Effects of a Physical Activity Intervention in Preschool Children

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ABSTRACT

ROTH, K., S. KRIEMLER, W. LEHMACHER, K. C. RUF, C. GRAF, and H. HEBESTREIT. Effects of a Physical Activity Intervention in Preschool Children. Med. Sci. Sports Exerc., Vol. 47, No. 12, pp. 2542–2551, 2015. Purpose: This study aimed to evaluate a multicomponent, child-appropriate preschool intervention program led by preschool teachers to enhance physical activity (PA) and motor skill performance (MS) in 4- and 5-yr-old children. Methods: Evaluation involved 709 children (mean age, 4.7 ± 0.6 yr; 49.5% girls) from 41 preschools (intervention group, n = 21; control group, n = 20) in the rural and urban surroundings of two German cities. Children in the intervention group received a daily PA intervention lasting 30 min and PA homework over one academic year, which was designed by professionals but led by preschool teachers. The intervention included educational components for parents and teachers. Primary outcomes were MS (composite MS score) and objectively measured moderate-to-vigorous PA (MVPA) by accelerometry. Measurements were performed at baseline, midintervention, and postintervention as well as 2–4 months after the end of intervention. Intervention effects were analyzed by repeated measurement analysis adjusted for group, sex, age, baseline outcomes, urban/rural location of the preschool, and cluster (preschool). Results: Compared with controls, children in the intervention group showed positive effects in MS at postintervention (estimate effect, 0.625 z-score points; 95% confidence interval (CI), 0.276–0.975; P = 0.001) and at follow-up (estimate effect, 0.590 z-score points; 95% CI, 0.109–1.011; P = 0.007) and an increase in MVPA from baseline to postintervention by 0.5% of total wearing time (95% CI, 0.002%–1.01%; P = 0.049) at borderline significance. There was no benefit on MVPA for the intervention group between baseline and follow-up. Conclusions: A child-appropriate, multidimensional PA intervention could sustainably improve MS but not PA. Findings suggest that a change in health-related behaviors is difficult. Future research should implement participatory intervention components in preschool setting and better integrate the families of the children. Key Words: MOTOR SKILL PERFORMANCE, MODERATE-TO-VIGOROUS PHYSICAL ACTIVITY, PRESCHOOL, OBESITY

Poor motor skills and low levels of physical activity are major public health concerns in children for several reasons, as follows: insufficient fundamental movement skills in early childhood are associated with poor self-perception (40), reduced cognitive abilities in linguistics and mathematics (32), and increased frequency of accidents (20). Furthermore, deficient motor development in early years has even been linked to anxious and depressive behavior at school age (30) and less engagement in physical activity during adolescence (3). On the beneficial side, fundamental motor skill competency is positively associated with cardiovascular fitness and is negatively associated with weight status in childhood (25). Likewise, a high level of physical activity is beneficial for health status even in early years (9,38).

There is a widespread call for effective intervention strategies for preschoolers targeting motor skills and/or physical activity behavior to prevent the development of health risks during childhood (9,25,33). Because motor skill performance and physical activity are interlinked at this age (45), interventions may target either of the two or both. Several physical activity intervention trials showed that enhancing physical activity and/or motor skills is possible in a preschool setting (42). However, most trials used an intervention shorter than one academic preschool year and no follow-up assessment took place after the end of the intervention (1,4,12,14,18,24,26,33). It is thus uncertain whether such interventions could induce some persisting beneficial effects. Furthermore, most studies used intervention contents that were highly standardized and/or designed to improve aerobic fitness rather than motor skills. It has been recognized that the mechanisms underlying physical activity engagement and special motor skill development in preschool children are different from one child to another (37,47). Thus, an intervention allowing individualized components

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based on developmental psychology and participatory principles might be more effective, especially in the long run. In addition, some of the reported interventions required extra staff and were thus costly. Enabling preschool teachers to provide the intervention after some training may allow better compliance from the teachers’ side and easier implementation of the program after the end of the study period.

The objective of the present study was therefore to evaluate a multidimensional child-appropriate preschool program, which can be easily implemented in preschools of different sizes and variable equipment and be performed by the preschool teacher. Using a cluster-randomized controlled design, we expected significant benefits of the intervention on physical activity and motor skills performance in 4- and 5-yr-old preschool children.

**MATERIALS AND METHODS**

**Design and study population.** The Prevention through Activity in Kindergarten Trial (PAKT) is a cluster-randomized controlled trial conducted in the cities and counties of Würzburg and Kitzingen, two regions in the south of Germany with an observed high incidence of obese children at school entry age before the start of the project (23). The study design and the recruitment into the study have been described in detail elsewhere (34). Briefly, recruitment started in autumn 2006 with an invitation to all preschools in the respective area, except those with a special focus on physical activity promotion concept. Preschools recruited for this study are institutions that are attended by children age 3–6 yr. In some of these institutions, children are organized in groups that are usually not matched by age. Some other institutions have open concepts, where children play without being in a certain group but where groups are formed according to certain activities. In this study, children were not recruited on the level of groups or classes but throughout the whole preschool. Of the 131 consenting preschools, 41 were selected for the study. The parents of 979 eligible children at the age of 4.0 up to 5.9 yr at the start of the intervention, which took place between September 2007 and July 2008, were invited to join the study.

**FIGURE 1—Cluster and participant flow through the study.** Inclusion criteria were health condition allowing unrestricted physical activity engagement of the children, an age of 4 or 5 yr during the start of the intervention program, and no existing formal physical activity promotion program in preschool. Reasons for refusals to participate were leaving preschool in the near future (moving) and lack of interest or time for passing a testing.

1 Rural area: kindergarten is located in a village with < 20,000 inhabitants; 2 urban area: kindergarten is located in a town with ≥ 20,000 inhabitants.
The study was approved by the ethics committee of the medical faculty of the University of Würzburg.

An informed consent was obtained from 764 children. Fifty-five children had to be excluded because they did not meet the inclusion criteria (health conditions, age) or were not willing to participate in the baseline assessments. A total of 709 (of 979) eligible children (72% participation rate) in 41 preschools were randomly assigned to a control group (CG) (341 children in 20 clusters) or an intervention group (IG) (368 children in 21 clusters). Figures 1 and 2 provide the sample size information throughout the trial and for each outcome measure, respectively. The data of 664 children (94% of the sample) could be analyzed for effects of the intervention, and 610 children (86%) participated in the follow-up assessments 2–4 months after the end of the intervention.

**Randomization and blinding.** After baseline assessments, preschools were randomized into IG (n = 21) and CG (n = 20) using a computer-generated random number table stratified for urban (n = 9) or rural location (n = 32). To minimize contamination, randomization was done at the level of preschools and not on an individual level. Randomization was performed by a person blinded to the identity of the preschool. Children in the CG were not informed about the existence of the intervention program in other preschools. The parents and teachers of the participants in the CG knew about the intervention arm but were not informed about its content. Preschools in the CG continued their routine schedule with their common daily activity and weekly physical activity classes they used to run before participating in the study but without formal motor skills teaching and without promotion of physical activity.

**Intervention.** The design and components of the intervention have been described in detail previously (35). Briefly, the intervention was offered over one academic preschool year (about 11 months). It was developed by physical education scientists, pediatricians, dietitians, and a physiotherapist and targeted the participating 4- and 5-yr-old children, their parents, and their preschool teachers.

The children received a daily 30-min physical activity lesson offered by the preschool teachers. The standardized structure contained an initial ritual and an introduction period that was coordinated with the main section, where the preschool teachers were asked to encourage the children in using and developing their motor skills while attending

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**FIGURE 2—Number of study participants providing data for each outcome measures.** Indicates time spent in MVPA related to total recording time (objectively measured physical activity by accelerometry).
joyful games and exercise tasks. After cooldown, a short feedback round closed the lesson. All contents of the lessons were appropriate for children, based on the holistic domain of psychomotor approach, easy to teach for the preschool teachers, and easily established in the preschools irrespective of their equipment, personnel, and/or space. The main focus of the activity lessons was to enhance coordinative skills and perception (optical, acoustical, tactile, vestibular, and kinesthetic). The teachers were encouraged to adjust the lessons according to the children’s abilities, interests, and ideas. Preschool teachers received a collection of games and exercise tasks developed to plan and organize the daily physical activity lessons as well as a manual including pedagogical, didactical, and methodological background information. These materials were free for the preschools. Teachers were trained in two workshops and were regularly supervised whenever there was a need, at least once per 8 wk.

To encourage physical activity of the children and their families during leisure time, the children received physical activity homework cards once or twice per week and, for holidays, seasonal letters composed of games and exercises to be performed by the child with or without other family members or friends. The games and tasks were designed to be joyful and foster an active lifestyle for the whole family.

Parents were invited to three interactive lectures that provided information and exchange on healthy development and promotion of motor skills in childhood. Furthermore, principles of nutrition, limited media use, and the importance of physical activity in early years were discussed. Flyers summarizing the information were provided during each meeting.

**Outcome measures.** Assessments were performed at baseline (summer 2007), at about half time during the intervention period (winter 2007/2008), at the end of the intervention (summer 2008), and 2–4 months after the end of the intervention (autumn 2008). Motor skill assessments were performed in gymnasiums or large rooms in the preschools. Assessment of height, weight, and skinfold thickness took place in a separate room. Physical activity was measured objectively by accelerometry over a full week including times outside the preschool. All outcome measures were taken by trained researchers blinded to the group assignment of the children. Additional details on the outcome measurements were previously described (34). Briefly, the PAKT project had two primary outcomes, as follows: 1) change in percentage of (wearing) time spent in moderate-to-vigorous physical activity (MVPA cut point, 420 counts per 15 s according to Pate et al. [28]) and 2) change in a composite motor skills score calculated by a mean z-score of an obstacle course (20), standing on one foot (modified) (6), a standing long jump (6), and jumping to-and-fro sidewise (6). The agility of the child was assessed by an obstacle course. The child was asked to manage a distance between a marking point and a bench, climbing over and crawling under the bench, and to pass the course two more times. Time was measured in seconds. Explosive leg strength was measured by the standing long jump task. With this task, the maximum distance a child jumped from both feet was measured in centimeters. The balancing-on-one-foot task assessed static balance ability by assessing the amount of penalty points contacting the ground with the free leg while balancing with the other foot on a 4.5 cm wide bar. With the jumping-to-and-fro-sidewise task, the jumping coordination ability of the child was assessed. Therefore, the child was asked to jump sidewise with both feet as often as possible for 15 s. The sum of valid jumps from two attempts was taken.

Because the results of a throwing ability (48) and a balancing backward task (48) were documented in an ordinal scale, they were not included in the motor skill score. For physical activity, the inclusion criterion was a minimum wearing time of 7 h d⁻¹ for at least three valid weekdays and one valid weekend day. Data on time spent in MVPA were calculated as average time related to individual wearing time per day.

Secondary outcomes included the changes in percentage of time spent in MVPA and the composite motor skills score between the baseline and follow-up (2–4 months after the intervention) and the changes in single motor performance tasks including the obstacle course, one-foot stand, balancing backward (48), standing long jump, jumping to-and-fro sidewise, and target throw (48) at all time points. Secondary outcomes also included age- and sex-related body mass index (BMI) (19), blood pressure, and sum of four skinfolds (triceps, biceps, subscapular, and suprailiac) as well as frequency of accidents and infections, which was assessed by the parents with a semiquantitative questionnaire (34).

For descriptive analyses, socioeconomic status (SES) and migrant status were assessed with a questionnaire for the parents (22). Children were categorized into three groups of SES (low, middle, and high) using the Winkler index (43).

**Statistical methods.** All analyses were performed with IBM SPSS 21, unless stated otherwise. With a postulated group difference of 0.6 SD, we calculated that 348 children would provide a power of $\beta = 0.80$ to detect relevant preventive effects between participants in the IG and participants in the CG at a Bonferroni-adjusted significance level of 0.025 for two primary outcomes. In this calculation, we accounted for possible missing data because of total dropout, missing a testing appointment, or nonparticipation of participants and for incomplete data in accelerometry. Furthermore, assuming an intraclass correlation of $\rho = 0.1$ and an average cluster size of 17 children per preschool, we accounted for random cluster effect. Statistical analyses were based on the intention-to-treat principle. Results are reported at the individual level. Data are described by means and SD or percentages. To document representativeness of our sample, anthropometric characteristics at baseline of the PAKT sample were compared with the national representative distribution in BMI for 3- to 6-yr-old children based on the study of Kurth and Schaffrath Rosario (21) by chi-square test.
TABLE 1. Baseline characteristics of the children reported by parental questionnaire and for primary and secondary outcomes.

<table>
<thead>
<tr>
<th>Characteristics/Outcome</th>
<th>IG</th>
<th>CG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Girls (n (%))</td>
<td>165 (47.6)</td>
<td>176 (47.8)</td>
</tr>
<tr>
<td>Age (yr)</td>
<td>4.7 ± 0.6</td>
<td>4.7 ± 0.5</td>
</tr>
<tr>
<td>Low SES* (n (%))</td>
<td>81 (23.3)</td>
<td>64 (19.6)</td>
</tr>
<tr>
<td>Middle SES* (n (%))</td>
<td>174 (50.0)</td>
<td>164 (50.2)</td>
</tr>
<tr>
<td>High SES* (n (%))</td>
<td>93 (26.7)</td>
<td>99 (30.3)</td>
</tr>
<tr>
<td>Status of migration* (%)</td>
<td>48 (13.1)</td>
<td>40 (11.8)</td>
</tr>
<tr>
<td>MVPA (% wearing time)</td>
<td>14.0 ± 3.6</td>
<td>14.0 ± 3.7</td>
</tr>
<tr>
<td>Motor skill proficiency (composite z-score)**</td>
<td>-0.03 ± 3.2</td>
<td>0.03 ± 3.1</td>
</tr>
<tr>
<td>Agility (s)</td>
<td>26.8 ± 9.5</td>
<td>26.4 ± 8.2</td>
</tr>
<tr>
<td>Static balance (ips)</td>
<td>20.7 ± 8.2</td>
<td>20.0 ± 9.1</td>
</tr>
<tr>
<td>Explosive leg strength (cm)</td>
<td>81.6 ± 19.9</td>
<td>81.0 ± 20.0</td>
</tr>
<tr>
<td>Jumping coordination (jumps)</td>
<td>24.3 ± 7.8</td>
<td>24.1 ± 7.5</td>
</tr>
<tr>
<td>Dynamic balance (n failure (%))</td>
<td>304 (82.6)</td>
<td>268 (78.6)</td>
</tr>
<tr>
<td>Throwing ability (n failure (%))</td>
<td>257 (70.0)</td>
<td>249 (73.2)</td>
</tr>
<tr>
<td>BMI (centile)</td>
<td>46.5 ± 26.2</td>
<td>48.5 ± 25.4</td>
</tr>
<tr>
<td>Sum of four skinfolds (mm)</td>
<td>28.6 ± 6.3</td>
<td>28.6 ± 6.0</td>
</tr>
<tr>
<td>Systolic blood pressure (mm Hg)</td>
<td>100.6 ± 9.3</td>
<td>101.1 ± 9.8</td>
</tr>
<tr>
<td>Diastolic blood pressure (mm Hg)</td>
<td>60.3 ± 8.3</td>
<td>60.3 ± 8.1</td>
</tr>
<tr>
<td>Accidents (n (%))</td>
<td>10 (2.7)</td>
<td>5 (1.5)</td>
</tr>
<tr>
<td>Infections (n (%))</td>
<td>27 (7.3)</td>
<td>29 (8.5)</td>
</tr>
</tbody>
</table>

There were no significant differences between the intervention and the CG. Values are reported as means ± SD, unless stated otherwise.

*According to Winkler Index, SES was categorized on the basis of parental school and professional education, professional position, and net household income (56).

Secondary analyses

For analyzing motor skills performance, a composite motor skills score was calculated by summing up the z-transformed changes of the obstacle course, standing long jump, balancing on one foot, and jumping to-and-fro sidewise tasks based on the total sample at each time point. Before this, the values of the balancing task and of the obstacle course were multiplied by “−1” to account for the fact that a low score in these tasks indicates better performance.

Baseline data were analyzed by descriptive statistics and differences in values at interval scale between the IG and CG by mixed-model ANCOVA, with group (IG vs CG), sex, and urban/rural location of the preschool as fixed factors, preschool (cluster) as random factor, and age as covariate. For outcome variables at the ordinal scale (balancing backward, target throw, infections, and accidents), dummy variables with a yes/no or failure/pass option were computed. Intervention effects were analyzed by a repeated-measures ANCOVA, with the changes from baseline to the two assessments during the intervention period as dependent variables, adjustment for group (IG vs CG), sex, and urban/rural location of the preschool as fixed factors, preschool (cluster) as random factor, and age and baseline outcomes as covariates. The same statistical model was used for the secondary outcome variables in an exploratory manner. The changes in MVPA, composite motor skills score, and the secondary outcome variables between baseline and follow-up were analyzed by the statistical model described previously, including the values of the two time points, baseline and follow-up testing. Effect estimates describe the difference between the mean changes in the IG over CG with 95% confidence intervals (CI).

Additional exploratory analyses

Subsidiary analyses were performed using the statistical model outlined previously.

These analyses assessed the differences in MVPA between groups separately on weekdays (Monday through Friday) and weekends and the effect of the intervention on BMI centile and the sum of skinfold thickness in the subgroup of overweight children (BMI > 90th centile) (19).

RESULTS

Baseline data. Table 1 summarizes the children’s characteristics and the baseline primary and secondary outcome variables according to group assignment. There were no significant differences between the groups at baseline.

Only 5.5% (n = 39) of all children (5.3% boys and 5.7% girls) were overweight or obese. Compared with a nationally representative sample of 3836 three- to 6-year-old children with a prevalence of overweight and obese children of 9.1%, our sample had significantly less overweight or obese preschool children (χ² = 9.893, degrees of freedom = 1, P = 0.002) (19,21).

Primary outcomes. The changes in primary outcomes are presented in Figures 3 and 4. At baseline, there were no significant differences in MVPA (IG, 14% ± 4%; CG, 14% ± 4%) or in the composite motor skills score (IG, −0.03 ± 3.18; CG, 0.03 ± 3.07) between the two groups. The IG showed a higher increase in proportion of daily time spent in MVPA compared with CG (effect estimate of 0.005 (95% CI, −0.00002 to 0.00101); P = 0.049) at the end of the intervention, which was—because of Bonferroni adjustment of the alpha level—close to statistical significance. In contrast, the intervention induced a statistically significant increase in the composite motor skills score, with children in the IG showing a higher motor skills performance than those in the CG with an estimated z-score difference of 0.623 (P = 0.001; 95% CI, 0.276–0.975).
Secondary outcomes. Table 2 presents changes in secondary outcomes during the intervention and follow-up period. Compared with children in the CG, children in the IG showed significant improvements in explosive leg strength, jumping coordination, and static balance, but there were no significant improvements in agility, dynamic balancing, or throwing ability.

The intervention did not lead to a significant difference between the intervention and CG in rates of accidents and infections. There was no significant effect of the intervention on changes in BMI centile or skinfold thickness nor on systolic or diastolic blood pressure.

The effects in physical activity and the composite motor skill score from baseline to short-term follow up 2–4 months after the end of intervention are shown in Figures 3 and 4. Although there was no significant effect of intervention on objectively measured MVPA between baseline and follow-up ($P = 0.859$; estimate, $0.006$; 95% CI, $-0.006$ to $0.007$; mean change in IG, $0.15 \pm 0.37$; mean change in CG, $0.15 \pm 0.04$) (Fig. 4), the increase in children’s motor skills performance (motor skill $z$-score) in favor of the intervention persisted even 2–4 months after the end of intervention ($P = 0.007$; estimate, $0.590$; 95% CI, $0.169$–$1.011$; mean change in IG, $0.309 \pm 3.033$; mean change in CG, $-0.374 \pm 2.998$) (Fig. 3). Table 2 shows the changes in secondary outcomes at follow-up assessment. Children in the IG showed significantly better improvements in agility and in explosive leg strength, whereas positive effects on static balance did not persist. There was no effect of the intervention on further secondary outcomes.

**Additional exploratory analyses.** Additional analyses of children’s MVPA separately for weekdays and for weekends showed that the children in the IG were significantly more active than those in the CG during weekdays ($P = 0.003$; estimate, $0.011$; 95% CI, $0.004$–$0.018$; mean change in IG from baseline to postintervention assessment, $0.021 \pm 0.035$; mean change in CG from baseline to follow-up, $0.009 \pm 0.041$), but there was no such difference in MVPA during weekends.

Sixteen children in the CG and 23 children in the IG were overweight or obese (>90th centile for BMI) at baseline. Although there was no significant intervention effect on BMI centile ($P = 0.054$), we found significant beneficial effects of the intervention on the decrease in the sum of four skinfolds at postintervention in favor of the IG ($-11.444 \text{ mm}; 95\%$ CI, $-22.091$ to $-0.798$; $P = 0.036$). However, this effect did not sustain at follow-up.

**DISCUSSION**

Our randomized, controlled, multicomponent physical activity intervention resulted in an improvement in motor skills performance at the end of the intervention. Children in the IG showed a 55% increase in motor skills performance over children in the CG after the intervention, which persisted with a slightly reduced benefit 2–4 months after the intervention. Thus, we could provide evidence that the motor skills performance of preschool children can be improved and maintained by an appropriate physical activity program in 4- to 5-yr-old boys and girls. The program consisted of a daily 30-min physical activity intervention instructed by the preschool teachers over one preschool year, including physical activity homework for the children, informational meetings for parents, and supervision and two workshops for the preschool teachers. The intervention also included some information about healthy nutrition for children and media use as well as information on how to establish an active family lifestyle.

Improvement in motor proficiency was based on statistically relevant benefits in static balance (standing on one foot), explosive leg strength (standing long jump), and jumping coordination (jumping to-and-fro sideways) from baseline to postintervention. Agility as a complex quality of motor control implies that contents of coordination and speed performance were improved at follow-up, suggesting that it may take some time to have sustained effects in preschoolers.

Most improvements in motor skills (explosive leg strength, jumping coordination, and agility) gained with the intervention were sustained 2–4 months later, with the exception of static balance and jumping coordination. It seems that permanent involvement in motor skills training is necessary for children to achieve benefits in static balance and jumping coordination skills. Because these tasks require a high level of concentration and coordination, they may need persistent training to maintain improvements. Although previous research has indicated that children with advanced motor skills may have benefits in cognitive development and academic performance, one has to acknowledge that this assumption was based on cross-sectional study results (11). Provided that balancing skills are related to cognitive performances, intervention effects on balancing abilities may be influenced by improvement in attentiveness (7).
Children in the IG showed a trend of being physically more active than those in the CG, as differences in change were of borderline statistical significance. Although the magnitude of the difference of increase observed among the groups is small, data need to be interpreted in the context of two considerations: First, physical activity baseline data in our sample showed that the children spent already a relatively high proportion of their time in MVPA with a mean of 14% of their daily measurement time or approximately 1 h and 20 min of MVPA per day. Second, physical activity guidelines for preschool children recommend a minimum of 60 min of MVPA per day (39,44). In light of the fact that the data of our sample showed that 93.5% of the children meet these guidelines at baseline assessment, there was a high level of physical activity in our sample, although this high ratio of active children might be fostered by the low cutoff of MVPA we used (28). Despite these characteristics, MVPA increased in the IG up to about 15% of total daily measurement time. Furthermore, we could show by exploratory analyses that the physical activity of the children could be significantly increased during weekdays (estimate, 1.1%; 95% CI, 0.4%–1.8%). In more specific terms, this means that children spent about 36-min more time in MVPA total recording time per week under intervention. Moreover, the intervention did not result in an increase in MVPA on weekend days. On the basis of the “activity stat” hypothesis, which suggests generally stable levels of physical activity in children (10), there should have been a compensatory decrease in MVPA on days off intervention to maintain an overall level of physical activity. Our study suggests that there is no “activity stat” in preschool children and levels in MVPA can be improved by a child-appropriate intervention. However, already 2–4 months after the end of intervention, benefits in physical activity in favor of the IG did not sustain. This effect is not easy to explain, as a long-term follow-up study (3) revealed motor skill development in childhood to be the key in long-term physical activity. Thus, improvement of motor proficiency in childhood as found in our study could be expected to have public health effects, despite a minor intervention effect on physical activity. It may be that the short time of follow-up in our study was not sufficient to reveal a longitudinal effect of enhanced motor proficiency on physical activity in children, especially since the start of primary school in many of our study participants may have confounded the effects. Further longitudinal research is necessary to clarify associations between motor skills and physical activity in children.

There were no considerable changes in any other health-related outcome variables such as BMI percentile, sum of skinfold thickness, rate of accidents or infections, and blood pressure. One has to bear in mind, though, that we dealt with a quite healthy population and prevalence of overweight or obesity, and the mean BMI percentile of the sample was low at baseline. Lowering the BMI of the children is therefore not needed for this sample. Nevertheless, it is reassuring that our population at risk did show a change in the sum of four skinfolds, which was reduced by 11.4 mm in the obese...
children in the IG compared with that in the CG. This result indicates that obese children reduced body fat under intervention and underlines the importance of measuring skinfold thickness rather than BMI as a more valid predictor for relative body fat in children (5). Such a benefit in children with special risks is of clinical importance especially when considering that obesity in childhood is the most important predictor of adult obesity (15) and that loss of adiposity from childhood to adulthood results in substantially low risk of type 2 diabetes, hypertension, and lipid abnormalities (16).

Strengths and limitations. Strengths of the present study represent having established a relevant and efficacious lifestyle intervention in preschoolers that is low cost and easy to implement into health systems, as it is joyful, appropriate for children, and taught by preschool teachers. Moreover, projects including repeated measures of outcome variables in the current field of preschool intervention studies are rare and results were almost invariably based on an isolated pre- and posttesting. It has been suggested that repeated measures of multiple outcome variables are necessary for valid analysis of the results of an intervention (36,41). Our measures at midintervention fostered the validity of our results and the inclusion of a short-term follow-up 2–4 months after the end of intervention revealed stability and persistence of the intervention effects with respect to motor skills.

We have designed and implemented a multicomponent intervention to promote physical activity in the preschool settings including families. With the inclusion of a collection of games and exercises as well as a manual for preschool teachers that provide comprehensive information and description of the program, this project can be easily transferred to other preschool settings. The strategies used in the project empowered the preschool teachers to organize the lessons on their own and allowed for individual enhancements, which might be a key to motivate all parties involved to take ownership of the intervention and process change (13). All participating preschools completed the two workshops with at least one or up to four teachers of the preschools in the IG. Finally, the large sample size in the study, the broad and objective assessment of outcome measures, and the use of multilevel analyses add to the rigor of our methodology.

Despite these strengths, we acknowledge some study limitations. For some relevant outcome measures, our sample may not be representative. Our sample showed a significantly low prevalence (<10%) of overweight and obesity compared with the national distribution (19), suggesting some selection bias. Active families may have been more motivated to join a study with a physical activity intervention than those who do not favor an active and healthy lifestyle. Unfortunately, we have no information about the nonparticipating children within the consenting preschools. Furthermore, although efforts were made to blind the children in the CG to the existence of the intervention arm (there was no information given by the study personal, nor were media informed about the intervention project), one cannot forget that preschool teachers or parents might have given information to children and data may be affected by some bias. Nevertheless, as we could see that physical activity of the children in the CG did not increase from baseline to midterm assessment, this bias might be very small.

In addition, the focus of the intervention on health status and sedentary behavior of the children was realized with a small amount of informational materials and seminars for the parents, and parental participation in informational lectures was decreasing by the end of the project. Whereas 326 persons took part in the first informational lecture, 155 visited the second, and only 22 joined the third one. Thus, these components of the intervention probably provided only a low dose to change behavior and have any beneficial effect on most of our measured secondary outcomes. Nevertheless, most secondary outcome results were in normal range and should be maintained rather than improved. Future projects should focus a participatory intervention strategy arm targeting parents to foster effects on children’s health markers.

Finally, our intervention project addressed only children for whom we had parental approval for participation. The key question is on how to involve all children within the preschools into such programs, as it is a well-known principle in prevention that if the program is voluntary, the population that needs it most and is at risk is not participating (17). The ideal public health solution would be to make physical activity promotion an integral part of health education policies of preschools as suggested (29).

Comparison with previous preschool intervention studies. In the present study, we confirm earlier findings that motor skill performance can be improved by a physical activity intervention. Several studies aimed to increase fundamental motor skills in preschool children (24,31,33,46). Most of them evaluated the effects with a pre–post analysis, only few integrated a follow-up assessment, and none of them applied a midterm test and a follow-up. Although most of the previous projects led to an improvement in at least some motor skills in preschool children, not all of them have shown success (24,33). From a public health perspective, we have ample evidence of short-term postintervention effects of lifestyle interventions, but evidence about persisting effects beyond the intervention period is still lacking. Our study shows not only that motor skill performance can be improved by a joyful intervention in preschools but also that benefits persist, at least in the short run.

Several randomized controlled trials in preschool children have aimed to increase physical activity with a child care–based, structured physical activity intervention program (1,2,4,26,31). As findings from reviews are divergent because of a large variability in quality, methods, and/or theory of the included studies and/or focus on different populations, evidence of the effects of interventions on physical activity in preschool children is generally lacking there (26). The physical activity intervention in our project was based on a holistic pedagogic approach that aims to assist children in their motor development, emphasizing their self-competence and self-efficacy (47). As addressed in previous studies,
such a participatory approach and a foundation on self-regulation skills could be a key factor in achieving an effect on physical activity in preschool age (13). Our study did not lead to a significant increase in MVPA overall. Given that we had a relatively “active” population at baseline and that there was a significant beneficial effect of the intervention on weekday physical activity, it is reasonable to postulate that physical activity behavior may be improved by child-appropriate interventions. However, further research is needed on the role of mediators and moderators of a potential beneficial intervention effect on physical activity in preschool children.

There is some evidence from randomized, controlled trials that children, being at special risk, can benefit from lifestyle interventions (28,27,31). One physical activity intervention, performed in a sample of African-American overweight children, reported a reduction in BMI in the IG, especially in those with an initially high BMI (2). Three studies revealed a beneficial effect on obesity markers like BMI, skinfold thickness, waist circumference, percentage of body fat, or prevalence of overweight participants in samples of migrant, minority, overweight, or low–socioeconomic status preschool children (8,27,31). With the results of our study, we are in line with these findings, as we found reduced increase in sum of skinfolds in a subsample of overweight children that persisted even after the intervention.

CONCLUSIONS

In conclusion, our results indicate that the PAKT prevention program led to a sustained improvement in motor skill performance but not in overall physical activity or other health-related behavioral patterns in healthy 4- to 5-yr-old children. Considering the few promising results of long-term intervention studies with less standardized intervention contents focusing on motor skills, our results are encouraging. We provided evidence that the program can be implemented by preschool teachers without further costs, which is in line with a holistic preschool developmental policy and is feasible independently of personal resources or space of preschools. Future research with the evaluation of long-term effects of preschool-based, child-appropriate physical activity interventions is needed to gain knowledge regarding whether such programs lead to long-term behavioral changes in motor skills performance that will ultimately transfer into sustained health.

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We declare that the results of our study do not constitute endorsement by the American College of Sports Medicine.

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