Promotion and Provision of Drinking Water in Schools for Overweight Prevention: Randomized, Controlled Cluster Trial
Rebecca Muckelbauer, Lars Libuda, Kerstin Clausen, André Michael Toschke, Thomas Reinehr and Mathilde Kersting
Pediatrics 2009;123:e661-e667
DOI: 10.1542/peds.2008-2186

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://www.pediatrics.org/cgi/content/full/123/4/e661
ARTICLE

Promotion and Provision of Drinking Water in Schools for Overweight Prevention: Randomized, Controlled Cluster Trial

Rebecca Muckelbauer, MSc\textsuperscript{a}, Lars Libuda, MSc\textsuperscript{a}, Kerstin Clausen, PhD\textsuperscript{a}, Andr\'e Michael Toschke, MD, MSc, MPH\textsuperscript{b}, Thomas Reinehr, MD\textsuperscript{c}, Mathilde Kersting, PhD\textsuperscript{a}

\textsuperscript{a}Research Institute of Child Nutrition Dortmund, Department of Dietary Behavior, Dortmund, Germany; \textsuperscript{b}Division of Health and Social Care Research, Department of Public Health Sciences, King’s College London, London, England; \textsuperscript{c}Department of Pediatric Nutrition Medicine, Vestische Hospital for Children and Adolescents Datteln, University of Witten-Herdecke, Witten-Herdecke, Germany

The authors have indicated they have no financial relationships relevant to this article to disclose.

ABSTRACT

OBJECTIVE. The study tested whether a combined environmental and educational intervention solely promoting water consumption was effective in preventing overweight among children in elementary school.

METHODS. The participants in this randomized, controlled cluster trial were second- and third-graders from 32 elementary schools in socially deprived areas of 2 German cities. Water fountains were installed and teachers presented 4 prepared classroom lessons in the intervention group schools (N = 17) to promote water consumption. Control group schools (N = 15) did not receive any intervention. The prevalence of overweight (defined according to the International Obesity Task Force criteria), BMI SD scores, and beverage consumption (in glasses per day; 1 glass was defined as 200 mL) self-reported in 24-hour recall questionnaires, were determined before (baseline) and after the intervention. In addition, the water flow of the fountains was measured during the intervention period of 1 school year (August 2006 to June 2007).

RESULTS. Data on 2950 children (intervention group: N = 1641; control group: N = 1309; age, mean ± SD: 8.3 ± 0.7 years) were analyzed. After the intervention, the risk of overweight was reduced by 31\% in the intervention group, compared with the control group, with adjustment for baseline prevalence of overweight and clustering according to school. Changes in BMI SD scores did not differ between the intervention group and the control group. Water consumption after the intervention was 1.1 glasses per day greater in the intervention group. No intervention effect on juice and soft drink consumption was found. Daily water flow of the fountains indicated lasting use during the entire intervention period, but to varying extent.

CONCLUSION. Our environmental and educational, school-based intervention proved to be effective in the prevention of overweight among children in elementary school, even in a population from socially deprived areas. Pediatrics 2009; 123:e661–e667

THE PREVENTION of overweight in children remains a major public health challenge, because of the continuously increasing prevalence of overweight throughout the world.\textsuperscript{1–3} To date, most preventive strategies have been based on individual or educational interventions and have widely neglected environmental modifications.\textsuperscript{4–6} In addition, many programs used multicomponent interventions that targeted diverse aspects of obesity-related behaviors,\textsuperscript{4,7} which makes it difficult to isolate the specific effects of interventions aimed at a single aspect. Two randomized trials, however, showed that targeting the drinking behaviors of children and adolescents seems to be a promising approach.\textsuperscript{8,9} Both trials focused on reducing the consumption of sugar-containing beverages, which are linked to weight gain and obesity in children and adolescents.\textsuperscript{10–15}
Pure water does not contain energy and thus may support a healthy weight status if it replaces sugar-containing beverages. A weight-regulating effect of water consumption itself, through reduction of energy intake in subsequent meals and/or through water-induced thermogenesis, has been suggested but remains speculative, especially with respect to children.16

Elementary schools represent an ideal setting for intervention programs,7 also because the prevalence of childhood overweight increases notably at the corresponding age in high-income countries.17,18 In particular, children of lower socioeconomic status are at increased risk for overweight and obesity.18,19

A comprehensible intervention for primary prevention of childhood overweight that concentrates on a single obesity-related behavior, supportively considering the environmental approach,3,5,7 and that is effective even for socially deprived populations is needed. To address these gaps, we conducted a randomized, controlled cluster trial that tested the effect of a simple, combined, educational and environmental intervention. Its sole intention was to promote water consumption for overweight prevention, specifically targeting children in elementary schools in deprived urban areas.

**METHODS**

**Setting and Participants**

The study population comprised children attending the second and third grades of elementary schools in deprived neighborhoods of 2 neighboring cities, namely, Dortmund and Essen, Germany. Both cities have a population of ~600,000 and are located in the Ruhr Area, a conglomerate of formerly industrial cities. Schools were eligible for participation if they were located in deprived areas, as defined with the following criteria: unemployment rate of ≥15%, proportion of social welfare recipients of ≥5%, and proportion of non-German residents of ≥5%, as indicated by the local public authorities. Schools in Dortmund represented the intervention group (IG) and schools in Essen the control group (CG). For each city, 20 schools were selected randomly (Fig 1). One IG school did not meet technical requirements for the installation of the water fountain, and 6 schools declined participation, mainly stating the time-consuming study requirements as a reason. We obtained written parental consent for 3220 (84%) of 3817 children attending the participating schools, with a higher rate in the IG (88%) than in the CG (80%; P = .004).
Study Design
The randomized, controlled cluster trial with 1 intervention arm and 1 control arm considered schools as cluster units of intervention. Randomization was performed at the city level to minimize contamination between neighboring schools in 1 city. The intervention lasted 1 school year, from August 2006 (baseline assessment) to June 2007 (follow-up assessment). Study materials, data collection, and intervention were pilot-tested in 1 school.

A calculated sample size of 3600 children was needed to detect a difference of 4% in the prevalence of overweight between the IG and the CG at the follow-up evaluation, with \( \alpha = .1 \) and a power of 0.8. The cluster design was considered by assuming an intracluster correlation coefficient of \(<0.005\) and a mean cluster size of 100 participants. The study was approved by the ethics committee of the University of Bonn (Bonn, Germany).

Intervention
In each IG school, 1 water fountain (Sodamaster-Aquatower 200; IONOX-Wassertechnologie, Obertraubling, Germany), or 2 for schools with \(>150\) participants, was installed. The fountains provided cooled, filtered, plain or optionally carbonated water. In addition, each child received a plastic water bottle (500 mL), and teachers were encouraged to organize filling of the water bottles each morning for all children in the corresponding classes. The educational intervention consisted of four 45-minute classroom lessons dealing with the water needs of the body and the water circuit in nature. At the beginning of the study, teachers received a booklet with the prepared curriculum and necessary materials to implement the lessons in the formal school curriculum. The lessons were developed by using the results of empirical teaching research and were intended to improve the constructs of intention, attitudes, and perceived behavioral control, on the basis of the theory of planned behavior.

Three months after the beginning of the study, teachers introduced a motivation unit (ie, booster sessions) that used a goal-setting strategy to reach a sustained increase in water consumption by giving quantitative targets and feedback. In month 5 after the baseline assessment, each participant received a new water bottle with an improved handling design. CG schools did not receive any intervention.

Outcome Measures

Body Weight Status
At baseline and follow-up assessments, body weight and height were measured to the nearest 0.1 cm and 0.1 kg, respectively, with portable stadiometers and digital scales (Seca 225 and 704; Seca, Hamburg, Germany) by 2 trained health care professionals, with participants in light clothing without shoes. Measured data were classified as implausible with a child’s growth of \(<0\) cm or \(\geq 8\) cm or weight changes of less than \(-10\) kg or \(>15\) kg between baseline and follow-up assessments.

The primary outcome prevalence overweight was defined according to the recommendations of the International Obesity Task Force. BMI values were converted into gender- and age-independent, continuous SD scores (SDSs) (secondary outcome) on the basis of German reference percentile values.

Beverage Consumption
Beverage consumption, in number of glasses (with 1 glass defined as 200 mL), was evaluated by using a 24-hour recall questionnaire that was self-completed under teachers’ supervision at baseline and follow-up assessments. Teachers received an information sheet on how to administer the picture-based questionnaires in the classroom. Children were asked to mark the number of consumed glasses of water, juice (including juicy drinks), and soft drinks, among other beverage categories, for 5 defined time periods over the previous 24 hours. Questionnaires were classified as implausible with a daily beverage consumption of \(\leq 20\) glasses.

Water Flow
The water flow from the fountains was measured in the IG schools by reading the integrated flow meters at baseline and at 6 control visits during the follow-up period.

Process Evaluation
For process evaluation, questionnaires and oral interviews were administered to the teachers at the IG schools. At the follow-up assessment, teachers were asked which of the classroom lessons they had implemented, whether they had introduced the booster sessions and had continued their implementation until the follow-up assessment (interview), and whether daily water provision from the fountains was organized for the entire class until the follow-up assessment (questionnaire). In the interview, the teachers were asked how water drinking affected regular classes, with 4 possible nominal response categories. In a questionnaire administered at the follow-up assessment, the teachers were asked to grade the concept of the intervention program from 1 (very good) to 6 (deficient).

Statistical Analyses
All analyses were performed by using the statistical software package SAS 8.02 (SAS Institute, Cary, NC). Considering the cluster design of the trial, we performed all statistical analyses by using generalized estimation equations (PROC GENMOD), with schools as cluster units. An identity link for continuous response variables, a logarithmic link for binary data, and an underlying binomial distribution were applied. Tests for baseline comparability between the groups were conducted for all outcome variables and potential confounders.

The model to test for intervention effects on the primary outcome prevalence of overweight at the follow-up assessment included significant confounders, besides the fixed intervention effect, although randomization was conducted. Potential confounders defined a priori included
**RESULTS**

**Study Sample**

Figure 1 summarizes school and participant flow through the trial. A total of 32 schools finished the follow-up period. One CG school withdrew from participation because of too-demanding requirements for follow-up assessment. Of 3190 children screened at baseline, a total of 2950 children (92%) were also measured at the follow-up assessment and were considered for analysis. Dropouts (n = 240) were similar to analyzed participants with respect to the prevalence of overweight (24.6% vs 24.5%; P = .741), mean BMI SDS (0.26 vs 0.26; P = .807), mean age (8.27 vs 8.30 years; P = .574), proportion of boys (50.4% vs 50.2%; P = .772), and proportion of children with migrational background (42.1% vs 44.3%; P = .568).

The IG and CG did not differ in baseline characteristics regarding prevalence of overweight, BMI SDS, gender, age, and migrational background. Water and soft drink consumption levels at baseline were similar in the IG and the CG, but the level of juice consumption was slightly higher in the IG than in the CG (Table 1).

Follow-up measurements were conducted 250 ± 8 days after baseline assessment, on average. The follow-up periods did not differ between the IG (249 ± 7 days) and the CG (252 ± 8 days; P = .300).

**Body Weight Status**

The prevalence of overweight at the follow-up assessment was 23.5% in the IG and 27.8% in the CG. The risk of overweight at the follow-up assessment was significantly reduced in the IG, compared with the CG, as indicated by an odds ratio of 0.69 (95% confidence interval [CI]: 0.48–0.98) (Table 2). The intracluster correlation coefficient for the prevalence of overweight was 0.011, indicating more clustering of final results than expected.

BMI SDS changes from baseline to the follow-up assessment were 0.005 ± 0.289 in the IG and 0.007 ± 0.295 in the CG. The estimated group difference (IG – CG) in BMI SDS changes of −0.004 (95% CI: −0.045 to 0.036) was not significant (P = .829), with adjustment for BMI SDS at baseline.

**Beverage Consumption**

Overall, 1987 (67%) of 2950 analyzed children (IG: 65%; CG: 70%) had plausible questionnaires on beverage consumption at both baseline and follow-up assessments.

Changes in water consumption from baseline to the follow-up assessment were significantly higher in the IG, compared with the CG, with an estimated difference of 1.1 glasses per day (95% CI: 0.7–1.4 glasses per day; P < .001), with adjustment for baseline consumption and migrational background.

Changes in juice consumption from baseline to the follow-up assessment differed significantly between the treatment groups (IG – CG) by −0.2 glasses per day (95% CI: −0.4 to 0.0 glasses per day; P = .039), with adjustment for migrational background; after adjustment for baseline juice consumption, however, the estimated difference of −0.1 glasses per day (95% CI: −0.2 to 0.1 glasses per day) was no longer significant (P = .500). No intervention effect on soft drink consumption was observed (P = .406).

---

**TABLE 1** Baseline Characteristics and Outcome Variables for Analyzed Participants in the IG and CG

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>IG</th>
<th>CG</th>
<th>P*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participants, N</td>
<td>1641</td>
<td>1309</td>
<td></td>
</tr>
<tr>
<td>Schools, N</td>
<td>17</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Classes, N</td>
<td>85</td>
<td>75</td>
<td></td>
</tr>
<tr>
<td>Participants per school, mean ± SD</td>
<td>97±29</td>
<td>87±34</td>
<td></td>
</tr>
<tr>
<td>Age, mean ± SD, y</td>
<td>8.26±0.73</td>
<td>8.34±0.76</td>
<td>.050</td>
</tr>
<tr>
<td>Male, n (%)</td>
<td>824 (50.2)</td>
<td>658 (50.3)</td>
<td>.405</td>
</tr>
<tr>
<td>With migrational background, n (%)</td>
<td>691 (42.1)</td>
<td>615 (47.0)</td>
<td>.596</td>
</tr>
<tr>
<td>Body weight status</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overweight, n (%)</td>
<td>384 (23.4)</td>
<td>339 (25.9)</td>
<td>.209</td>
</tr>
<tr>
<td>BMI SDS, mean ± SD</td>
<td>0.23±1.06</td>
<td>0.30±1.13</td>
<td>.37</td>
</tr>
<tr>
<td>Beverage consumption, mean ± SD, glasses per day*</td>
<td>3.0±2.7</td>
<td>3.4±2.7</td>
<td>.064</td>
</tr>
<tr>
<td>Water</td>
<td>1.5±1.8</td>
<td>1.3±1.7</td>
<td>.032</td>
</tr>
<tr>
<td>Juice</td>
<td>1.3±1.7</td>
<td>1.3±1.7</td>
<td>.771</td>
</tr>
</tbody>
</table>

a Unadjusted values on an individual level.

b P values for differences between the IG and CG, with adjustment for clustering according to school.

c Defined according to the recommendations of the International Obesity Task Force.

d On the basis of age- and gender-specific German reference percentiles.

---

**TABLE 2** Intervention Effect on the Prevalence of Overweight at the Follow-up Assessment (IG Versus CG)

<table>
<thead>
<tr>
<th>Group</th>
<th>Crude Change, n (Percentage Points)*</th>
<th>Adjusted Risk, Odds Ratio (95% CI)*</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>IG</td>
<td>1 (0.06)</td>
<td>0.69 (0.48–0.98)</td>
<td>.040</td>
</tr>
<tr>
<td>CG</td>
<td>25 (1.91)</td>
<td>1.00 (reference)</td>
<td></td>
</tr>
</tbody>
</table>
Introduction of the educational motivation units occurred at point M2 and introduction of the new water bottles at point M3.

The collaboration of teachers is essential for sustainable modification of the school environment. Our process evaluation suggested good and lasting compliance for the majority of teachers. Compliance was better with

**DISCUSSION**

This large, randomized, controlled cluster trial showed for the first time that a combined educational and environmental intervention, with a single focus on the promotion and provision of drinking water, could reduce effectively the risk of overweight for children in elementary school. The intervention effect was accompanied by increased water consumption by the children, as estimated from questionnaires and confirmed by the measured water flow of the fountains. The reduction in consumption of sugar-containing beverages did not reach significance, probably because our prevention program did not actively discourage drinking of those beverages but only promoted water consumption.

Two smaller intervention trials also focused on drink-
respect to implementing the daily use of the water fountains than presenting the educational lessons. For interpretation of these results, it must be considered that teachers could not refuse study participation, because the head of the school made that decision. This might reflect common conditions at schools and might point to good transferability of our intervention strategy to other schools.

The study was not designed to differentiate between the isolated effects of the educational and environmental approaches. Here, as in the study by Loughridge and Barratt, only the combination of the 2 approaches proved to be effective in increasing water consumption, although in the present trial teachers’ compliance was not complete.

From a public health perspective, it is of importance that this intervention was effective in a deprived population, in which the prevalence of obesity was up to 3 times greater than that among children of a higher socioeconomic background. To date, only a few preventive interventions have been tested in this or other high-risk groups and most have not been effective, perhaps because of potential social barriers.

Economic data on programs for overweight prevention are widely missing. In our study, the initial costs per water fountain were ~2500 euros and the long-term costs per enrolled child were ~13 euros per year. The educational intervention was presented by the teachers; therefore, no additive costs emerged. Two school-based intervention trials with classroom lessons and physical education showed a partly beneficial effect on body weight status and had estimated costs similar to ours, of ~15 US dollars per year per student.

Adverse effects were not reported during the study period. The water fountains were provided with filters for microbiologic and chemical purification and a thermic system for inhibition of external bacterial contamination. Teachers ordered the children to take the bottles home once each week for dishwasher cleaning.

Some limitations of this study must be mentioned. First, with an actual sample size of 2950 participants, the study was slightly underpowered according to the originally targeted sample size of 3600. Second, we did not evaluate dietary behaviors of the children besides beverage consumption, because of the general limitations of self-reporting by children. Differences in school lunches between schools did not play a role, because all classes finished at lunchtime and snacks and beverages, except for school milk, were not purchasable at all. Third, selection bias cannot be ruled out, because 7 of 40 schools declined participation and 16% of all children provided no written consent. However, dropouts did not differ from the analyzed study sample with respect to body weight status and sociodemographic characteristics.

CONCLUSIONS

Our environmental and educational, school-based intervention, with the single focus on the promotion and provision of drinking water, proved to be effective in the prevention of childhood overweight. It was effective even with a population from socially deprived areas, which encourages introduction in the general population. The extent to which the single parts of the combined educational and environmental intervention accounted for the preventive effect and whether this intervention results in long-term behavior and weight changes remain to be determined.

ACKNOWLEDGMENTS

This trial was carried out by the Research Institute of Child Nutrition Dortmund (Dortmund, Germany), and was supported by grant 05HS026 from the German Federal Ministry of Food, Agriculture, and Consumer Protection. Intervention materials (water fountains, bottles, and lesson booklets) were provided by the Association of the German Gas and Water Industries. Ms Muckelbauer and Mr Libuda received research funding from grant 05HS026 from the German Federal Ministry of Food, Agriculture, and Consumer Protection. Professor Eissing (Technical University of Dortmund, Germany) provided didactical expertise in the development of the educational intervention.

REFERENCES


Promotion and Provision of Drinking Water in Schools for Overweight Prevention: Randomized, Controlled Cluster Trial
Rebecca Muckelbauer, Lars Libuda, Kerstin Clausen, André Michael Toschke, Thomas Reinehr and Mathilde Kersting
Pediatrics 2009;123:e661-e667
DOI: 10.1542/peds.2008-2186

Updated Information & Services
including high-resolution figures, can be found at:
http://www.pediatrics.org/cgi/content/full/123/4/e661

References
This article cites 29 articles, 12 of which you can access for free at:
http://www.pediatrics.org/cgi/content/full/123/4/e661#BIBL

Citations
This article has been cited by 4 HighWire-hosted articles:
http://www.pediatrics.org/cgi/content/full/123/4/e661#otherarticles

Post-Publication Peer Reviews (P³Rs)
One P³R has been posted to this article:
http://www.pediatrics.org/cgi/eletters/123/4/e661

Subspecialty Collections
This article, along with others on similar topics, appears in the following collection(s):
Nutrition & Metabolism
http://www.pediatrics.org/cgi/collection/nutrition_and_metabolism

Permissions & Licensing
Information about reproducing this article in parts (figures, tables) or in its entirety can be found online at:
http://www.pediatrics.org/misc/Permissions.shtml

Reprints
Information about ordering reprints can be found online:
http://www.pediatrics.org/misc/reprints.shtml