European Journal of Clinical Nutrition (2004) 58, 1649–1660

0954-3007/04 $30.00
www.nature.com/ejcn

ORIGINAL COMMUNICATION

Increasing children's fruit and vegetable consumption: a peer-modelling and rewards-based intervention

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Objective: To evaluate a peer-modelling and rewards-based intervention designed to increase children's fruit and vegetable consumption.
Design: Over a 5-month period, children in an experimental and a control school were presented with fruit and vegetables at lunchtime. Children aged 5–7 y also received fruit at snacktime (mid-morning). The intervention was implemented in the experimental school and levels of fruit and vegetable consumption were measured at baseline, intervention and at 4-month follow-up.
Setting: Two inner-city London primary schools.
Subjects: In total, 749 children aged 5–11 y.
Intervention: Over 16 days children watched video adventures featuring heroic peers (the Food Dudes) who enjoy eating fruit and vegetables, and received small rewards for eating these foods themselves. After 16 days there were no videos and the rewards became more intermittent.
Main outcome measures: Consumption was measured (i) at lunchtime using a five-point observation scale; (ii) at snacktime using a weighed measure; (iii) at home using parental recall.
Results: Compared to the control school, lunchtime consumption in the experimental school was substantially higher at intervention and follow-up than baseline ($P<0.001$), while snacktime consumption was higher at intervention than baseline ($P<0.001$). The lunchtime data showed particularly large increases among those who initially ate very little. There were also significant increases in fruit and vegetable consumption at home ($P<0.05$).
Conclusions: The intervention was effective in bringing about substantial increases in children's consumption of fruit and vegetables.
Sponsorship: Horticultural Development Council, Fresh Produce Consortium, ASDA, Co-operative Group, Safeway, Sainsbury, Somerfield, Tesco and Birds Eye Wall's.
European Journal of Clinical Nutrition (2004) **58,** 1649–1660. doi:10.1038/sj.ejcn.1602024
Published online 14 July 2004

Keywords: child; diet; food habits; fruit; health behaviour; vegetables

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Contributors: PJH and CFL were the principal investigators; they devised the intervention, the central experimental design, and provided the theoretical underpinning. They directed the overall programme and contributed to data analysis and interpretation, and to the writing of the paper. KT supervised the data analysis, drafted the paper and contributed to programme development and implementation; data collection, analysis and interpretation; and staff training. CAH, MCJ and JW contributed to programme development and implementation; data collection, analysis and interpretation; and editing of the paper. The measures were designed by PJH, CFL and KT. Chris Whitaker advised on statistical analyses.
Received 22 January 2004; revised 6 April 2004; accepted 21 May 2004; published online 14 July 2004

Introduction

While there is now a great deal of evidence demonstrating the health benefits of eating fruit and vegetables, much less progress has been made in developing effective means of ensuring that people consume enough of these foods. In a paper investigating a new school-based programme designed to increase fruit and vegetable consumption in children, Lowe *et al* (2004) have reviewed research findings in this domain, and they have identified three factors that reliably influence children's eating behaviours. These are taste exposure, modelling and rewards.

There is a large body of evidence to indicate that repeated taste exposure to particular foods or flavours leads to increased consumption of and preference for those foods or flavours (Birch and Marlin, 1982; Birch *et al*, 1987, 1998; Sullivan and Birch, 1990; Wardle, Cooke *et al*, 2003; Wardle, Herrera *et al*, 2003). To achieve the goal of increased fruit and vegetable consumption it is important, therefore, to ensure that children repeatedly taste these foods.

One way to influence children to taste foods is through observational learning, or 'modelling' (Harris and Baudin, 1972; Harper and Sanders, 1975; Birch, 1980; Greer *et al*, 1991; Dowey, 1996; Hendy and Raudenbush, 2000; Woolner, 2000). This has been shown to be particularly effective when the model has his or her behaviour rewarded (Flanders, 1968), is the same age or slightly older than the child (Brody and Stoneman, 1981), and is liked or admired by the child (Bandura, 1977). The likelihood of imitation is also increased with the use of multiple as opposed to single models (Fehrenbach *et al*, 1979).

Rewards can also be used to influence children to taste fruit and vegetables. The research findings in this area are more controversial. However, there is evidence to suggest that, when used appropriately, rewards can be effective at altering behaviour, including children's food consumption. In order for rewards to be effective, it is important that they are highly desirable (ie that they are potent reinforcers) and that they indicate to the child that they are for behaviour that is both enjoyable and high status (eg, see Dickinson, 1989; Lowe *et al*, 1998; Cameron *et al*, 2001).

It is a procedure that combines peer modelling and rewards to increase taste exposure that forms the basis of the new intervention described by Lowe *et al* (2004). The main components of this intervention consist of (i) a peer modelling video featuring four hero figures (the 'Food Dudes') who eat and enjoy a variety of fruit and vegetables, coupled with video clips of children's television presenters and popstars who voice their support for the Food Dudes' healthy eating mission, (ii) a set of Food Dude rewards such as stickers, pencils and erasers, awarded to children for eating target amounts of the fruit and vegetables that are presented to them. The peer modelling video and the rewards encourage children to repeatedly taste the fruit and vegetables presented and in this way bring about increases in their liking and consumption of these foods.

Of course, the behaviour modelled during the intervention includes verbal as well as nonverbal behaviour and there is evidence to indicate that an individual's own verbalisations have a powerful influence on his or her behaviour (eg, Lowe, 1979; Catania *et al*, 1989; Horne and Lowe, 1996). Indeed, behaviour that is governed by an individual's own verbalisations may be more resistant to change than behaviour shaped directly by reward contingencies (Lowe, 1979; Catania *et al*, 1989; Horne and Lowe, 1993). Thus, the programme materials were designed to encourage children to talk about fruit and vegetables in ways that would help maintain their increased levels of consumption (see Lowe *et al*, 2004).

Research has shown this intervention to be very successful at increasing 5–7-y-old children's consumption of fruit and vegetables in the home (Horne *et al*, 1995; Dowey, 1996; Lowe *et al*, 1998), 2–4-y olds' in the nursery (Woolner, 2000) and 5–7-y olds' in the classroom (Horne *et al*, 1998), with increases maintained at follow-ups taken up to 15 months after the intervention (see Tapper *et al*, 2003 for an overview). However, these studies were carried out with relatively small numbers of children, ranging in age from 2 to 7 y and with the exception of some of the research conducted with 2–4 y olds (see Woolner, 2000), the interventions were implemented by researchers. In order to be of benefit to large groups of children in a cost-efficient manner, the intervention has recently been adapted for use across a much larger age range (4–11 y). It has also been designed so that school staff can implement it independently. Lowe *et al* (2004) conducted a preliminary evaluation of this programme with 402 children in three schools in different parts of the UK. The study found that the intervention brought about substantial increases in children's consumption of fruit and vegetables at lunchtime, at 'snacktime' (immediately prior to mid-morning break) and at home. Measures, however, were only taken during the 16-day intervention period and did not include any follow-ups to determine whether the effects would last over longer periods of time. Nor was any attempt made to directly compare fruit and vegetable consumption over time following the Food Dude intervention with controls where the same foods were made available but no intervention was introduced. The present study, of 749 children aged from 5 to 11 y, followed a similar procedure to that of Lowe *et al* (2004), but in addition: (a) conducted a 4-month follow-up of the main outcome measures, (b) directly compared the results from an experimental school with those from a control school and (c) assessed the applicability of these procedures in a large inner-city school environment where there were high levels of social deprivation and most children were from ethnic minorities. In contrast to several previous investigations of school-based interventions (Domel *et al*, 1993; Foerster *et al*, 1998; Nicklas *et al*, 1998; Perry *et al*, 1998; Baranowski *et al*, 2000; Reynolds *et al*, 2000), in the present programme there was a tight focus on carefully specified rewards contingencies and modelling to ensure that taste exposures occurred during the intervention; there was also an attempt to use robust and objective outcome measures including weighed and observational measures of food consumed during baseline, intervention and follow-up phases in both the experimental and control schools. These measures allowed a systematic assessment to be made of what happens when fruit and vegetables are made freely available to schoolchildren over time, regardless of any intervention. In addition, this study explores the intervention's effectiveness across different groups of children whose initial consumption levels of fruit and vegetables ranged from very little to substantial. It is changing the diet of those children who eat the least of these foods which is of most importance, because it is these children whose health is most threatened by their dietary habits, and it is also this group whose eating patterns might be most resistant to change.

Method

Ethical approval

Granted by the School of Psychology Ethics Committee, University of Wales, Bangor.

Participants

The children were aged from 5 to 11 y. The local education authority identified two inner-city London schools that were matched, as far as possible, in terms of size, location, level of social deprivation (as assessed by the proportion of children entitled to free school meals) and proportion of children from ethnic minorities. These schools were located in Brixton (364 pupils, 67% free-meal entitlement and 85% from ethnic minorities) and Stockwell (385 pupils, 46% free-meal entitlement and 80% from ethnic minorities). In both schools levels of deprivation were much higher than the national average of 17% meals entitlement. The education authority designated the Brixton school as the experimental school and the Stockwell school as the control largely on grounds of administrative convenience.

Materials

The peer modelling videos were six 6-min episodes featuring the 'Food Dudes' who were two boys and two girls, aged 12–13 y. In each episode, the Food Dudes (who are played by child actors) battle against the evil 'Junk Punks' who plan to take over the world by depriving people of their life-giving fruit and vegetables. To help them in their battle, the Food Dudes eat, and are seen to enjoy, a variety of fruit and vegetables. They also urge the children, in speech and in song, to keep the 'Life Force' strong by doing the same. The videos include an animation sequence, a Food Dude theme tune and a range of celebrity endorsements and accompanying soundbites. The rewards were customised Food Dude items consisting of, for example, pens, pencils, pencil cases, rulers, certificates and stickers. (During the maintenance phase (see Procedures), these were used in combination with a wall chart.) In addition, a series of letters, addressed from the Food Dudes to the children, were used to provide encouragement and praise and to remind children of the reward contingencies.

Two 'homepacks' were also employed to encourage children to eat fruit and vegetables at home as well as at school and to help parents become actively involved in the programme. These included information for parents and charts to enable children to record the fruit and vegetables they ate at home each day.

Procedures

Experimental school. In the experimental school, the study began with a 12-day baseline phase followed by a 16-day intervention phase, and then by a 4-month maintenance phase. Measures were taken throughout baseline and intervention and, at follow-up, during the last 8 days of maintenance. All intervention procedures were under the control of the school.

At lunchtime, throughout the study, children who had school lunches could, as part of their meal, select a portion of cooked vegetables weighing approximately 60 g, and a whole fruit weighing (after the subtraction of any core or peel weight) approximately 80 g. In total, four different fruits (apples, pears, bananas and satsumas) and four different cooked vegetables (peas, carrots, sweetcorn and broccoli) were presented in a fixed cycle. For measurement purposes, on entry to the dining hall all children were given a badge displaying their name and participant number. When children selected vegetables from the canteen, an adult placed a small coloured sticker on their number badge to indicate that they had taken vegetables. The presence of a core or peel was used to determine whether or not they had selected fruit. (To enable them to participate in the programme, children who brought packed lunches from home could select fruit and raw vegetables.) Children aged 5–7 y were also given a whole fruit at 'snacktime' (immediately prior to mid-morning break). For measurement purposes these were presented in tubs, or on paper plates, labelled with the child's name and participant number. (For further details of all procedures and results, see Lowe *et al*, 2002.)

Each day during the intervention phase the teacher read out the Food Dude letter to the class and, on at least 2 days out of 3, showed them an episode of the Food Dude video. This took place immediately prior to snacktime for 5–7-y olds and immediately prior to lunchtime for the older children. At lunchtime, during the first 4 days of the intervention, children received a red hand stamp for eating half or more of their fruit and a green hand stamp for eating half or more of their vegetables. These hand stamps were indicators used by teachers to allocate rewards in the classroom after lunch (see below). For the next 3 days, the red and green hand stamps were given only for eating all of the fruit and vegetables, respectively. However, lunchtime supervisors reported that some children, especially the younger ones, had difficulty meeting this more stringent criterion. For this reason, from day 8 of the intervention the procedure reverted to that employed on days 1–4. To determine the reward(s) each child received, teachers were provided with a schedule listing each day of the intervention and whether it had been designated a 'fruit day' or a 'vegetable day'. (These days occurred equally often, in mixed order.) On fruit days, children received a prize if they had a fruit hand stamp and a collectable sticker if they had a vegetable hand stamp and *vice versa* on vegetable days. Teachers were asked not to tell children whether it was a fruit or vegetable day until after they had eaten their lunch.

At snacktime, during the first 4 days of the intervention, children received a sticker for tasting their fruit or a prize and a sticker for eating at least half of their fruit. During the remainder of the intervention, they received a sticker for tasting their fruit or a sticker and a prize for eating all of their fruit.

At the start of the intervention, the children were given the first homepack to deliver to their parents and at the end of the intervention the teachers gave prizes to those children who had recorded a sufficient quantity and/or variety of fruit and vegetables on their home chart.

During the maintenance phase, there were no Food Dude videos and school staff were asked to read out just one Food Dude letter at the start of each week. In addition, Food Dude wall charts, consisting of a large block of blank squares, were introduced to enable rewards to be delivered more intermittently. School staff were asked to monitor children's food consumption at snacktime and lunchtime on a daily basis. Each time a child ate a target amount of food (a whole portion of fruit at snacktime, at least half a portion of fruit or vegetables at lunchtime), staff were requested to ensure he or she initialled one of the squares on the wallchart. Once all the squares had been filled, every child in the class was to receive a Food Dude prize and the next chart introduced. There were five charts in total, each designed to last for approximately 2 weeks. The second homepack was delivered to parents, via the children, at the start of the maintenance phase.

Control school. In the control school, baseline conditions corresponding in duration to the three main phases for the experimental school were sustained throughout. These are indicated as baseline 1 (12 days), baseline 2 (16 days) and baseline 3 (4 months). Apart from the absence of the Food Dudes program, all procedures were the same as those employed in the experimental school; fruit and vegetables were made available to all children at lunchtime, fruit was provided to 5–7-y olds at snacktime, and measures of consumption were taken throughout baseline 1, baseline 2 and during the last 8 days of baseline 3.

Measures

Consumption at lunchtime and snacktime. On a daily basis, the amount of each portion of fruit and vegetables that each child consumed at lunchtime was visually estimated and rated on a five-point scale (either 0, 25, 50, 75 or 100%) by independent raters (at least three in each school) located by the waste bins in the dining hall. Inter-rater measures were taken for over 25% of the total sample. Cohen's Kappa coefficient (weighted by the difference between the points on the scale) was used to assess agreement between each pair of raters in each school; coefficients ranged from 0.89 to 0.96. Snacktime consumption was assessed by weighing each child's fruit before and after consumption.

Consumption at home. Children's consumption of fruit and vegetables at home was assessed using a parental 24-h food recall procedure in which interviews were conducted with a subset of parents (each paid £35, about 52EUR, for participating) during the first week of baseline and the last week of the intervention. Parents were telephoned daily, over 5 days, by an interviewer who, using a standardised interview, asked them what their child had eaten at home during the previous 24 h. The parents used food diaries to aid their recall (for details, see Lowe *et al*, 2004). The target sample size was 100 for both schools combined. A total of 45 participation forms were returned from the Brixton school and 39 from the Stockwell school and all of these parents were asked to participate.

Results

Consumption at lunchtime

For data collected at lunchtime, six scores were computed for each child. These were the mean levels of consumption of fruit and of vegetables at the end of each of the three study phases. Means were calculated only for children with data relating to all of the eight foods presented. Where possible the data used were the child's consumption of each food at its final presentation during each of the three phases; if the child was absent on any of these days, the datum for the previous presentation of that food was employed. However, because consumption levels showed a marked decline in the course of the first baseline phase, where a child was absent for two or more presentations of a food during baseline, the data for that child were excluded.

Figure 1 shows lunchtime fruit consumption, averaged across children of all ages, in both schools. The data were analysed using a four-way mixed ANOVA and *post hoc* *t*-tests. (Since it is difficult to justify normality with a five-point scale, a randomisation test was conducted using these data. For all the terms in the ANOVA model, the *P*-values derived from the observed quantiles for the permutations were similar to those derived from the standard ANOVA and did not alter the conclusions.) Independent variables were: school (experimental, control), study phase (baseline/baseline 1, intervention/baseline 2, follow-up), food (fruit, vegetables) and age (5–7 y, 7–11 y). The analysis revealed significant interactions between school and study phase, $F(2, 700) = 233.41$, $P < 0.001$; school, study phase and food, $F(2, 700) = 5.88$, $P < 0.005$; and school, study phase, food and age, $F(2, 700) = 3.46$, $P < 0.05$. *Post hoc* tests (see Table 1) showed that, for the experimental school, in all instances (ie for fruit and vegetable consumption by both 5–7 and 7–11-y olds), consumption was significantly higher at intervention compared to baseline. In all instances, consumption was also significantly higher at follow-up compared to baseline.

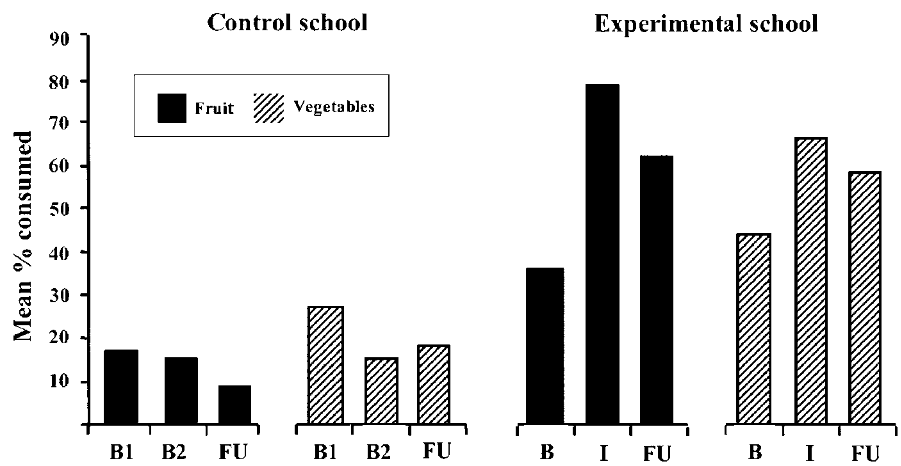

Figure 1 Mean percentage of fruit and vegetables consumed at baseline 1 (B1), baseline 2 (B2) and follow-up (FU) in the control school compared with the percentage consumed at baseline (B), intervention (I) and follow-up (FU) in the experimental school. The numbers at the top of each bar indicate percentage consumed in that phase.

Table 1 Mean levels of lunchtime fruit and vegetable consumption in the experimental and control schools during baseline (A), intervention/baseline 2 (B) and follow-up (C) together with results of *post hoc* *t*-tests ($N=354$)

Study cell		*Baseline mean (s.d.)*	*Intervention/baseline 2 mean (s.d.)*	*Follow-up mean (s.d.)*	*A and B comparison, t-value (df)*	*A and C comparison, t-value (df)*	*B and C comparison, t-value (df)*
Experimental							
5–7 y	Fruit	20% (23)	69% (22)	56% (27)	14.37 (59)*	9.27 (59)*	−4.58 (59)*
	Vegetables	35% (24)	55% (26)	53% (26)	6.76 (59)*	6.40 (59)*	−0.67 (59)
7–11 y	Fruit	47% (33)	86% (16)	65% (29)	12.00 (87)*	4.73 (87)*	−7.93 (87)*
	Vegetables	51% (28)	74% (22)	63% (28)	9.59 (87)*	4.69 (87)*	−4.33 (87)*
Control							
5–7 y	Fruit	11% (15)	11% (15)	9% (16)	−0.21 (76)	−0.95 (76)	−0.84 (76)
	Vegetables	16% (16)	6% (10)	10% (15)	−5.86 (76)*	−3.26 (76)*	3.04 (76)
7–11 y	Fruit	20% (27)	18% (22)	9% (17)	−1.33 (128)	−4.68 (128)*	−4.57 (128)*
	Vegetables	36% (30)	20% (25)	23% (25)	−9.36 (128)*	−607 (128)*	1.17 (128)

*$P<0.002$ (required significance level after Bonferroni adjustment).

Further comparisons showed significant declines between intervention and follow-up for fruit consumption by both age groups and for vegetable consumption by 7–11-y olds. Vegetable consumption by 5–7-y olds, however, showed no decline between intervention and follow-up.

In the control school, vegetable consumption was significantly lower at baseline 2 compared to baseline 1 and at follow-up compared to baseline 1. However, it showed no change between baseline 2 and follow-up. These findings were consistent across both age groups. In contrast, fruit consumption showed no change across the three study phases for 5–7-y olds, but showed significant declines between baseline 1 and follow-up and between baseline 2 and follow-up for 7–11-y olds.

Additional analyses were conducted on the lunchtime data in order to determine the way in which overall consumption means were constituted, specifically, (a) whether in baseline there were children who ate little, a moderate amount, or a great deal of the fruit and vegetables presented, and (b) the way in which consumption in these different groups was affected by the intervention. Each data set was initially split into five subsets according to the amount each child consumed during the baseline phase: either 0–19, 20–39, 40–59, 60–79 or 80–100%. This breakdown is presented in Figure 2, which shows that a large proportion of children were consuming less than 20% of the foods provided to them at baseline; 38 and 26% of children for fruit and vegetables, respectively, in the experimental school, 63 and 47%, respectively, in the control school. In contrast, only a small proportion of children were consuming over 80% of these foods; 14 and 11% of children for fruit and vegetables, respectively, in the experimental school; 3 and 9%, respectively, in the control school.

Figure 2 also illustrates the way in which children in each of these subsets showed changes in consumption of fruit and vegetables at lunchtime during the course of the study. In the experimental school, those children who ate the least during baseline (0–19%) showed the largest increases in

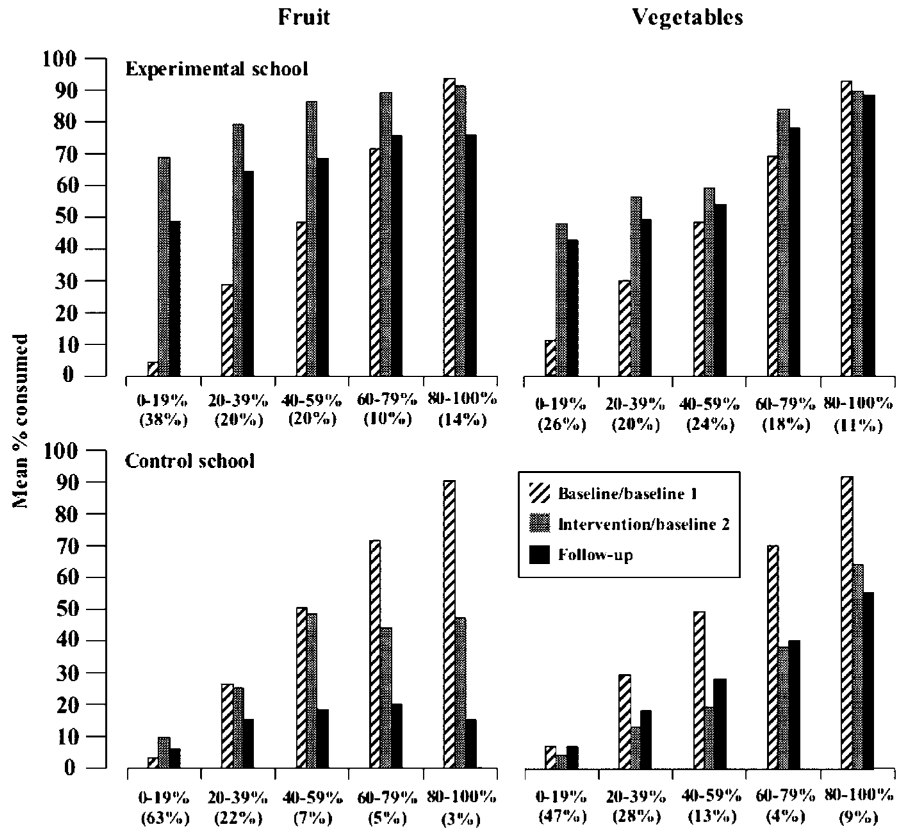

Figure 2 Mean percentage of fruit and vegetables consumed in the experimental and control schools at baseline/baseline 1, intervention/baseline 2 and follow-up according to the child's level of consumption at baseline/baseline 1. For each graph, the proportion of children falling into each of the five subsets is shown in parenthesis.

Table 2 Mean levels of snacktime fruit consumption in the experimental and control schools during baseline (A), intervention/baseline 2 (B) and follow-up (C), together with results of *post hoc t*-tests ($N=249$)

School	*Baseline mean (s.d.)*	*Intervention/baseline 2 mean (s.d.)*	*Follow-up mean (s.d.)*	*A and B comparison, t-value (df)*	*A and C comparison, t-value (df)*	*B and C comparison, t-value (df)*
Experimental	75% (23)	87% (20)	76% (24)	7.99 (113)*	0.65 (113)	5.86 (113)*
Control	65% (30)	61% (29)	64% (24)	1.75 (134)	0.27 (134)	1.40 (134)

*$P<0.001$ (required significance level after Bonferroni adjustment = 0.008).

consumption during intervention and at follow-up; from 4% (baseline) to 68% (intervention) and 48% (follow-up) for fruit and from 11% (baseline) to 48% (intervention) and 43% (follow-up) for vegetables. Those children who ate the most at baseline (80–100%) consumed 94% fruit in baseline, 92% in the intervention and 76% at follow-up; for vegetables it was 93% (baseline), 90% (intervention) and 89% (follow-up). Clearly, there are ceiling and floor effects restricting the direction of change at either ends of the scale. Nevertheless, in the control school, those children who ate the least during baseline showed little change during the course of the study; from 2% (baseline 1) to 7% (baseline 2) and 5% (follow-up) for fruit, and from 7% (baseline 1) to 4% (baseline 2) and 7% (follow-up) for vegetables. By contrast, the consumption of those who ate the most during baseline went from 90% (baseline 1) to 47% (baseline 2) and 13% (baseline 3) for fruit, and from 92% (baseline 1) to 64% (baseline 2) and 55% (baseline 3) for vegetables.

Consumption at snacktime

Following the procedure employed for the lunchtime data, three scores were computed for each child (5–7-y old children only) at snacktime. These were the mean levels of consumption of fruit towards the end of each of the three phases, shown in Table 2. The data were analysed using a two-way mixed ANOVA and *post hoc t*-tests with school (experimental, control) and study phase (baseline/baseline 1, intervention/baseline 2, follow-up) as independent variables. Analysis revealed a significant interaction between school and study phase, $F(2, 494) = 17.09$, $P < 0.001$. *Post-hoc t*-tests (see Table 2) showed that in the experimental school consumption was significantly higher at intervention than at baseline or follow-up, but there was no difference between baseline and follow-up levels. In the control school there were no significant differences among the three study phases.

Consumption at home

The parental recall data relating to fruit and vegetables consumed outside of school were re-coded into standardised portions based on UK government recommendations for primary school children (Department for Education and Employment, 2000). Depending on the particular fruit or vegetable, these ranged from approximately 40–100 g for fruit and 40–85 g for vegetables, and were comparable with the portion size recommendations provided by the National Cancer Institute in North America (Heimendinger *et al*, 2001). Owing to missing data, one weekday (ie Monday or Wednesday) and one weekend day (ie Sunday) at both baseline and intervention were used as the basis for subsequent calculations (for details, see Lowe *et al*, 2004). This resulted in a sample size of 55 for the weekday data and 78 for the weekend day data. Calculation of overall levels of consumption revealed that on weekdays, in the experimental school, the mean number of fruit portions consumed averaged 0.84 (s.d. = 0.81) at baseline and 1.45 (s.d. = 1.16) during the intervention, while the mean number of vegetable portions consumed averaged 1.52 at baseline (s.d. = 1.28) and 1.13 (s.d. = 1.08) during the intervention. On weekdays in the control school, the mean number of fruit portions consumed averaged 0.88 (s.d. = 0.87) at baseline and 0.81 (s.d. = 0.77) during the intervention; the corresponding figures for vegetables were 1.23 (s.d. = 1.02) at baseline and 0.82 (s.d. = 0.75) at intervention. On weekend days, the mean number of fruit portions consumed by children in the experimental school averaged 1.26 (s.d. = 1.27) at baseline and 1.41 (s.d. = 1.37) during the intervention; vegetable consumption was 1.21 (s.d. = 1.61) at baseline and 1.65 (s.d. = 2.06) at intervention. On weekend days in the control school consumption of fruit averaged 1.28 (s.d. = 1.42) at baseline and 1.28 (s.d. = 1.39) during the intervention, vegetables 1.46 (s.d. = 1.58) at baseline and 1.26 (s.d. = 1.51) at intervention.

To normalise the distributions, a square root transformation was applied to the data, which were then analysed separately for the weekday and weekend using two three-way mixed ANOVAs. In each case the independent variables were school (experimental, control), study phase (baseline/baseline 1, intervention, baseline 2) and food (fruit, vegetables). For the weekday data the results showed a significant interaction between phase and school, $F(1, 53) = 4.02$, $P < 0.05$ and a significant interaction between phase and food, $F(1, 53) = 15.07$, $P < 0.001$, but no significant interaction between phase, school and food, $F(1, 53) = 3.28$, ns. The back-transformed weekday means indicate that, for fruit and vegetables combined, consumption in the experimental school increased significantly relative to the control school (from 2.13 in baseline to 2.31 at intervention in the experimental school compared to a shift from 1.93 to 1.39 in the control school). For the weekend data, the results failed to show a significant interaction between phase and school, $F(1, 76) = 2.64$, ns, or between phase, school and food, $F(1, 76) = 0.48$, ns.

Discussion

Lunchtime: all children

Baseline conditions. The baseline data relating to lunchtime consumption of fruit and vegetables in the experimental and control schools provide valuable information about children's consumption of these foods when they are made freely available at school. Across both the experimental and control schools, children consumed an average of just 25% of the fruit presented at baseline/baseline 1—approximately 20 g. This figure is similar to that obtained in previous research where fruit consumption at the end of baseline averaged 21% (Lowe *et al*, 2004). Corresponding levels of vegetable consumption in the present study averaged 38% (approximately 23 g), compared to the 24% obtained by Lowe *et al* (2004). It is possible that the higher levels obtained in the present study were in part due to the fact that, for measurement purposes, children who selected vegetables from the canteen received a coloured sticker on their name badge. Initially this may have rewarded the taking of vegetables and led to an increase in consumption. This interpretation is supported by the fact that vegetable consumption showed a significant decline in the control school from 28% at baseline 1 to just 15 and 18% at baseline 2 and follow-up, respectively, possibly because the children habituated to the coloured stickers. On the other hand, fruit consumption by 7–11-y olds in the control school also showed a significant decline between baseline 1 and follow-up, and between baseline 2 and follow-up, even though the coloured stickers described above were not employed for these foods. However, in contrast to vegetables, which had always been available in the canteen, fruit was introduced specifically for the study. The higher initial levels of fruit consumption (in baseline 1) may then be the result of a novelty effect of the introduction of this fruit. Indeed, this finding is consistent with previous research that has also shown a decline over time in consumption of fruit introduced at lunchtime in the absence of any intervention (Lowe *et al*, 2004).

Nevertheless, these data clearly show that the continued presentation of fruit and vegetables at lunchtime even over a period of approximately 5 months does not lead to increases but rather, if anything, to declines in consumption. This is important because it has been suggested that exposure-based interventions could be used to increase children's consumption of fruit and vegetables (see Wardle, Cooke *et al*, 2003). Although repeated taste exposures may indeed be an important determinant of food preferences (eg, Birch and Marlin, 1982; Birch *et al*, 1987), the results from the present study clearly show that simply presenting foods repeatedly to children, in the absence of any other motivational intervention to ensure that they eat them, is ineffective.

The baseline data discussed thus far are averages based on the two age groups in each of the schools and they disguise, for instance, the fact that many of the children consumed far less in baseline than the averaged data might suggest. Taking children from both schools together ($n = 354$), 53% ate just 3% of the fruit presented and 38% ate just 8% of the vegetables. The data from baseline 2 and follow-up in the control school show, again, that simply presenting fruit and vegetables over time has little or no impact on the behaviour of the children in this crucial category.

The intervention. When the intervention was introduced in the experimental school, there were substantial increases in consumption for both age groups. Averaged across all children, consumption of fruit more than doubled from 36 to 79%, while that of vegetables increased from 44 to 66%. The subset analysis indicated that the largest increases in consumption were obtained by those children in the experimental school who ate the least during the baseline phase. For example, those children who fell into the 0–19% consumption bracket in baseline (see Figure 2) went from eating an average of just 4% to 68% of their fruit and from 11% to 48% of their vegetables during baseline and intervention, respectively. In the control school, such increases were not obtained for children who fell into this category or, indeed, any of the other subgroups. Rather, in baseline 2, the general pattern was one of substantial decline in fruit and vegetable consumption, even in subgroups who initially consumed the foods at or near ceiling levels. These findings are consistent with previous research (Lowe *et al*, 2004, see also Horne *et al*, 1995, 1998; Dowey, 1996; Lowe *et al*, 1998; Woolner, 2000; Tapper *et al*, 2003) and show that it is possible to bring about large improvements in children's diets, particularly for those who initially consume very little fruit and vegetables.

Comparison of consumption levels across the two schools in the first baseline phase (see Figure 1) suggests that baseline consumption may have been higher in the experimental school—for reasons that are not clear. If this were to have had an impact on the effectiveness of the intervention then, given the negative relation between consumption levels in baseline and intervention (shown in Table 2), it would not be in favour of the experimental school but, if anything, might lead to an underestimate of the intervention's effectiveness relative to the control condition. In addition, Table 2 suggests that there were variations in these baseline differences across the two age groups and food categories, but shows that the intervention (and follow-up) effects were significant regardless of initial baseline level.

Follow-up. At follow-up, 4 months later, there was some decline from intervention levels (see Table 1) but children in the experimental school were still consuming substantially more fruit and vegetables compared to baseline. At 61%, fruit consumption at follow-up was almost double that in baseline (36%), while vegetable consumption was 59% at follow-up compared to 44% in baseline. These differences were significant for both 5–7 and 7–11-y olds. Again, the largest increases in consumption were found for those children who consumed least at baseline (see Figure 2), with 38% of these children showing a more than 10-fold increase in fruit consumption at follow-up (to 48%) compared to baseline (4%). In all, 26% of the children who ate just 11% of their vegetables in baseline were eating 43% at follow-up. These findings contrast with those obtained in the control school where overall mean vegetable consumption was significantly lower at follow-up (18%) compared to baseline (28%); fruit consumption averaged 9% at follow-up compared to 17% at baseline, showing a significant decline among 7–11-y olds. As indicated by Figure 2, the declines were very marked in those groups who consumed most in baseline 1, again contrasting with the results from the experimental group.

In line with previous studies that conducted long-term follow-ups of this type of programme (Horne *et al*, 1995, 1998; Dowey, 1996; Lowe *et al*, 1998; Woolner, 2000), these results indicate that much of the gains achieved by the 16-day intervention can be sustained over long periods of time. With the exception of 5–7-y olds' vegetable consumption, however, there was a decline in consumption between intervention and follow-up, for which there are a number of possible reasons. First, it was clear that over the 4-month maintenance period procedures were not always implemented consistently, and by all teachers. There were neither rewards nor sanctions for the schools' full implementation of the programme requirements over this period and, clearly, failure to conduct the maintenance procedure systematically would lessen its effectiveness. It may therefore be beneficial if school staff, as well as children, were to receive incentives or support for their participation in the programme. Second, it is possible that the maintenance procedures themselves could have been strengthened. In particular, due to a preference expressed by the school, all children received a reward once the maintenance chart for each class as a whole had been completed. Thus, the rewards were not contingent upon the amount eaten by any particular individual and some children may have failed to eat any fruit or vegetables but still received a reward. It is likely that rewards contingent upon individual rather than group consumption would be more effective at maintaining the increases in consumption. Indeed, we are currently evaluating such a maintenance procedure using follow-up measures conducted at both 6 and 12 months.

It should also be noted that, in this study, to meet the reward criterion the children were required to eat at least half of the fruit and vegetable serving, as compared to the 100% criterion in the Lowe *et al* (2004) study. The fact that consumption levels at follow-up in this study exceeded the 50% criterion suggests then that it was not extrinsic rewards alone that were responsible for maintaining consumption. Nevertheless, the effects of maintenance, and indeed those of the intervention itself, may well have been stronger had the reward criterion been set at 100% as in the study by Lowe *et al* (2004). This possibility is also being investigated in ongoing studies by the present authors.

Snacktime: 5–7-y olds only

At snacktime, consumption levels during baseline were much higher than those obtained at lunchtime, with children across both the experimental and control schools consuming an average of 70% of the fruit presented. This difference may be due to the fact that the fruit was presented in isolation at snacktime but alongside other foods at lunchtime. Since, according to teachers, many children came to school without eating breakfast, it is also possible that many of the children were hungrier at snacktime (ie at mid-morning) than they were at lunchtime, especially since at lunchtime children tended to eat their fruit after their main course.

With the introduction of the intervention into the experimental school, there was a significant increase in fruit consumption, from 75 to 87%. Over the same time period (from baseline 1 to 2) in the control school there was no change in consumption nor indeed was there any at follow-up, which again indicates that the repeated presentation of fruit does not lead to increased consumption. Unlike lunchtime, however, snacktime fruit consumption in the experimental school had returned to baseline levels (76%) at follow-up 4 months later. There are a number of possible reasons for the failure to maintain the increases achieved during the intervention. First, children were already consuming very high levels at baseline, higher percentages than reported in previous studies (Lowe *et al*, 2004) and this may have made further increases difficult to sustain. There are also issues concerning group-based reward contingencies and possible inconsistent implementation of the maintenance programme, as discussed above in relation to the lunchtime outcomes.

Home: subsample

The parental recall procedure showed that during the baseline phase, across both the experimental and control schools, children consumed an average of 2.24 portions of fruit and vegetables outside school on weekdays and 2.60 portions on weekend days. These figures are similar to those obtained previously (1.68 and 3.16 for week and weekend days, respectively, Lowe *et al*, 2004). As in the study by Lowe *et al*, the data also showed an increase in consumption of fruit and vegetables on weekdays during the intervention by children in the experimental school relative to those in the control school. For weekend days there was no significant difference. Given that most of the intervention was delivered at school during the week, the absence of change during the weekend may have been due to a lack of appropriate cues (for example being reminded of the Food Dudes). Thus, incorporating specific weekend activities into the homepack may help increase consumption of fruit and vegetables on these days. It should also be noted, however, that the parental recall procedure had substantial limitations. The final number of participants was small for statistical purposes and assessment of portions eaten, particularly when dealing with a variety of ethnically diverse cooking, was difficult. As the procedure may also be subject to error as a result of respondent fatigue or recall inaccuracies, further work is needed to experimentally validate it.

General issues

Taken together with other investigations of this type of intervention (Horne *et al*, 1995, 1998; Dowey, 1996; Lowe *et al*, 1998, 2004; Woolner, 2000), the present study shows that it is possible to bring about large and long-lasting changes in children's consumption of fruit and vegetables. Moreover, the increases in consumption obtained by the programme were especially pronounced among those children who consumed the least at the outset. This is important since it is these children who are likely to benefit most from dietary change. The study also showed that the programme could be successfully implemented in a large, multi-cultural, inner-city school environment where there were high levels of social deprivation. Again, it is children in deprived areas such as these who may have the most to gain from the intervention.

The increases obtained in the present study compare favourably with those obtained by other multi-component interventions (Domel *et al*, 1993; Foerster *et al*, 1998; Nicklas *et al*, 1998; Perry *et al*, 1998; Baranowski *et al*, 2000; Reynolds *et al*, 2000), aimed at increasing children's consumption of fruit and vegetables (see Lowe *et al*, 2004). It should also be noted that, unlike many of these other evaluations, the present study employed weighed measures and direct observations of behaviour as the principle measures of food consumption and dietary change as opposed to mere self-report. This is important since self-report measures may be subject to a number of biases and inaccuracies, particularly given that health interventions in themselves may increase social desirability bias (Herbert *et al*, 1995; Kristal *et al*, 1998; Lytle *et al*, 1998; Livingstone and Robson, 2000). Clearly, however, further work remains to be done with more extended follow-ups, refinement of the procedures to further enhance their effectiveness, and the use of cluster randomised controlled trials. It is also essential that future research continues to explore the determinants of children's food preferences and how changes, such as those seen in this study, are brought about.

Although the present findings show that repeated visual presentation of foods does not in itself lead to increases in consumption, it is almost certainly critical that the children do achieve *taste* exposures (Birch *et al*, 1987). In this study, through the peer modelling videos and rewards, the children were influenced to repeatedly taste the foods that many of them had previously shunned. Since, as several studies have shown (eg, Wardle, Cooke *et al*, 2003; Wardle, Herrera *et al*, 2003; Lowe *et al*, 2004), there is an increase in consumption and expressed liking for foods that are repeatedly tasted, the children come to find these fruits and vegetables rewarding in their own right. The greater the number of tastings of each food, the greater the likelihood that extrinsic rewards could thus be gradually faded out from the programme as the intrinsically rewarding properties of the foods themselves began to take their effect. Evidence that this occurred for many of the children is indicated by the fact that the post-intervention consumption levels of lunchtime fruit and vegetables in this study often exceeded the 50% criterion required for extrinsic rewards.

It should be noted, on the other hand, for practical reasons related to costs and the time constraints involved in a detailed evaluation such as this, the 16-day intervention allowed for only four tastings of each food (or eight tastings for fruit for 5–7-y olds). The programme thus relies on the maintenance procedures being implemented effectively to ensure that further tastings occurred. But, as already discussed, this did not happen consistently. To maximize effectiveness, future work needs to ensure either that there is a longer intervention period or effective implementation of the maintenance procedures.

The role of rewards themselves is also a vital issue that needs to be systematically addressed in future research in this domain, not least because of the view expressed by some researchers (Birch *et al*, 1982, 1984; Newman and Taylor, 1992) that rewards have a detrimental effect on food preferences. According to this account, if a child is rewarded for eating a particular food, not only will this fail to increase the child's preference and consumption of that food, but also it will actually lead to the child's rejecting it all the more. The results of studies supporting this viewpoint may in part be explained by the way in which rewards were employed. Research shows that rewards are most effective when they are highly desirable (ie they are potent reinforcers) and when they convey the message that they are for behaviour that is both high status and enjoyable (eg, see Dickinson, 1989; Lowe *et al*, 1998; Cameron *et al*, 2001). However, research studies reporting decreases in food preference have tended not to use rewards in this way. In the studies by Birch *et al* (1982) and Newman and Taylor (1992) rewards consisted of middle-ranking foods or activities, that is, in a pre-experimental preference test, they were ranked by children as being neither most nor least preferred. Thus, it is highly likely that they did not function as reinforcers, let alone potent reinforcers. Therefore, one would not expect them to result in increases in either consumption or preference.

In addition, the procedures employed in studies reporting decreases in food preferences indicate that the rewards may have had coercive associations for children rather than positive ones. For example, in the study by Birch *et al* (1982) children were told 'Drink this juice and then you can (ride the tricycle)' (p 129). In the study by Birch *et al* (1984) children were told 'You need to drink more fruit shake to get a movie ticket' or 'You didn't drink enough yet; drink some more to get your movie ticket' (p 435). The impact of children's prior experience of such contingencies should not be overlooked. It is likely that in the past, where children have encountered contingencies verbalised in this way, they have been used to persuade them to eat foods they dislike, or to engage in tasks that are unpleasant (see Lepper *et al*, 1982). There is evidence to suggest that this can influence children's responses to foods placed in contingencies verbalised in a similar manner, so that they come to devalue these foods (Lepper *et al*, 1982). Thus, it is likely that this would result in negative effects not only on their preferences, but also on their subsequent consumption levels. In contrast, in the present study the materials (eg, the video and letters) were designed to ensure that the rewards signified success. It was also made clear to teachers that the rewards should be used as marks of achievement and should be paired with praise. Indeed, a large body of research shows that rewards do not have negative effects when they convey positive messages of, for example, achievement and competence (eg, see Cameron *et al*, 2001).

The present study suggests that television can be used to positively influence children's diets. Given that children in Western cultures routinely watch an average of 3 h of television per day (Liebert and Sprafkin, 1988; Gunter and McAleer, 1997), they are frequently exposed to advertisements for snacks high in sugar, salt and saturated fats (Carruth *et al*, 1991; Byrd-Bredbenner and Grasso, 2000; Kuribayashi *et al*, 2001), which in turn may influence children's food choices in favour of these unhealthy options (Gorn and Goldberg, 1982; Borzekowski and Robinson, 2001). The effects of the Food Dude series suggest that, particularly when integrated into a school- or home-based reward system, children's enthusiasm for video hero figures and celebrities and their desire to emulate them may be harnessed to provide a potent counter influence to the mass marketing of foods and dietary habits that may be damaging to health.

In conclusion, the present study indicates that the Food Dude Programme can be successfully implemented by school staff and with large groups of children. It brings about significant and long-lasting increases to children's consumption of fruit and vegetables.

Acknowledgements

The project was supported by the Department of Health, Department for Education and Employment, Department of Environment, Food and Rural Affairs and the Food Standards Agency. We would also like to thank all the school staff, pupils and parents who participated, the education authority for recruiting the schools, and Team Lambeth for supplying fruit and vegetables. We are particularly grateful to Doug Henderson, Colin Harvey, Margaret Charrington, Teresa Wickham and Richard Hutchins for their unfailing support.

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