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RESEARCH ARTICLE

The Effects of the Jump-In Whole-School Intervention on the Weight Development of Children in Amsterdam, the Netherlands

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ABSTRACT

BACKGROUND: This study assessed the effects of the ''Jump-in'' whole-school intervention in Amsterdam, the Netherlands, on children's weight development by comparing children exposed to the intervention and controls from 3 other large Dutch cities. Jump-in is a comprehensive intervention that aims to stimulate healthy nutrition and physical activity in children at primary schools in Amsterdam. In addition, the relationship between the intervention's implementation degree and its effectiveness was studied.

METHODS: Demographic and anthropometric data, collected by youth health care professionals via routine health checks at T0 (2014) and T1 (2019), were used to analyze possible intervention effects by comparing the weight development of children exposed to the Jump-in intervention versus unexposed controls. Implementation logs from health promotion professionals were used to determine intervention effects per implementation degree. Multilevel regression analyses were used for all analyses.

RESULTS: In total, 4299 children were included mean age ± 5.5 years (T0), 10.6 years (T1), and ≈50% boys/girls at both times. Receiving the fully implemented intervention resulted in a decline in standardized body-mass index (zBMI) compared to the controls (−0.23, confidence interval [CI] −0.33, −0.13). It also led to higher odds to move into a healthier weight category over time (odds ratio [OR] 1.36, CI 1.06, 1.74), yet no statistically significant shift towards a healthy weight was found.

CONCLUSIONS: Relative to the controls, children exposed to the intervention showed positive zBMI developments, with stronger effects when the implementation degree was higher. Despite positive results, creating more impact might require the further integration of school-based programs into whole-systems approaches that include other energy-balance behaviors.

Keywords: health-promoting school; overweight; obesity; prevention; school-based intervention; implementation.

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Childhood overweight and obesity is a major current public health problem with a worldwide prevalence that tripled from 1975 to 2018.[1,2] This means that in 2018 a staggering 340 million children worldwide between the ages of 5 to 19 had overweight or obesity.[2] Their weight puts these children at higher risk for a range of serious negative consequences to their physical, mental, and social health.[3,4] Overweight and obesity are caused by a wide variety of factors that are strongly linked within a complex social system,[5] which results in a long-term energy imbalance where daily energy intake exceeds daily energy expenditures. Different determinant models clearly illustrate that a wide range of interrelated factors is at play across many domains that influence children's weight development.[5,6] For example, factors such as what food is available at school, what social norms are set at home, the prices of (un)healthy foods, or what health education children are provided with are all intertwined and impactful,

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as illustrated in the Foresight Obesity Systems Map (FOSM).[5]

One such domain where interventions have been shown to potentially impact children's healthy development is at school.[7-11] Unfortunately, thus far, few school-based interventions have shown significant, meaningful effects on children's weight development.[11-14] First, studies state that there is a need for methodologically stronger designs that still take into account the complex real-world situations, the long-term effects, and intervention institutionalization.[11,15] In addition, more focus should be placed on interventions' fidelity and implementation success when evaluating what works in which contexts.[12,15] Finally, several recent systematic reviews conclude that while school-based interventions show promise in the battle against overweight and obesity, they should nonetheless be developed and implemented as part of a more extensive, integrated approach.[7-9,13,14] This means pursuing strong alliances between health and education professionals, family engagement, parental involvement, and combining physical activity and healthy eating within comprehensive, integrated health-promotion programs that apply the Whole-School Model (WSM, formerly the Health-Promoting School Model).[9,10,16]

In 2013, the city of Amsterdam therefore started a comprehensive initiative to prevent and combat childhood overweight and obesity: the Amsterdam Healthy Weight Approach (AHWA).[17] At that time, about 13.2% of Dutch youth had overweight or obesity, whereas this averaged around 20% to 25% in Amsterdam with large variations among different city areas, meaning that these averages were much higher in low-socioeconomic position (SEP) neighborhoods than they were elsewhere. By aiming to stimulate healthy energy-balance behaviors (eg nutrition, PA) in children, it tries to stimulate their healthy weight development. One of the ways this is done is via its comprehensive Whole-School program ''Jump-in.'' As a collaboration between several municipal departments, ie, the public health services (GGD), Department of Sports, and Department of Education, primary schools throughout Amsterdam are supported and facilitated to stimulate healthy nutrition and PA habits among their children. Jump-in is shaped as a multicomponent, whole-school intervention[18,19] and was originally developed using the intervention mapping (IM) protocol.[20] Although previous evaluation studies have shown that certain interventions used as part of the Jump-in program had positive effects on the health behaviors they targeted,[19,23,24] there is still a lack of insights into the long-term effects of this whole-school intervention program on children's body mass index (BMI), and whether this impact differs based on implementation degree.

Study Objectives: The current article presents a 5-year intervention study into the effects of the Jump-in intervention on the standardized body-mass index (zBMI) and (un)healthy weight development of primary school children that were exposed to the Jump-in intervention versus a sample of children from 3 comparable Dutch cities that served as controls. The research question that poses the central aim of this study is twofold, namely (1) does the Jump-in intervention positively affect the zBMI and weight development of primary school-aged children from low-SEP schools in Amsterdam, the Netherlands, compared to children from similar schools in several other large Dutch cities, and (2) do these potential effects differ depending on the degree of implementation of the intervention program.

METHODS

The weight development of children exposed to Amsterdam's Jump-in whole-school intervention was compared to that of children from 3 of the other top-10 largest cities in the Netherlands over the course of 5 years from age 5 to 10. These cities were selected because of their relative comparability to Amsterdam in terms of size, urbanization and SEP-variety, and since they did not have a similar, structurally implemented program.

Participants

The main criterion for a school to be included in this study was having an average percentage of

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overweight/obese children that equaled or exceeded the 13.2% Dutch average for primary school children at T0, ie, school year 2013 to 2014, since this was the precondition to participate in the Jump-in program. All eligible Amsterdam schools were enrolled in the program, or had successfully implemented it, at the time of the current evaluation. Data from all children at all schools that met this inclusion criterion were provided by all participating cities' public health services (GGD). These data are routinely collected by each GGD with approval to use in studies such as the current evaluation, so no active consent was required. This means there was no refusal to participate or drop-out. In addition, Amsterdam's GGD also provided data on the intervention's implementation per school per year.

The Jump-in intervention. Jump-in is Amsterdam's whole-school program that aims to stimulate healthy nutrition and physical activity at primary schools (ages 4-12). It entails a collaboration between several municipal departments, ie, the public health services (GGD), department of sports, and department of education, and schools. It aims to stimulate, support and enable schools to implement and institutionalize a combination of several intervention components over the course of 3 school years. It is implemented at ''at-risk'' schools where overweight/obesity rates were higher than the Dutch average for primary school-aged children at baseline T0, meaning 13.2% in 2013/2014. Originally designed with use of the intervention mapping (IM) protocol[18,20] to be a PA-stimulating intervention, it was later expanded to a whole-school program with a focus on PA as well as healthy nutrition.[16,19,21] Alongside integrating the elements ''structurally involving parents'' and ''structural agenda setting'' as standard practices, Jump-in encompasses the following 3 main intervention components, implemented throughout the school in all grades:

1. A nutrition component, consisting of a combination of (1) different healthy nutrition policies,[22] (2) educational workshops for parents and children, and (3) integration of the health education program ''Tasting Lessons.''[23] The nutrition policies entail (a) only drinking water, tea without sugar, or milk at school, (b) only eating fruit and/or vegetables during the morning break, (c) only having a healthy lunch, (d) having only healthy, small or non-food treats as presents during festivities such as birthdays or holidays. The school implements these policies during a period of maximum 3 years, with support of a Jump-in team (see below), after which they are institutionalized as standard parts of a school's policies. The specifics of this implementation are tailored to each school's preferences. Furthermore, several support tools, eg, practical materials, workshops, information, are used to create support among children, parents, and school staff and facilitate the program's implementation processes. Lastly, the educational program Tasting Lessons is integrated as part of Jump-in's whole-school approach. Details on Tasting Lessons' evaluation are described elsewhere.[23]
2. A physical activity component, consisting of (1) monitoring PA and motor skill development, and providing tailored support for those in need, (2) organizing extra PA opportunities for all children, with a focus on those most in need. This means organization of extra PA at least twice a week during physical education (PE) class, but also after school hours to get children acquainted with all sorts of different types of PA and sports. If possible, these sessions are held in collaboration with neighborhood sports clubs, so that when children try out a new sports activity and like it, they have the opportunity to go and do it structurally at that club nearby, and (3) provide children who cannot afford a sports club membership with the opportunities to purchase one via the City of Amsterdam.
3. An active recess component, via integration of the ''PLAYgrounds'' intervention[24] that entails (1) providing children with sufficient room for outside recess play twice daily for at least 15 minutes a day, (2) creating a playground with physical features and structures that invites children to engage in active play and provide sufficient opportunities for it, (3) ensuring children have sufficient means to play and are challenged at their level of development, (4) a connection to PE class by teaching them games during PE they can practice during recess, and, lastly, (5) ensuring there are sufficient teachers/professionals to stimulate children to be active during recess.

Lastly, at age 7, children are invited for an extra health check by a Youth Healthcare Services professional to check their height, weight, and calculate their BMI accordingly. Children at risk and children with overweight or obesity are invited for an extra health check the following year.

Intervention implementation. Jump-in schools are assisted by 2 specialized health promotion professionals to implement the program. One, employed at the municipality's Department of Sports, supports implementing its PA components, while the other assists with all other program components. Furthermore, to stimulate ownership, responsibility, and at-school implementation each school appoints its own internal ''Jump-in coordinator,'' Together with the school's principal and other involved teachers, they form a ''Jump-in team,'' which is responsible for program implementation and institutionalization within 3 years' time. Twice per school year, the Jump-in team logs the school's progress in the school's "Jump-in scan" (see Additional File S1).

Instrumentation and Procedures

Anthropometric measurements. The youth health care professionals from Amsterdam's parent and child teams,[25] and the equivalent organizations within the other participating cities, perform standard routine health checks on children aged 5 and 10 years old at the start of each school year. For these checks, measuring height and weight is standard practice. Children's weight was measured with a calibrated mechanical or electronic scale with an accuracy to detect at least ±100 g differences, and their height via a microtoise or stadiometer. All measurements were carried out in a private room, with the child remaining in drawers and a T-shirt. BMI was calculated by dividing the weight (in kg) by height (in m) squared (kg/m^2). Children's weight status was then categorized based on sex- and age-specific cut-offs using international, standardized reference values[26] and further transformed into BMI-z-scores adjusting for a child's specific age and sex.[26,27]

Degree of implementation. Drawing data from all schools' Jump-in scans from 2013 to 2014 up to 2018 to 2019, we determined an implementation degree per school per year. Full implementation of a main intervention component (nutrition, PA, PLAYgrounds) provided one point each; half a point was granted for general participation in the intervention. Specific elements making up a main intervention component were equally added up to a maximum of 1 point (for details, see Additional File S1). We then added up the scores per year to get a total 5-year implementation/(exposure) score. Controls received a score of zero points.

Socioeconomic position. As a proxy measure for SEP, we used the Dutch "SCP Statusscore." This measure represents an aggregate measure per postal code in the Netherlands widely used by the Dutch national government. It encompassed the average income in a neighborhood and the percentage of adult inhabitants with low education, the percentage with a low income, and the percentage which is unemployed.[28] This score was then assigned to a school, based on the postal code where the majority of the school's students live, using information from the Dutch "Dienst Uitvoering Onderwijs," part of the Dutch government's Ministry of Education, Culture, and Science.[29]; in general >95% of children lived in the same postal code as where their school was located. A score of lower than zero we considered low-SEP and a higher than zero score as high-SEP. Having a baseline percentage of 13.2% overweight/obesity coincided with a low SEP for practically all schools in Amsterdam, so the final analytic sample was chosen to consist of only low SEP-schools.

Data Analysis

Using linear mixed model analyses, we examined the changes in zBMI over time and whether these were significantly different for the intervention and control group. These models contained the group variable (intervention exposure), time and the interaction between the group variable and time, with zBMI as the dependent outcome variable. In addition, likelihood ratio tests showed significant, yet small model improvements when also adding "school" as a clustering variable (ICC ≈ 3%). Furthermore, we analyzed the effects on several dichotomous outcomes, ie, "having overweight/obesity," "having a healthy weight" and "shifting towards a healthier weight category." The latter meaning shifting one or more steps towards "healthy weight," based on the International Obesity Task Force's classifications that range via 7 categories from "extremely underweight" to "obesity degree 3."[2,26] For example, a child that was classified as obese at T0, but had overweight or perhaps a normal weight at T1 would be considered to have shifted towards a healthier weight category. Likelihood ratio tests showed significant clustering at the individual level for dichotomous outcomes, yet not of the "school" level. Therefore, 2-level mixed model analyses and generalized estimating equations (GEE) analyses were used for analyzing all dichotomous outcomes. These mixed models also allowed for also using information from children who only provided data at T0 or T1. All analyses included sex as a covariate to correct for confounding. Information on race was not available in the received data sets. Analyses were performed using the statistical software package Stata Version 15.[30]

RESULTS

A total of 4299 children were included in this study, 2795 intervention group participants coming from 89 schools versus 1504 controls from 66 schools. In total, 2732 children provided data at baseline T0 (2013-2014) and after 5 years of follow-up T1 (2018-2019), while the remaining 1567 children only provided data at either T0 or T1. The mean age of participants was 5.5 years (SD 0.4) at T0 and 10.6 years (SD 0.5) at T1; 49.9% were boys and 50.1% girls. In the Amsterdam intervention sample, 9 schools implemented 0% to 25% of the intervention (N = 247 children), 45 schools implemented 25% to 75% of it (N = 1367 children), 18 schools implemented 75% to 90% (N = 580 children), and 17 schools implemented all components completely (N = 601 children), whereas in the control cities no comparable intervention was structurally implemented during the study period. For more details on the study population characteristics, see Table 1.

Table 1. **Study Population Characteristics**

	Intervention Group		Control Group	
Study Population Characteristics	**To (n = 2660)**	**T1 (n = 2335)**	**T0 (1198)**	**T1 (838)**
Age in months	M 65.4 (SD 4.4)	M 126.3 (SD4.3)	M 68.1 (SD 6.1)	M 129.7 (SD7.2)
Sex	49% girls	49% girls	51% girls	54% girls
Body mass index (BMI)				
Overall	M 16.2 (SD 1.9)	M 18.9 (SD 3.7)	M 16.2 (SD 1.9)	M 19.4 (SD 3.6)
Jump-in 90% to 100% implemented	M 16.3 (SD 1.9)	M 18.5 (SD 3.3)		
Jump-in 75% to 90% implemented	M 16.4 (SD 1.9)	M 19.4 (SD 3.7)		
Jump-in 25% to 75% implemented	M 16.1 (SD 1.9)	M 18.9 (SD 3.7)		
Jump-in 0% to -25% implemented	M 16.0 (SD 2.0)	M 18.6 (SD 4.0)		
zBMI*				
Overall	M 0.52 (SD 1.1)	M 0.59 (SD 1.3)	M 0.51 (SD 1.1)	M 0.74 (SD 1.2)
Jump-in 90% to 100% implemented	M 0.56 (SD 1.1)	M 0.48 (1.3)		
Jump-in 75% to 90% implemented	M 0.64 (SD 1.2)	M 0.81 (SD 1.3)		
Jump-in 25% to 75% implemented	M 0.47 (SD1.1)	M 0.57 (SD1.3)		
Jump-in 0% to 25% implemented	M 0.38 (SD 1.2)	M 0.47 (SD 1.3)		
Normal weight†				
Overall	69.1%	60.2%	67.5%	59.7%
Jump-in 90% to 100% implemented	68.9%	62.3%		
Jump-in 75% to 90% implemented	69.2%	58.0%		
Jump-in 25% to 75% implemented	69.6%	60.1%		
Jump-in 0% to 25% implemented	66.0%	60.4%		
Overweight†				
Overall	15.4%	23.0%	19.1%	26.5%
Jump-in 90% to 100% implemented	16.2%	22.4%		
Jump-in 75% to 90% implemented	16.0%	26.6%		
Jump-in 25% to 75% implemented	14.9%	22.5%		
Jump-in 0% to 25% implemented	13.9%	19.3%		
Overweight, incl. obesity†				
Overall	22%	32%	24%	34%
Jump-in 90% to 100% implemented	22.9%	28.7%		
Jump-in 75% to 90% implemented	24.8%	37.2%		
Jump-in 25% to 75% implemented	21.4%	31.3%		
Jump-in 0% to 25% implemented	20.4%	28.4%		

*Children's BMI was transformed into BMI-z-scores adjusting for a child's specific age and sex.[26,27]

† Weight categories were constructed using sex- and age-specific cut-offs using international, standardized reference values.[26]

zBMI Development

In comparison to the controls, children who were exposed to the Jump-in intervention showed a decline in zBMI; the strongest effects were visible when the intervention was implemented for 90% or more (see Table 2). Their zBMI declined by −0.02 in absolute terms, whereas that of the children from the control group increased by 0.22, ie, a relative difference of −0.23 (95% CI −0.33 to −0.13). As illustrated in Table 2, intervention effects became more pronounced when the intervention's implementation degree increased. Especially when the intervention's nutrition component was >80% implemented, stronger relations with a relative decline in zBMI showed. Furthermore, Table 2 illustrates the different effects per implementation situation, ranging from an overall implementation of 0% to 25% implementation, regardless of which intervention component(s) was/were implemented to 90% to 100% total program implementation. It also illustrated the effects of implementing at least ≥80% of Jump-in's PA component and/or at least ≥80% of its nutrition component, and the effects of the intervention regardless of implementation degree (''Intervention Overall'').

Shifting between Weight Categories

Table 3 shows how children that attended a Jump-in school were more likely to shift from a certain weight category into a healthier weight category compared to the controls. Overall, intervention group children had higher odds of shifting towards a more positive weight category (OR 1.20, 95% CI 0.82-1.00) as well as lower odds of shifting towards a negative weight category (OR 0.74, 95% CI 0.57-0.95). Among those who were exposed to a ≥90% implemented intervention these odds were even higher, resp. OR 1.36, 95% CI 1.06 to 1.74 and OR 0.59, 95% CI 0.42 to 0.83. The effect sizes and significance levels declined as the implementation degree did and effects were highest among those exposed to the intervention with ≥80% of the nutrition and PA intervention components properly implemented.

Table 2. **Results of the Linear Mixed Model Analysis Comparing zBMI[†] development between intervention and control groups**

Degree of Jump-in Implementation	Mean zBMI To	Mean zBMI T1	Δ zBMI T1 to T0	Δ zBMI T1 to T0 Intervention vs to Control Group Children
Controls	0.51	0.73	+0.22	-
Intervention overall	0.52	0.59	+0.07	-0.13** (95% CI −0.20, −0.05)
Jump-in 90% to 100% implemented	0.56	0.54	−0.02	−0.23** (95% CI −0.33, −0.13)
Jump-in 75% to 90% implemented	0.60	0.68	+0.08	−0.14** (95% CI −0.22, −0.05)
Jump-in 25% to 75% implemented	0.47	0.57	+0.10	−0.12** (95% CI −0.20, −0.04)
Jump-in 0% to 25% implemented	0.38	0.47	+0.09	−0.13*** (95% CI −0.27, 0.01)
Only Jump-in physical activity component ≥80% implemented	0.55	0.66	+0.11	−0.11* (95% CI −0.20, −0.02)
Jump-in nutrition intervention component ≥80% implemented	0.59	0.63	+0.04	−0.18** (95% CI −0.29, −0.08)
Jump-in physical activity and nutrition components ≥80% implemented	0.60*	0.63	+0.03	−0.19** (95% CI −0.30, −0.09)

*p ≤ .05.
**p ≤ .01.
***p ≤ .10.
† Children's BMI was transformed into BMI-z-scores adjusting for a child's specific age and sex.[26,27]

Table 3. **Results of the Logistic Multilevel Regression Analyses Comparing the Shifts in Weight Categories[†] Between Intervention and Control Groups**

Degree of Jump-in Implementation	Odds Ratio (OR) Intervention vs Control Groups
Positive shift towards a healthier weight category	
Intervention overall	OR 1.20* (95% CI 0.82-1.00)
Jump-in 90% to 100% implemented	OR 1.36** (95% CI 1.06-1.74)
Jump-in 75% to 90% implemented	OR 1.20*** (95% CI 0.97-1.49)
Jump-in 25% to 75% implemented	OR 1.18 (95% CI 0.96-1.45)
Jump-in 0% to 25% implemented	OR 1.25 (95% CI 0.90-1.78)
Only Jump-in physical activity intervention component ≥80% implemented	OR 1.13 (95% CI 0.87-1.47)
Jump-in nutrition intervention component ≥80% implemented	OR 1.28*** (95% CI 0.99-1.67)
Jump-in physical activity and nutrition components ≥80% implemented	OR 1.26*** (95% CI 0.97-1.65)
Negative shift in weight category towards overweight/obesity	
Intervention overall	OR 0.74* (95% CI 0.57-0.95)
Jump-in 90% to 100% implemented	OR 0.59** (95% CI 0.42-0.83)
Jump-in 75% to 90% implemented	OR 0.77*** (95% CI 0.66-1.11)
Jump-in 25% to 75% implemented	OR 0.74* (95% CI 0.55-0.98)
Jump-in 0% to 25% implemented	OR 0.69*** (95% CI 0.44-1.08)
Only Jump-in physical activity intervention component ≥80% implemented	OR 0.85 (95% CI 0.61-1.18)
Jump-in nutrition intervention component ≥80% implemented	OR 0.67* (95% CI 0.48-0.93)
Jump-in physical activity and nutrition components ≥80% implemented	OR 0.68* (95% CI 0.49-0.95)
Negative shift in weight category in any direction	
Intervention overall	OR 0.85 (95% CI 0.66-1.09)
Jump-in 90% to 100% implemented	OR 0.70* (95% CI 0.52-0.96)
Jump-in 75% to 90% implemented	OR 0.84 (95% CI 0.64-1.09)
Jump-in 25% to 75% implemented	OR 0.86 (95% CI 0.65-1.14)
Jump-in 0% to 25% implemented	OR 0.87 (95% CI 0.60-1.30)
Only Jump-in physical activity intervention component ≥80% implemented	OR 0.97* (95% CI 0.71-1.32)
Jump-in nutrition intervention component ≥80% implemented	OR 0.73* (95% CI 0.54-0.99)
Jump-in physical activity and nutrition components ≥80% implemented	OR 0.75*** (95% CI 0.55-1.02)

*p ≤ .05.
**p ≤ .01.
***p ≤ .10.
†Children's BMI was transformed into BMI-z-scores adjusting for a child's specific age and sex.[26,27]

Weight Outcomes

Table 4 shows the comparison of children exposed to the Jump-in intervention and their odds of respectively having overweight/obesity at T1 or a healthy weight at T1. No significant differences were found between intervention and control conditions.

All analyses were also performed within the subgroup of children who had an unhealthy weight at T0 to explore whether intervention effects differed for them. Yet, all results were very similar without any significant differences. Therefore, those are not presented separately.

Table 4. **Results of the Logistic GEE Analyses Comparing the Intervention and Control Groups in Terms of Weight Outcomes† at T1 Versus T0**

Degree of Jump-in Implementation	Odds Ratio (OR) Jump-in vs Controls
Outcome: children having overweight or obesity	
Intervention overall	OR 0.99 (95% CI 0.83-1.19)
Jump-in 90% to 100% implemented	OR 0.90 (95% CI 0.71-1.14)
Jump-in 75% to 90% implemented	OR 0.99 (95% CI 0.81-1.22)
Jump-in 25% to 75% implemented	OR 1.00 (95% CI 0.82-1.62)
Jump-in 0 % to 25% implemented	OR 0.92 (95% CI 0.65-1.29)
Only Jump-in physical activity intervention component ≥80% implemented	OR 1.09 (95% CI 0.87-1.36)
Jump-in nutrition intervention component ≥80% implemented	OR 0.83 (95% CI 0.64-1.08)
Jump-in physical activity and nutrition components ≥80% implemented	OR 0.86 (95% CI 0.66-1.12)
Outcome: children having a healthy weight	
Intervention overall	OR 0.98 (95% CI 0.81-1.17)
Jump-in 90% to 100% implemented	OR 1.03 (95% CI 0.81-1.31)
Jump-in 75% to 90% implemented	OR 0.95 (95% CI 0.77-1.17)
Jump-in 25% to 75% implemented	OR 0.97 (95% CI 0.79-1.19)
Jump-in 0% to 25% implemented	OR 0.91 (95% CI 0.62-1.32)
Only Jump-in physical activity intervention component ≥80% implemented	OR 0.84 (95% CI 0.68-1.06)
Jump-in nutrition intervention component ≥80% implemented	OR 1.15 (95% CI 0.88-1.49)
Jump-in physical activity and nutrition components ≥80% implemented	OR 1.08 (95% CI 0.83-1.40)

†Children's BMI was transformed into BMI-z-scores adjusting for a child's specific age and sex.[26,27]

DISCUSSION

This study investigated the effects of the Jump-in whole-school intervention on zBMI and weight development of primary school children by comparing children exposed to the intervention at Amsterdam schools to an unexposed control sample of children from other large, Dutch cities with a relative comparability to Amsterdam in terms of size, urbanization and SEP-variety. Effects were studied for different degrees of intervention implementation. When the implementation degree was >90%, zBMI remained stable, indicating a positive development compared to the controls. Similarly, children exposed to such a high implementation degree had greater odds to shift to a healthier weight category from T0 to T1. Effects strengthened when the implementation degree increased, illustrating the specific insights that result from accurately measuring an interventions' implementation degree.[31] However, the intervention group did not have different odds of having a ''healthy weight'' or ''overweight/obesity'' at the age of 10. Therefore, despite these positive results, further development of school-based interventions, and their integration into systems approaches, might be warranted to combat the obesity epidemic. Implications for school-based interventions are discussed below.

Like Jump-in, other whole-school interventions have also shown their potential to impact children's weight development,[8,9,13] especially those that also targeted a combination of PA and nutrition habits rather than only one or the other.[13,32] However, generally, most interventions to date do not affect (z)BMI significantly, and those that do generally report smaller effects than Jump-in.[8,9,13,14,32] Although the variety in intervention and evaluation study designs makes direct comparisons between programs difficult, certain characteristics of Jump-in can be expected to contribute to its relatively promising effects.[13,14,33] First, its components are designed via the Intervention Mapping (IM) protocol.[20] ensuring the use of appropriate behavioral change techniques to exert effects on set intervention performance objectives.[18,19,22,24] This application of IM was not a one-time event; Jump-in is continuously monitored and re-evaluated using IM. Second, the systemic, long-term collaborations between the intervention's implementers, school actors (incl. children, and parents), and researchers, intervention designers, communication specialists, and policy makers from Amsterdam's municipally-led whole systems approach ''the Amsterdam Healthy Weight Approach''[17] ensure Jump-in is structurally implemented on all target schools. These collaborations also make for a knowledge-exchange system in which lessons are learned from research, practice and policy and the intervention can be continuously improved. Such structural knowledge exchange systems have been shown to hold promise for complex public health intervention design.[34]

Unfortunately, despite its positive effects compared to most other whole-school interventions, a school-based intervention such as Jump-in seems insufficient to turn the tides of the obesity pandemic on its own. In effect, recent literature emphasizes the need for a stronger systems science perspective to expand upon the WSM and further evolve the symbiosis between health and education.[7,35-37] For example, the Action Scales Model (ASM),[38] helps to view a system as containing components on different ''levels'' (ie, events, structures, goals, and beliefs). At a system's core, beliefs and goals determine its purpose and shape its actors' beliefs and driving forces. These then shape its structures and events to achieve said goals. Thus, rather than managing system ''symptoms'' (structures, events), it can be more effective and sustainable to (also) deal with its core drivers, ie, its goals and beliefs. For example, Jump-in requires teachers to be health promoters as well as educators. Sometimes these roles conflict with each other, eg, when arguing with a parent about school nutrition guidelines. This endangers the teacher-parent relationship. Given that the primary function of a school is education, a system structure that requires teachers to also be health promoters, might be unsustainable and health promotion efforts will likely come up short when not aligned with the educational core goals of the school system. Successful, sustainable health promotion may require having a better understanding of core systems drivers and addressing those as well as (possibly) intervening on structures and events.[36-38] This may also help to prevent oversimplified conclusions on why something is or is not effective or successfully implemented.

Furthermore, whole-school interventions targeting overweight/obesity might create more sustainable impact when they would align with intervention components aimed at other environments such as the home or community setting,[35,39] as well as when they would integrate relevant health behaviors other than nutrition or PA, might also add to the impact public health prevention efforts.[35,39,40] This vision was what recently drove the further integration of Jump-in as a key component of Amsterdam's systems approach to overweight/obesity prevention. Future research is needed to determine its potential added value for children's healthy weight development.

IMPLICATIONS FOR SCHOOL HEALTH

This evaluation shows that whole-school interventions are a promising way to impact long-term health outcomes such as zBMI. Important factors to take into account seem to be the implementation fidelity of such comprehensive programs as well as their long-term sustainment within the existing infrastructures. This means focus should not solely be on the intervention content, but also on program governance, in order for interventions to be sustainably implemented and included in regular school and municipal policies. In terms of intervention content and form, within the WSM of school health promotion, intervention design should be guided by frameworks such as the IM protocol.[20] This makes it possible to connect program objectives with the proper behavioral change techniques via a systematic, evidence-based process. However, in order to truly reverse the tides of the obesity pandemic, future programs should focus (even) more on furthering the symbiosis between health and education, integrate efforts across different environments, eg, school, home, community, and address all energy-balance related behaviors such as sleep or sedentary behavior within more comprehensive whole systems approaches.

Limitations

Strengths of the current study are its controlled design, large sample size, and study period duration. In addition, the intervention's evidence-based design, its uniform implementation procedures, its detailed implementation monitoring, and objective, reliable anthropometric outcome measurements all add value to the study. Furthermore, analyzing the intervention's effects based on implementation degree provides rare, valuable insights, as does the fact that this study provides one of the few examples to date of a large-scale whole-school obesity prevention program evaluation carried out in a low-SEP population.

However, our study also has some weak points. First, Jump-in was structurally implemented on all eligible schools in Amsterdam, and almost exclusively on those schools. In the current design, this left no opportunities to compare intervention effects to other schools within Amsterdam via RCT or to compare effects based on SEP in the current design. Thus, the current design introduces more uncertainty with respect to attributable causality, compared to when an RCT design could have been applied. Furthermore, integrating non-health outcomes and health behavior determinants would be a valuable addition to future studies. Due to privacy and availability restrictions, differential intervention effects between cultural or ethnic groups could not be analyzed, while this could have provided valuable additional insights. Moreover, although weight development is an important outcome measure of an intervention like Jump-in, future research should include evaluating its effects on the underlying healthy habits that shape such weight development, such as nutrition and PA behavior. Lastly, the presented intervention effects were potentially underestimated because of two aspects. First, the true exposure to Jump-in entails the time when a child enters primary school at age 4 until it leaves it at age 12. However, since we used data from the GGD's routine health checks at ages 5 and 10, we were only able to analyze developments in that age range. Second, although cities with known, similar, structural interventions were excluded as controls, it cannot be said with absolute certainty that no intervention took place in those control areas at all.

Conclusion

This study evaluated the effects of the implementation of the Jump-in whole-school intervention on the weight development in primary school children in Amsterdam, the Netherlands, compared to that of children from several other large Dutch cities. Results showed a clear dose-response effect of the intervention on the development of children's zBMI and in the shift to a more positive weight category, with a stronger degree of program implementation leading to stronger, positive effects.

Researchers, intervention designers and policy makers should consider these results in context of the effects of most other current school-based intervention programs that aim to simulate healthy child weight development. They should strive for future programs to be developed systematically using behavior change intervention design frameworks such as IM[20] in order to connect program objectives with the proper behavioral change techniques. In addition, they should not only focus on the intervention content, but also on program governance in order for interventions to be sustainably implemented and included in regular municipal policies. Furthermore, creating structural collaborations between science, practice and policy in the context of health promotion intervention programs may facilitate more dynamic program development (in form and in content) and it may ensure interventions are more suited to local contexts.

However, even though the results of the current study were relatively positive, to reverse the tides of the childhood obesity pandemic, future research, and policy developments should have a stronger systems view and focus more on furthering the symbiosis between health and education. This will enable them to have more profound, sustainable effects on child health. For Jump-in this means continuing its recent integration into the AHWA, which has been transitioning from a multi-component program into a whole systems approach from 2017 to 2018 onwards.

Authors Contributions

Vincent Busch: Conceptualization (lead), writing - original draft preparation (lead), methodology (lead), project administration (lead), data curation (lead), formal analysis (supporting). **Ilona Steenkamer:** Writing - review & editing (supporting), data curation (supporting), formal analysis (supporting). **Paul van Opdorp:** Writing - original draft preparation (supporting), Writing - review & editing (supporting), conceptualization (supporting). **Lieke van Houtum:** Writing - review & editing (supporting). **Femke van Nassau:** Methodology (supportive). **Arnoud Verhoeff:** Supervision (lead), conceptualization (supporting). **Jos Twisk:** Writing - review & editing (supporting), formal analysis (lead).

Human Subjects Statement

This study was approved by the medical ethical committee of the Amsterdam University Medical Centre (ID: W22_018 # 22.047). All participant data was fully anonymized prior to the delivery by the primary data managers at the participating municipal health services to the research team.

Conflict of Interest

All authors declare no conflict of interests.

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