except for light PA. Heavier girls were physically more active than lighter girls, and on average, girls were more active in the fall than in winter. Significant interaction effects between group and age for weekday MVPA and LMVPA revealed that there were, in particular, group differences in the highest tertile of age in favor of the HIPPA girls. In addition, significant group differences were observed in the middle and upper percentiles of BMI in favor of HIPPA girls in MVPA, LMVPA and cpm.

A significant main effect of the season on boys' cpm was found, along with significant group and season interaction in cpm. Boys were, on average, more active in the fall than in winter. Control boys were more active than HIPPA boys on weekdays during the fall, and vice versa during the winter, although the differences were not statistically significant.

Significant interaction effects between the time and the group in girls' weekday MVPA and LMVPA were found, as was a slightly significant main effect of the group on weekday cpm. Among boys, significant interaction effects between group and time were found for weekday MVPA and cpm.

A post hoc test with Bonferroni correction revealed that HIPPA girls spent significantly more time at the MVPA intensity level than control girls did at post-intervention (estimated difference: 12 min/day), $F(1, 23.8) = 7.41$, $p = 0.012$, and at the MVPA (estimated difference: 15 min/day), $F(1, 40.1) = 7.98$, $p = 0.007$, and also at the LMVPA intensity levels at follow-up (estimated difference 20 min/day), $F(1, 36.4) = 7.15$, $p = 0.011$. Among boys, Bonferroni pairwise comparisons showed no significant differences at specific time points.

OUTDOOR TIME IN CHILDCARE CENTERS

At the baseline the outdoor time provided by HIPPA centers was 3.0 hours (SD= 0.3) per day and 3.0 hours (SD= 0.6) per day by control centers. There were significant differences in the provided outdoor time between HIPPA and control childcare centers at the initiation of the intervention (HIPPA: $M = 3.3$ hours, $SD = 0.3$; control: $M = 2.8$ hours, $SD = 0.5$, $U = 8.00$, $p = .038$) and post-intervention (HIPPA: $M = 3.8$ hours, $SD = 0.4$; control: $M = 3.1$ hours, $SD = 0.7$, $U = 8.50$, $p = 0.038$).

Median outdoor time at the post-intervention was significantly longer than at the baseline in the HIPPA centers ($Z = 2.21$, p =0.027). At follow-up, the mean outdoor time in hours was 2.9 (SD= 0.6) and 2.5 (SD= 0.6) at intervention and control centers, respectively ($p = .259$).

DISCUSSION

The findings of this cluster-randomized study conducted in real-life contexts indicated that the preschool one-year-long HIPPA intervention increased children's weekday PA among childcare children. Six months after the intervention the PA increment compared to control was significant in girls but not in boys. The intervention had no significant impact on children's PA on weekend days.

It has been suggested that an effective childcare-aged PA intervention is short duration, implemented at childcare centers, led by teachers, and involving outdoor play, unstructured activity, and environmental modifications [45]. The results of our study support the findings of the review in that the HIPPA intervention was found to be feasible and effective, though most of the children's levels did remain below the current PA recommendations after the intervention [3, 46, 47]. It is worth noting that, in this study, the teachers were the primary deliverers of the intervention, as well as participants in its planning. This may have influenced the intensity of the intervention, but it might also enhance the sustainability of it. From the socio-ecological perspective, the factors that most directly influence the sustainability of HIPPA are factors related to the teachers. In HIPPA teachers chose those components that seemed to be most suitable for that particular center. In this way, the intervention context was taken into account more carefully; the program was possible to better integrate into the policies and practices of centers than if it had been delivered to teachers as pre-designed and to be followed strictly. Teachers are more likely to continue to carry out an intervention if they perceive it to be user-friendly and easy to fit into their day [48].

HIPPA took place over one year, a relatively long period. Reviews have found some evidence of the effectiveness of short-term interventions (less than three months) in increasing PA, but the effects are rarely sustained over a longer time (12 months), or the sustainability of behavior change is not even assessed [45, 49]. In this study, the PA levels of the HIPPA intervention group increased significantly during the intervention when compared to those of control group. After six months, the group difference was significant only in LMVPA, although MVPA levels of HIPPA children remained elevated. This finding further highlights the importance of long-term support in children's PA as well as of evaluations in studies on health behavior promotion. PA recommendations are set so that PA levels remain high enough to ensure children's overall health [50]. The minimal or biologically significant amount of increase in habitual PA is, however, unclear. The results of a review by Metcalf et al. [31] indicated that PA interventions have had only a small effect on children's total PA, a finding that could also, according the authors, explain null findings in the body composition improvements of children. In a more recent, single longitudinal study by Remmers et al. [2] concluded that a small subsequent decrease in the body mass index (BMI) z scores achieved by heavier children with a daily increment of about 6.5 min MVPA per year would prevent obesity over the long term. The amount and the type of PA needed to improve body composition might also differ based on targets [42]: the development of motor skills increases the possibility of children being physically active in adulthood as well [13, 51, 52]. Even small effects on PA in early childhood when fundamental motor skills are developing may induce large effects over the long term [51]. Our study focused on promoting healthy PA habits among children, and the dose–response relationships between MVPA and BMI or motor skills were not assessed. However, in our study, the estimated average MVPA level increment was high (13 min/day), which is twice as high as needed to prevent obesity [2].

In the present study, when analyses were done separately for boys and girls, the intervention effect was observed to be significant only in girls. In a recent teacher-led preschool intervention study [30], a significant intervention effect on physical activity was also found for girls only. It was assumed that this occurs due to the fact that, on average, girls have lower baseline physical activity levels than boys do, thus they have more room to improve. As a low-intensity intervention, HIPPA may have increased the PA of the least active children in particular. The baseline results show that, also in this study, most of them were girls. In addition, adults, parents and teachers, and the physical environment may influence PA preferences through a different level of access to and promotion of activities among boys and girls [53]. It has been observed that external prompts such as high parental PA for girls may partly explain the higher MVPA for this age group while for boys intrinsic motivation (i.e., the frequency of rough-and-tumble play) is more important [54]. It should be remarked upon that, in this study, most of the teachers of the childcare centers as well as the members of the research team were women. It is not only that rough-and-tumble play is more common among boys than it is among girls, but it is also more difficult for women to distinguish pretend fighting from real fighting. Thus, rough-and-tumble play is, unfortunately, often restricted or forbidden in childcare centers. [55]. The female-domination in this study may have unintentionally led to sex differentiation of physical activities. The more pronounced influence of the social-environment for the MVPA of girls compared to that of boys is supported by the observation in the present study that the proportion of variances in the MVPA was explained by the centers only for girls, not for boys. Whether this study promoted activity in less active children or included sex-specific methods for specifically promoting PA in girls remains to be examined in future studies.

Yet there has been a call to find an effective intervention targeted at girls. From that perspective, HIPPA was successful. Even though girls are commonly known to be physically less active than boys are already before school age, their PA continues declining during both childhood and adolescence [56]. Considering that health behaviors are learned already in early childhood, it is important to promote all children’s PA before the school age.

Correlational studies have shown that the home environment (e.g., parent’s role-modeling and support) have a relationship to children’s PA [9, 53]. However, only a few center-based interventions with a home component have succeeded in increasing children’s PA levels [21]. In this study, although not significant, there was an increasing trend in the weekend-day PA of HIPPA girls, but not that of HIPPA boys when these groups were compared to the control group. In addition to the materials and information offered to parents in other multicomponent PA interventions conducted in nurseries [16], we also tried to increase the communication and the sense of partnership between the teachers and parents, which may be essential in promoting children’s PA [57]. It may be that this strategy better influences the parents of girls rather than those of boys, or that the girls had already assimilated habitual PA that reflected their PA behavior in the home context. Unfortunately, we do not know the extent to which parents implemented the offered material.

Even though childcare centers offer a great opportunity for intervention, they also turned out to be challenging environments in which to conduct a PA intervention. Meetings and discussions with the teachers revealed many barriers to implementing the intervention in the desired way. The lack of resources and the existing safety rules were the constraints that were most often mentioned. Children were not allowed to run indoors, except in the gym. However, the gym was rarely in use by a child group more than once a week, and in some centers there may not be any gym. Increasing the amount of physical exercise sessions in an already crowded childcare curriculum was not proposed as the intervention method; the efficiency of this kind of strategy may not be enough [58] in proportion to the amount of time used and may overload teachers. It seems that in order to implement interventions successfully, the existing practices of childcare centers need to be overcome.

Due to the small sample size in this study, it should be replicated with a larger sample and with an observation tool, so that information about the environment in which the PA occurs could be obtained separately for boys and girls. The small sample size also meant that no mediating analysis has been made. The factors that correlate to boys’ and girls’ PA separately remain a question for future studies. It also would be important to find out what kind of light physical activities or movements can be detected by the accelerometer. For example, how much light PA measured by the accelerometer contains movement such as balancing on the trunk of a tree or on top of a beam or hanging on a jungle gym, in other words, those activities that promote development of motor skills [59]?

STRENGTHS AND LIMITATIONS

This study has several strengths. It widens the limited research area of childcare children's PA interventions, and responds to the previously stated need for long-term follow-up and multicomponent studies [60]. The total activity during the day was assessed excluding the possibility that children replace activity that would have otherwise occurred at other times of the day [31]. The feasibility of the HIPPA intervention for the childcare environment was ensured by its low-burden, participatory, real-life context approach.

This study is, of course, not without limitations. The sample was rather small and gathered from one Finnish city only, so generalizing the study results should be done with caution. In this kind of longitudinal study, it is a challenge to keep the same participants throughout the whole study. Generally, there is a high churn rate among the clients in childcare centers due to factors such as unemployment or having a newborn in the family. Furthermore, we accounted for the risk that there would be some children absent during the measurement periods due, for example, to sickness.

Although the growth curves (i.e., slopes) differed between the treatment and control groups, there was large variability among children. Explanations for this variability (e.g., teacher and parent variables) were not explored.

Seasonal differences may also affect the levels of PA. In the current study, the baseline and post-intervention measurements were conducted in the fall, but the follow-up measurements came during the winter. However, the PA levels of the intervention group were compared to the control group and the measurements in the intervention and control groups were always made at the same time.

In this study, the time spent at childcare on weekdays was not separated from the time after the childcare, so it is not possible to differentiate if, during the weekdays, the HIPPA intervention affected childcare PA or home PA. The children, however, spend most of the day (over 7 hours/day) at the childcare center, so the effect of childcare on children's overall weekday activity levels is relatively large. Furthermore, the context in which and with whom children spent their time on weekends (home, grandparents) were not adjusted for in the models, so the results of weekends should be interpreted carefully.

CONCLUSIONS

The HIPPA intervention, conducted in a real-life context, was found to be effective in increasing childcare-aged children's PA, especially that of girls. Moreover, teachers found it was feasible to implement in childcare centers. This study provides support for the sparse evidence of the effect of multicomponent PA interventions, additional knowledge about the PA of childcare-aged children, and resources to increase children's habitual PA. In the future, we need more intensive interventions or ones targeted at the specific needs of individual children to reach current PA recommendations for children. Future interventions should also try to modify factors at the community and/or policy levels (e.g., through cooperation between childcare centers and different organizations, and teachers' PA education). Such modifications could lower the barriers (e.g., in policies and practices, attitudes, and the physical environment) that children face in being physically active enough in their immediate surroundings.

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APPENDIX

Table A1. Final model of weekday MVPA of whole sample

Source	Numerator df	Denominator df	F	Sig.
Intercept	1	91.7	9573.50	.000
Time_lin	1	183.6	40.77	.000
Time_qd	1	176.6	1.21	.273
Time_cub	1	173.4	3.09	.080
Group	1	63.2	0.55	.460
Sex	1	60.4	11.89	.001
Age	1	59.4	1.40	.242
BMI	1	60.1	4.43	.040
Season	1	174.6	3.25	.073
Group * Time_lin	1	181.8	6.73	.010
Group * Time_qd	1	176.1	0.98	.324
Group * Time_cub	1	174.0	5.60	.019

Table A2. Final model of weekday LMVPA of whole sample

Source	Numerator df	Denominator df	F	Sig.
Intercept	1	93.5	706.60	.000
Time_lin	1	186.7	30.19	.000
Time_qd	1	179.5	1.12	.292
Time_cub	1	176.5	5.22	.023
Group	1	63.8	2.32	.132
Sex	1	61.7	17.06	.000
Age	1	60.4	0.88	.352
BMI	1	61.4	3.68	.060
Season	1	177.6	1.82	.179
Group * Time_lin	1	185.1	5.92	.016

Table A3. Final model of weekday light PA of whole sample

Source	Numerator df	Denominator df	F	Sig.
Intercept	1	99.2	1223.26	.000
Time_lin	1	188.9	1.28	.260
Time_qd	1	181.6	1.47	.227
Time_cub	1	174.2	0.03	.867
Group	1	64.0	4.02	.049
Sex	1	64.9	25.61	.000
Age	1	61.1	0.01	.937
BMI	1	62.0	2.36	.130
Season	1	177.2	0.04	.848
Group * Time_lin	1	185.4	3.62	.059
Time_lin * Sex	1	184.2	0.06	.812
Time_qd * Sex	1	178.4	4.82	.029
Time_cub * Sex	1	177.2	4.27	.040

Table A4. Final model of weekday cpm of whole sample

Source	Numerator df	Denominator df	F	Sig.
Intercept	1	84.4	43281.49	.000
Time_lin	1	187.2	41.76	.000
Group	1	59.3	1.05	.310
Sex	1	57.4	12.63	.001
Age	1	56.1	1.15	.288
BMI	1	57.1	3.14	.082
Season	1	177.2	24.38	.000
Group * Time_lin	1	185.4	4.03	.046

Table A5. Final model of weekday MVPA of girls

Source	Numeratordf	Denominatordf	F	Sig.
Intercept	1	2.3	408.42	.001
Time_lin	1	104.4	28.33	.000
Group	1	13.8	3.41	.086
Age	1	31.0	2.05	.162
BMI	1	41.1	16.14	.000
Season	1	99.0	12.09	.001
Group * Time_lin	1	103.6	4.56	.035
Group * Age	1	31.4	6.37	.017
Group * BMI	1	37.6	6.97	.012

Table A6. Final model of weekday LMVPA of girls

Source	Numerator df	Denominator df	F	Sig.
Intercept	1	3.0	617.45	.000
Time_lin	1	102.6	18.85	.000
Group	1	13.5	2.72	.122
Age	1	25.6	1.03	.320
BMI	1	35.8	12.70	.001
Season	1	96.5	8.47	.004
Group * Time_lin	1	101.4	4.56	.035
Group * BMI	1	32.3	5.65	.024
Group * Age	1	28.0	6.59	.016

Table A7. Final model of weekday light PA of girls

Source	Numerator df	Denominator df	F	Sig.
Intercept	1	20.3	1028.32	.000
Time_lin	1	100.7	1.41	.238
Group	1	10.8	2.05	.180
Age	1	22.3	0.70	.411
BMI	1	21.4	3.99	.059
Season	1	93.3	0.72	.398
Group * Time_lin	1	99.1	3.56	.062

Table A8. Final model of weekday cpm of girls

Source	Numerator df	Denominator df	F	Sig.
Intercept	1	4.4	654.59	.000
Time_lin	1	100.8	17.57	.000
Group	1	28.1	4.34	.046
Age	1	29.5	1.43	.241
BMI	1	35.1	8.81	.005
Season	1	94.1	16.73	.000
Group * Time_lin	1	101.0	0.34	.559
Group * Age	1	27.6	3.09	.090
Group * BMI	1	35.4	5.11	.030
Group * Season	1	94.0	3.89	.052

Table A9. Final model of weekday MVPA of boys

Source	Numeratordf	Denominatordf	F	Sig.
Intercept	1	51.2	419.64	.000
Time_lin	1	82.7	15.63	.000
Time_qd	1	79.6	4.81	.031
Time_cub	1	81.4	6.31	.014
Group	1	30.2	0.00	.983
Age	1	29.1	0.03	.856
BMI	1	27.9	0.01	.928
Season	1	81.3	0.01	.907
Group * Time_lin	1	81.6	1.69	.198
Group * Time_qd	1	79.3	0.02	.900
Group * Time_cub	1	80.3	4.76	.032

Table A10. Final model of weekday LMVPA of boys

Source	Numeratordf	Denominatordf	F	Sig.
Intercept	1	48.6	624.53	.000
Time_lin	1	83.0	13.33	.000
Time_qd	1	80.4	4.74	.032
Time_cub	1	81.9	9.95	.002
Time_qn	1	80.9	3.86	.053
Group	1	30.1	0.12	.735
Age	1	29.4	0.00	.986
BMI	1	28.3	0.03	.870
Season	1	81.8	0.00	.970
Group * Time_lin	1	82.4	0.72	.399

Table A11. Final model of weekday light PA of boys

Source	Numeratordf	Denominatordf	F	Sig.
Intercept	1	53.8	1151.03	.000
Time_lin	1	85.8	1.33	.252
Time_qd	1	82.5	3.57	.062
Time_cub	1	84.4	8.15	.005
Group	1	30.6	1.15	.292
Age	1	29.8	0.52	.475
BMI	1	28.3	0.17	.682
Season	1	84.4	0.20	.658
Group * Time_lin	1	84.9	0.36	.548

Table A12. Final model of weekday cpm of boys

Source	Numeratordf	Denominatordf	F	Sig.
Intercept	1	45.4	28820.60	.000
Time_lin	1	79.8	26.34	.000
Time_qd	1	76.3	4.40	.039
Time_cub	1	78.8	1.58	.213
Group	1	45.3	0.93	.340
Age	1	27.8	0.04	.848
BMI	1	26.7	0.10	.750
Season	1	79.6	6.54	.012
Group * Time_lin	1	80.0	0.07	.791
Group * Time_qd	1	76.3	0.28	.596
Group * Time_cub	1	78.9	8.84	.004
Group * Season	1	79.6	4.35	.040

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