Children’s physical activity level and sedentary behavior in Norwegian early childhood education and care: effects of a staff-led cluster-randomized controlled trial

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Abstract

A growing body of evidence suggest that the children’s physical activity (PA) level in early childhood education and care (ECEC) settings are insufficient. Since most children attend ECEC settings for many hours on most days of the week, and these institutions reach children across the socioeconomic spectrum, the ECEC settings may serve as an ideal avenue for increasing physical activity (PA) level, reduce sedentary time and enhance the overall health of young children. This paper investigates the effectiveness of the “Active Kindergarten – Active Children” study to increase children’s PA level and reduce sedentary time within the ECEC setting. Accelerometers were used to assess PA and sedentary time. A total of 116 four-year-olds took part in a randomized controlled trial in 11 ECEC settings. Participants were cluster-randomized, by ECEC setting, to either a 12 week staff-led and expert-supported intervention or a waiting list control group. The intervention group increased time spent in moderate- and vigorous intensity PA by 10 min/day (95% CI = 3, 18; P=0.01), took 1909 more steps per day (95% CI = 1130, 2688; P<0.01) and reduced sedentary time with 14 min/day (95% CI = -27, -1; P=0.04) compared to the control group. The intervention group had a 2.4 higher odds (95% CI = 1.05, 5.7; P = 0.04) of meeting the PA recommendations compared to the control group at follow-up.

Our results show that a flexible staff-led and expert-supported multicomponent PA intervention can increase total PA level, moderate- and vigorous intensity PA and reduce time spent sedentary in four-year-old children during their stay in ECEC settings.
Introduction

A growing body of evidence suggest that the children’s physical activity (PA) level in childhood education and care (ECEC) settings are insufficient [1, 2]. Moreover, sedentary behavior, defined as any waking behavior characterized by an energy expenditure $\leq 1.5$ metabolic equivalents, while in a sitting, reclining, or lying posture [3], is highly prevalent [4] and has been identified as detrimental to children’s health [5]. Although many children have healthy and active lifestyles, there seems to be a relatively large group of children with a low PA level [6]. In turn, this could lead to negative developmental effects such as low fitness level, weak motor skills and obesity [7]. This is especially worrying because it is known that PA level often tracks from childhood into adulthood [8, 9]. Thus, early intervention is crucial, given that PA plays a pivotal role in children’s overall health and is associated with many positive health outcomes, including physical fitness [10], cardiovascular health [11], bone health [12] and psychosocial and cognitive development [12, 13].

PA levels has been found to be highly variable among children in ECEC settings [14, 15], and may therefore have great potential for effective interventions.

Furthermore, since most children attend ECEC settings for many hours on most days of the week [16], and these institutions reach children across the socioeconomic spectrum, the ECEC settings may serve as an ideal avenue for increasing PA level, reduce sedentary time and enhancing the overall health of young children. Yet, early childhood educators identify parents rather than themselves as persons responsible for promoting children’s PA [17], and often falsely assume that young children receive adequate PA via their daily routines [18]. Thus, intervening with
children and staff in ECEC settings, to equip them with the knowledge, abilities and motivation to promote PA in children during their time in the ECEC, may provide substantial public health benefits [19].

Relatively few PA interventions have been conducted in ECEC settings [20, 21], and intervention effects have shown to be small to moderate and inconsistent across studies [20, 22, 23]. Most PA interventions that have been implemented in the ECEC settings are structured programs developed by PA experts and delivered by staff alone or with great influence of trained research personnel [24]. Staff-led interventions have shown to be less effective in increasing PA compared to interventions implemented by PA experts [24, 25]. Similar findings have emerged regarding intervention effects on fundamental movement skills [26]. The main explanation for lower efficiency of staff led interventions may be that PA experts have more knowledge and competencies regarding this issue [26, 27]. In order to succeed with staff-led programs the need for multiple staff training sessions and maximizing the number of trained staff has been emphasized [25]. A missing perspective in the above-mentioned reviews focusing on PA interventions in ECEC settings is that they may not fully take into account the fact that ECEC teaching professions practice has become increasingly complex due to growing multi-diverse societies and multiple components related to working conditions [28]. Thus, top-down approaches and standardized solutions (programs) will possibly be harder to implement in an ever more diverse environment in terms of individual, social, cultural and physical differences within and between institutions. Therefore, it might be a suitable approach to establish an organizational and collaborative learning processes, a community of professional learning, to improve and maintain the staffs’ competence [28, 29]. This means to contextualize pedagogical practice
through continuous negotiation and reflection between staff members and through collective responsibility for improvement of practice, instead of purely implementing structured programs developed by external experts. While expert delivered interventions seem to be best suited for effect studies, “real-world” approaches implemented by preschool teachers may have a greater potential for developing a sustainable and improved long-term practice.

The current study therefore suggests a dialogical and bottom up approach that will take into account differences within and between local ECEC settings such as child group characteristics, staffs’ competencies and personal preferences and practices for sustainable implementation, differences in the physical indoor and outdoor environments, as well as available equipment to promote physically active play [30]. Interventions that can be adapted to specific circumstances within an organization while maintaining overall fidelity are more likely to be successful [30].

Hence, the theoretical frame of the current intervention is based on Wenger’s theory on Communities of Practice (COP) [31]. Crucial for this theoretical perspective is the idea that organizations are learning communities sharing competence and experiences to develop new practices. Trusting in the staff’s professionalism and their knowledge about and sensitivity towards the individual child and the child groups as well as their awareness regarding barriers and possibilities in terms of environment and equipment. COP includes three modes of belongings; engagement, imagination and alignment. Engagement is active participating in the practice revealing needs for learning and changes, and establishing collective development of the organization. Imagination connects to the staff’s visions and their experience of meaning regarding the intervention, as well as their understanding of the purpose. Alignment is about the commitment to the
entire project. To achieve positive changes based on COP these types of belonging has to be linked to particular processes such as the establishment of mutual engagement over time to promote changes, self-awareness and reflection concerning institutional practices. It is also important to transfer knowledge and purpose of a practice across boundaries in the institution. A further key element is to establish practices where multiple perspectives are heard and appreciated to ensure that the staff members can use opportunities to develop and experience themselves as acknowledged contributors to the institution. The current study, “Active Kindergarten - Active Children” (AK-AC), aims to examine the potential of a staff-led and expert-supported intervention to increase children’s PA level and reduce sedentary time within the ECEC setting compared to standard care.

Materials and methods

The AK-AC study was designed as a two-arm, randomized by ECEC institution, evaluative controlled trial with the overarching aim of increasing the children’s PA level and reduce sedentary time. The Regional Committee for Medical & Health Research Ethics found the research project to be outside the remit of the Act on Medical and Health Research; therefore, the study could be implemented without its approval (ref nr. 2015/1034). Approval from the Norwegian center for research data was not required because no personal or sensitive information was collected or stored (ref nr. 44760/3). Written consent was obtained from all parents based on both oral and written information about the project.

Participants

All children attending one of the 11 public ECEC institutions in Sandefjord municipality and born in 2011 (three or four year olds) (n = 130) were invited to
participate in the study. Parents of a total of 116 children (89%) signed the informed consent form and children of these parents where included in the study. Figure 1 provides an overview of participant flow through the study. Intervention and control group was formed at the center level; six ECEC institutions were randomly assigned to intervention group and five institutions to the control group.

Intervention

Four PA experts in collaboration with two members of the ECEC staff and two members of the municipality health department developed a frame for the intervention based on COP elements to be further developed, concretized and implemented by the staff. The intervention lasted for four months and contained the following components (Table 1): pre-meetings and follow up meetings in each ECEC institution; start up seminar and two follow up courses with all the staff members; ongoing planning and collective reflections practice in the ECEC institutions; Facebook group; and an equipment-package.

Table 1. The components, dosage and a brief description of the content of the intervention based on the theory of Communities of Practice [31].
| Intervention component                                      | Dose     | Description                                                                                                                                                                                                                                                                                                                                 |
|-------------------------------------------------------------|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Pre-meetings in each kindergarten                           | 1 h      | Information about project                                                                                                                                                                                                                                                                                                                                                     |
| Information brochure to parents                             |          | Information about project                                                                                                                                                                                                                                                                                                                                                     |
| Start-up seminar                                            | 6 h      | • Lecture; Physical activity in the ECEC setting  
• Discussing baseline data and outdoor areas with each ECEC  
• Practical session with different play activities  
• Each ECEC institution developed an intervention program tailored to their institution, based on research and data from baseline. Focus on: staffs attitudes, knowledge, skills and competences and organization / environment |
| Two courses with 2 month intervals                          | 3 + 3 h  | Lecturing and discussion of self-determination theory. Practical sessions, sharing examples                                                                                                                                                                                                                                                                                  |
| Planning and implementation in each kindergarten            | 4 months | The ECEC institutions implemented their program                                                                                                                                                                                                                                                                                                                                 |
| Detailed planning of daily physical activity activities     | Weekly   | Documentation of planned physical activity in weekly schedule                                                                                                                                                                                                                                                                                                                     |
| Reflections on how to promote physical activity             | Regular  | Reflection on who to promote physical activity were documented and discussed in each ECEC institution                                                                                                                                                                                                                                                                 |
| Follow-up meetings in each kindergarten 1 month after start up seminar | 1 hour   | • Supporting planning and implementing by project team  
• Practical session; example of physical activities and sharing of ideas  
• Discussions  
  o How does the ECEC institution of your dreams look like?  
  o What can you do to increase physical activity among the children? |                                                                                                                                                                                                                                                                                                                     |
| Facebook group                                              | 4 month  | Networking between ECEC institutions for ideas and inspiration                                                                                                                                                                                                                                                                                                               |
| Equipment                                                   | 1000 EUR | Equipment for physical active play and sweaters with logo for staff                                                                                                                                                                                                                                                                                                               |

**Measurements**

The baseline measurements were conducted in September 2015 and the follow-up measurements immediately after the end of the intervention, May 2016. Physical activity was assessed using ActiGraph GT3X + accelerometers (ActiGraph, LLC, Pensacola, FL, USA) which are seismic instruments that continuously measure acceleration. Raw data from these instruments are referred to as “counts”, which are the sum of acceleration in a given time period. Accelerometers are small and non-invasive and provide a valid estimate of overall PA, which includes frequency, intensity and duration of PA, and steps [32]. The children wore the accelerometer on
the left hip during their stay at the ECEC setting for five consecutive days (Monday morning to Friday afternoon) on both time points. The staff attached the named monitors to the children every morning when they arrived at the ECEC institution and removed it at the end of each day. In order to ensure compliance with wearing the monitor, the staff were also instructed to make sure the monitor was fastened properly at all times and in the right position. The epoch length (sample interval) was set to 15 s [33]. In the analysis of accelerometer data, consecutive strings of epochs with a count value of zero lasting at least 60 minutes (with two exceptions) were treated as non-wear and thus removed from the data array [34]. Analyses were restricted to participants who wore the accelerometer for a minimum of six hours per day on at least two days. Accelerometer data were downloaded using Actilife (version 6 from Actigraph) and further processed and analyzed using a specialized accelerometer analytical software (Kinesoft, version 3.3.80, Saskatchewan, Canada).

To identify different intensities of PA, count thresholds corresponding to the energy cost of the given intensity were applied to the data set. The time (minutes) spent in various levels of PA intensity were calculated according to the cut-offs set by Butte et al. (2014), in which sedentary behavior (sedentary time) was defined as ≤ 239 counts, light intensity PA was defined as 240 to 2119 counts, moderate intensity PA was defined as 2120 to 4449 counts, and any amount above 4450 was considered vigorous or very vigorous intensity PA [35].

Statistical analysis

All statistical analyses were performed using SPSS (Statistical Package for the Social Sciences for Windows, version 24, IBM, Inc., Chicago, USA). Visual inspection of histograms and values of skewness and kurtosis indicated that all data were normally distributed. Descriptive data are presented as proportion, mean, and
standard deviation (SD) with 95% confidence intervals (CIs) where appropriate. Within- and between-differences of interval data were evaluated by t-tests (independent t-tests and paired t-tests). Delta PA scores (T1-T0) were calculated and used as the dependent variable in the analysis of covariance (ANCOVA), with baseline measurements, age, wear time and sex as covariates when calculating the significance of differences between the groups. Odds ratios and 95% confidence intervals (CI) were computed from logistic regression using PA recommendations as the dependent variable, group as the primary independent variable and with age, gender and wear time as covariates. The 50% least physically active children and the 50% most physically active were defined by 50% lowest and highest total counts per min (CPM) on baseline, respectively. When analyzing differences between the least and most active, adjustments were made for wear time, gender and age. The results are presented as mean differences between the two groups ± CI. All tests were based on two-sided probability.

Results

The children were on average 3.7 years old (SD ± 0.4) at baseline, and fifty-seven percent were girls. There were no differences between the intervention and control groups on any of the PA variables at baseline. After excluding participants with unusable accelerometer data (N = 15), a final sample of 101 children was included in the analyses (see Fig. 1 for more details). Excluded participants were equally distributed between groups and did not differ in age, sex or PA level compared to included participants.

Except for vigorous intensity, the intervention group increased significantly more on all PA variables (Table 2). Adjusted for wear time and other potential confounders
the intervention group increased their weekly time spent in MVPA by 50 min, took approx. 10000 more steps and reduced sedentary time by 70 min compared to the control group.

There was an increase in the number of children meeting the PA recommendations of ≥ 60 min of MVPA per day at follow-up compared to baseline for both the intervention group (47%) and the control group (25%) (Fig. 2). The intervention group had a 2.4 higher odds (95% CI = 1.05, 5.7; P = 0.04) of meeting the PA recommendations compared to the control group at follow-up.

The intervention group increased their PA level from baseline to follow-up at all time points except early morning and during food breaks (11 and 14 o’clock) while the control group only significantly increased their PA level at 11 and 14 o’clock (Fig. 3). Compared to the control group, the increment from baseline to follow-up was significantly larger in the intervention group at hours 09–10 (mean diff. 331 CPM, 95% CI = 600, 62; P = 0.01), 10–11 (mean diff. 364, 95% CI = 202, 527; P < 0.01), 13–14 (mean diff. 241, 95% CI = 44, 438; P = 0.01) and 15–16 (mean diff.
The 50% least active children on baseline in the intervention group increased MVPA by 14 min per day (95% CI = 5, 22, P < 0.01) more than the 50% least active children in the control group (Fig. 4). Furthermore, the 50% least active in the intervention group had a significantly greater increase in total PA level (mean diff. 23%, 95% CI = 4, 44; P = 0.02) and steps per day (mean diff. 1936, 95% CI = 1124, 2749; P < 0.01) than the 50% least active children in the control group. Both groups reduced sedentary behavior, but there were no statistical difference between the two groups concerning sedentary time (Fig. 4). For the 50% most active children, those in the intervention group significantly reduced sedentary time (mean diff. -17 min, 95% CI = -2, -32; P = 0.02), but not MVPA, compared to the 50% most active in the control group (Fig. 4). Except for steps per day (mean diff. 1738, 95% CI = 449, 3026; P = 0.01) no other differences were found between the most active children in the two groups. The 50% least active children in the intervention group increased total PA level by 38% (95% CI = 19, 58; P < 0.01), MVPA by 12 min/day (95% CI = 2, 22; P = 0.02) and steps per day by 1228 (95% CI = 431, 2024; P < 0.01) more than the 50% most active in the intervention group. There were no differences in changes in sedentary time between the two subgroups. In the control group, there were no delta differences on any of the PA variable between the least and most active children.

Discussion

The intervention increased four-year-old children’s total PA level, step count, time spent in light- and moderate intensity, and reduced sedentary time during their stay in the ECEC setting. By that, the number of children adhering to the PA
recommendations increased significantly. Especially encouraging was that the least physically active at baseline gained the most from the intervention. The lack of effect on vigorous intensity PA can possibly be explained by the fact that the preschools, according to their self-developed plans, did not have specific goals of influencing this behavior. The staff rather focused on routines, games, plays and activities that targeted the general PA level, moderate intensity and sedentary time. The baseline data were in line with findings from other studies indicating an insufficient degree of PA in children in ECEC settings [1, 2, 36]. The findings in this study are important because most children (83.5% and 97.1% of children between 1-2 and 3-5 years of age respectively) attend ECEC settings most days of the week, mostly for more than 40 hours per week [16]. An effective intervention will thus benefit children across the socioeconomic spectrum.

An increase in the number of children adhering to the PA recommendations is important although we are only starting to understand the dose-response relationship of PA with health parameters in young children [37, 38]. However, there are some studies indicating increased PA can cause long time effects in terms of lower blood pressure [39] and improved aerobic fitness and cardiovascular health as well as decrease body fat [40, 41]. Hence, although we did not measure cardiovascular disease risk factors in this study, the results are most likely clinically important.

It is of particular interest, that these effects have been achieved through a staff-led intervention. As such, our results are contrasting studies that indicate no or only weak effects of staff-led interventions compared to the effects that has been achieved in some studies where the interventions was led by PA experts [20, 22, 24, 25, 42]. The explanation for these contrasting findings may be two folded. Firstly, a
significant proportion (40%) of the about 93 000 staff in Norwegian ECEC services is trained as pre-school teachers, which means that they have higher education at least on a bachelor level and an additional 18% has relevant vocational education (child- and youth worker) [43]. Another 8% has higher education and 4% other forms of vocational education. This educational profile of staff indicates that staff, as least partly, has high competence in terms of both pedagogical and subject knowledge and, by this, is well suited to lead a PA intervention. This is in accordance with Finch et al. (2014) who have highlighted the importance of competence as a prerequisite for staff-led interventions [25]. Secondly, applying the collaborative and “bottom-up” Communities of Practice approach (COP; Wenger, 1999) might be particularly suited for Norwegian ECEC settings as both the national framework plan for pre-school teacher education [44] and the national framework plan for ECEC [45] emphasizes the importance of staff collaboration and organizational learning. Thus, a large proportion of the employees in ECEC settings might be sufficiently prepared to understand their organization as learning communities and capable of sharing competence and experiences to develop new practices. A high degree of professionalism and a combination of pedagogical and content knowledge relevant for facilitating PA in a collaborative and child centered way might have been an important factor for understanding the findings in this study.

The fact that the intervention in the current study was collaborative and staff-led makes the results especially promising because, in comparison to expert-led programs, staff-led programs may be more cost-effective and easier to scale-up. Furthermore, this approach possibly increases the staff’s “sense of ownership” to the intervention and building a more autonomous organization, making it more likely that the institution will carry on focusing on PA once the research project
ends, and succeed in this important work. As MacDonald and Green (2001) highlighted, a dialogical and bottom up approach will take into account the specific context as well as differences within and between ECEC settings relevant for the promotion of physically active play and, by that, have the potential to be successful [30].

This study has some significant strengths and some important limitations. Strengths include a rigorous research design, objective measurement of physical activity and high attendance rate. The fact that almost all of the children that were eligible for the study agreed to wear an accelerometer on two occasions strengthens the generalizability of the study. This is an important point for this kind of studies, because the least physically active individuals, hence those we want to target the most, tend not to volunteer for studies of this nature. Further, a major strength of the study was that it was guided by PA experts but led by staff in each of the ECEC institutions. This flexible and pragmatic approach taken is most likely less costly than expert-driven programs, easier to scale-up and probably more likely to be continued after the research project ends. A limitation of this study is that we are not able to specifically evaluate the contribution of each of the intervention components and by that, assess which one were the most effective or feasible. Furthermore, a lack of process evaluation makes it difficult to determine to what degree the ECEC institutions followed the strategy laid out in the logic model. Furthermore, although we were successful in creating immediate post-program results, a lack of long-term follow-up leaves the question of whether the programme is effective in the long run.

In summary, our results show that a flexible staff-led and expert-supported multicomponent PA intervention can increase total PA level, MVPA and reduce time
spent sedentary in four-year-old children during their stay in ECEC settings. Instead of purely implementing structured programs developed by external experts to increase physical active play in ECEC institutions, the findings from the current study indicate that there is a potential for interventions that emphasize collaborative reflection pedagogical practice between staff members for improvement of complex practice.

Declarations

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Figures

**Figure 1**

Flow of participants through the trial.
Figure 2. Percentage of children in the two groups meeting PA recommendations at baseline and follow-up.

Percentage of children in the two groups meeting PA recommendations at baseline

Figure 3. Delta (follow-up - baseline) physical activity level hour-by-hour for both groups.

Delta (follow-up - baseline) physical activity level hour-by-hour for both groups.
Figure 4. Delta differences (follow-up – baseline) for MVPA and sedentary time for the 50% least active and 50% most active at baseline in the intervention group (left) and control group (right).