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

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What's Known on This Subject

The prevention of childhood overweight is a major public health challenge. Intervention trials have shown that schools are a promising setting for overweight prevention. To date, no particular intervention has been proved to be effective in overweight prevention.

What This Study Adds

This study showed that a simple intervention with the sole focus of promoting water consumption effectively prevented overweight among children in elementary schools in socially deprived urban areas.

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 \pm 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

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This trial has been registered at www.clinicaltrials.gov (identifier NCT00554294).

Key Words

overweight, prevention, children, diet, environment

Abbreviations

CG—control group
CI—confidence interval
IG—intervention group
SDS—SD score

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THE PREVENTION OF overweight in children remains a major public health challenge, because of the continuously increasing prevalence of overweight throughout the world.^{1–3} To date, most preventive strategies have been based on individual or educational interventions and have widely neglected environmental modifications.^{4–6} In addition, many programs used multicomponent interventions that targeted diverse aspects of obesity-related behaviors,^{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.^{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.^{10–15}

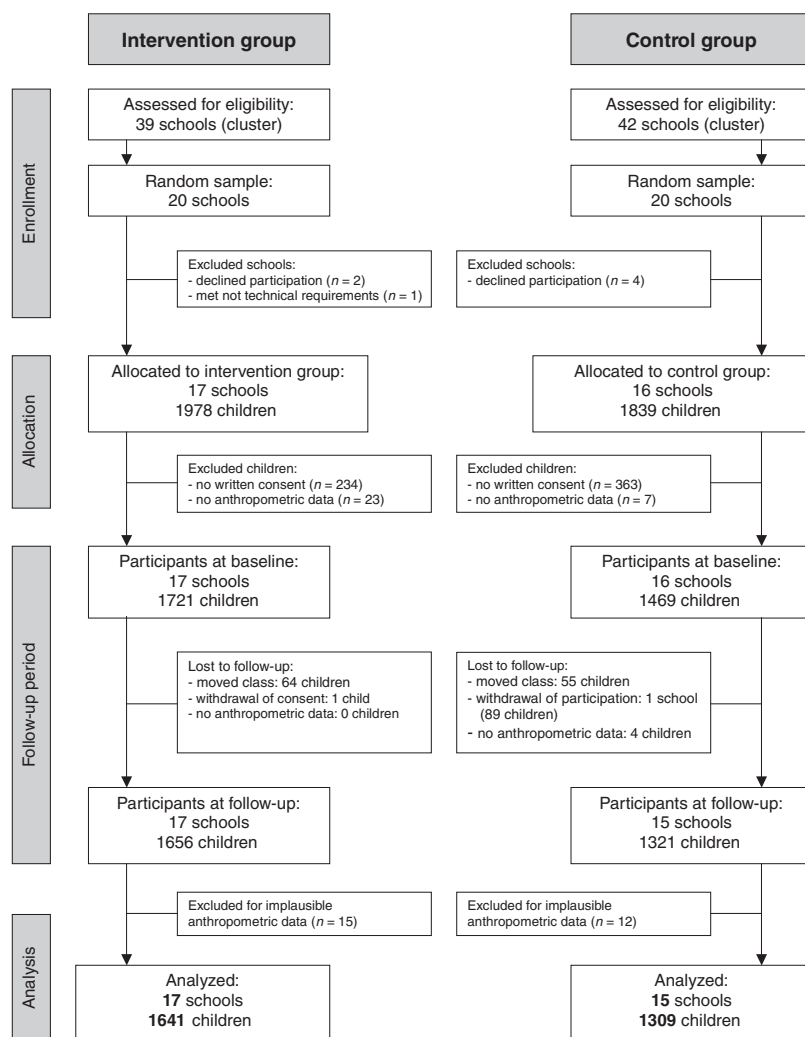


FIGURE 1
Participant and school flow in the IG and CG, with school as the cluster unit.

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 $\geq 15\%$, proportion of social welfare recipients of $\geq 5\%$, and proportion of non-German residents of $\geq 5\%$, 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-Aqua-tower 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 research²⁰ and were intended to improve the constructs of intention, attitudes, and perceived behavioral control, on the basis of the theory of planned behavior.²¹

Three months after the beginning of the study, teachers introduced a motivation unit (ie, booster sessions) that used a goal-setting strategy²² to reach a sustained increase in water consumption by giving quantitative targets and feedback.²⁰ 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 >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 de-

finied according to the recommendations of the International Obesity Task Force.²³ BMI values were converted into gender- and age-independent, continuous SD scores (SDSs) (secondary outcome) on the basis of German reference percentile values.²⁴

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 ≤ 0 glasses or >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

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

Characteristic ^a	IG	CG	P ^b
Participants, <i>N</i>	1641	1309	
Schools, <i>N</i>	17	15	
Classes, <i>N</i>	85	75	
Participants per school, mean ± SD	97 ± 29	87 ± 34	
Age, mean ± SD, y	8.26 ± 0.73	8.34 ± 0.76	.050
Male, <i>n</i> (%)	824 (50.2)	658 (50.3)	.405
With migrational background, <i>n</i> (%)	691 (42.1)	615 (47.0)	.596
Body weight status			
Overweight, <i>n</i> (%) ^c	384 (23.4)	339 (25.9)	.209
BMI SDS, mean ± SD ^d	0.23 ± 1.06	0.30 ± 1.13	.137
Beverage consumption, mean ± SD, glasses per day ^e			
Water	3.0 ± 2.7	3.4 ± 2.7	.064
Juice	1.5 ± 1.8	1.3 ± 1.6	.032
Soft drinks	1.3 ± 1.7	1.3 ± 1.7	.771

^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.²³

^d On the basis of age- and gender-specific German reference percentiles.²⁴

^e On the basis of all available data for the IG (*N* = 1070) and the CG (*N* = 917).

body weight status at baseline, age at baseline, gender, and migrational background. To achieve a final model containing the intervention effect and only significant confounders, we used backward selection. We also tested interactions of the intervention with gender, age, and body weight status at baseline, but none of the interaction terms was significant. Separate models for secondary outcomes considered BMI SDS and beverage consumption as response variables. The time effect on the daily water flow of the fountains was tested with repeated-measures analysis. Continuous variables are presented as means ± SDs and binary and categorical data as proportions on an individual level unless stated otherwise. *P* < .05 was considered statistically significant.

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

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

Group	Crude Change, <i>n</i> (Percentage Points) ^a	Adjusted Risk, Odds Ratio (95% CI) ^b	<i>P</i>
IG	1 (0.06)	0.69 (0.48–0.98)	.040
CG	25 (1.91)	1.00 (reference)	

Overweight was defined according to the recommendations of the International Obesity Task Force.²³

^a Unadjusted change from baseline to the follow-up assessment in the prevalence of overweight on an individual level.

^b Risk of overweight at the follow-up assessment, with adjustment for the prevalence of overweight at baseline and clustering according to school.

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 intraclass 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).

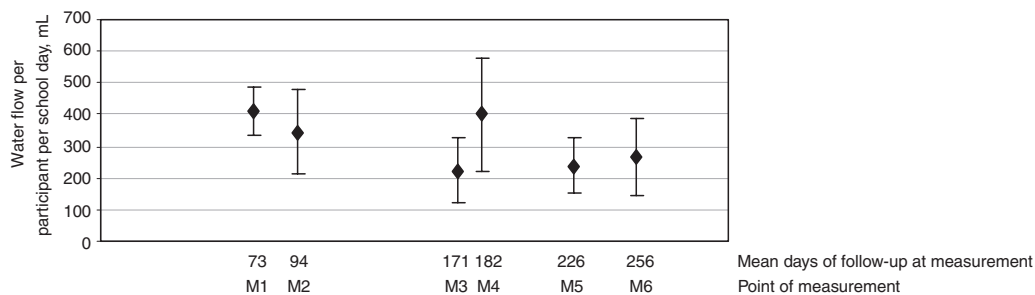


FIGURE 2

Water flow per participant per school day in the IG schools ($N = 17$) during the follow-up period, at measurement points M1 to M6. Values are means, with SDs indicated by error bars. Introduction of the educational motivation units occurred at point M2 and introduction of the new water bottles at point M3.

Water Flow

The daily water flow gives the average volume of water supplied per participant per school day from the fountains in the IG schools, as calculated from the water flow measured 6 times during the intervention period (Fig 2). The daily water flow decreased from 412 mL at month 2 to 223 mL within 3 months ($P < .001$). After the participants received a new water bottle at measurement point 3, the daily water flow increased significantly to 400 mL ($P < .001$). The daily water flow then decreased to 268 mL at the follow-up assessment ($P < .001$).

Process Evaluation

Interviews with the teachers ($N = 85$) in the IG schools showed that 94% of the teachers implemented ≥ 1 and 85% implemented ≥ 2 of the 4 classroom lessons, whereas 16% implemented all lessons. The booster sessions were introduced by 68% of the teachers, and 24% of the teachers continued their regular implementation until the end of the intervention period. In the majority of classes (71%), daily provision of drinking water from the fountains was organized for the entire class during the intervention period. One half (49%) of the teachers stated that drinking water from the bottles did not disturb their classes, 26% considered it a little disturbing, 10% considered it very disturbing, and 15% did not allow drinking during classes. At the end of the trial, 65% of the teachers graded the intervention program as 1 (very good) or 2 (good), 27% graded it as 3 (satisfactory), and 8% graded it worse.

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-

ing habits of children and adolescents. A cluster-randomized, controlled trial in elementary schools aimed at decreasing the consumption of carbonated drinks through an educational program and resulted in a reduced prevalence of overweight after 12 months.⁸ Two years later, however, the preventive effect was no longer significant.²⁵ The other randomized, controlled trial combined behavioral with environmental interventions in the family setting through weekly home deliveries of noncaloric beverages. This intervention reduced the consumption of sugar-sweetened beverages and had a beneficial effect on body weight status in overweight adolescents.⁹

Similar to our intervention strategy, Loughridge and Barratt²⁶ provided a secondary school with water coolers, in combination with lessons on the health benefits of water. Their combined approach also resulted in increased water consumption, although the volume of soft drinks purchased by students in schools did not change. Unfortunately, body weight status was not reported.

The present trial resulted in a reduction in the risk for overweight but did not find an intervention effect on the mean changes in BMI SDS, similar to the results of another prevention trial,²⁷ which indicates that there was no general weight-reducing effect. This suggests that children with body weight status close to the cutoff point for overweight received the greatest benefit from our intervention.

Our program was in line with calls for supportive environmental modifications to produce sustainable behavioral changes.^{1,3,5,7} Although we cannot determine the long-term effects of our intervention beyond the follow-up period of 1 school year, there is some evidence for a change in drinking behaviors. The measured water flow of the fountains indicated lasting use of the fountains during the entire period, although the extent varied. The introduction of new water bottles yielded newly increased use, which demonstrates that the bottles worked as an incentive for the children. In contrast, the booster sessions as motivation units did not seem to be effective, perhaps partly because teachers showed low levels of compliance in presenting these units regularly.

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

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,²⁶ 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.¹⁸ To date, only a few preventive interventions have been tested in this or other high-risk groups and most have not been effective,²⁸ perhaps because of potential social barriers.²⁹

Economic data on programs for overweight prevention are widely missing.³ 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^{27,30} and had estimated costs similar to ours, of ~15 US dollars per year per student.^{31,32}

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.³³ 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.

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

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