

### Abstract

**Background:** One of the driving factors of dietary overconsumption throughout the last decennia is the increase of food portion sizes. Larger portions induce higher daily energy intake, so reducing portion size may reduce intake of excess calories. However, real-life studies about the effects of portion size reduction are lacking. Therefore, this study examined the effect of a French fries portion size reduction on French fries consumption, French fries plate waste, satiety and caloric intake during the subsequent afternoon among university students and employees in a Belgian on-campus restaurant setting. Moreover, this study evaluated consumers' perception about the portion size reduction.

**Methods:** The study took place over a two-time (i.e. baseline and intervention week) 4-day period (Tuesday–Friday) in the on-campus restaurant where  $\pm 1200$  meals are served every day. French fries' portions were reduced by 20% by replacing the usual porcelain bowl served during the baseline week ( $\pm 200$  g) with smaller volume paper bags during the intervention week ( $\pm 159$  g) in a pre-post real-life experiment. French fries consumption and plate waste were measured in 2056 consumers at baseline and 2175 consumers at intervention. Additionally, interviews were conducted directly after lunch and again between 4 and 6 p.m. on the same day to assess satiety and caloric intake at pre and post in a small subsample of both French fries consumers ( $n = 19$ ) and non-French fries consumers ( $n = 14$ ). Post-intervention, the same subsample was interviewed about their perception of the portion size reduction ( $n = 28$ ).

**Results:** Total French fries intake decreased by 9.1%, and total plate waste decreased by 66.4%. No differences were found in satiety or caloric intake between baseline and intervention week among the French fries' consumers. The majority ( $n = 24$ , 86%) of French fries consumers noticed the reduction in portion size during the intervention. Although most participants ( $n = 19$ , 68%) perceived the reduced portion size as sufficient, only a minority of participants ( $n = 9$ , 32%) indicated post-intervention that they would agree with a permanent implementation.

**Conclusions:** Reducing portion size may lead to reduced caloric intake, without changing perceived levels of satiety.

**Keywords:** Portion size, Consumption, Plate waste, Satiety, Caloric intake, University, Nudging, Choice architecture

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## Background

Colleges and universities have the ability, like most educational institutions [1–5], to set up public health initiatives for their students via education, physical activity, but also via food environments [6–8]. In this perspective, they provide the ideal setting to promote healthy eating [6–8]. It has been demonstrated that, on average, college and university students gain a substantial amount of weight during their years at college or university [9, 10]. Research also shows that this weight gain coheres with poor diets, including low intakes of fruits and vegetables, insufficient variety in food consumption, and consumption of large portions [11, 12]. Moreover, it was found that students were more likely to gain weight when eating more frequently at the university restaurant [13]. A similar relation was found for those students frequently eating French fries [13]. Obviously, colleges and universities provide also services and employment for a large number of employees. Since the low intakes of fruits and vegetables and high fat intake is not only manifested in students, but also in the adult population in general [14], strategies that produce opportunities for healthy choices are also needed for employees [14]. Because adults spend most of their waking hours at work, the workplace can be a good setting for health related interventions [15]. When installing an intervention in a work-site cafeteria or restaurant a large number of people with varying age and socioeconomic status can be reached [16]. From this perspective dietary interventions conducted in a workplace setting are plentiful but not recent and little innovative, as most of workplace interventions used a labelling system or provided product information [14, 17–22]. However, few dietary interventions approached both students and employees simultaneously.

With regard to intervention development, manipulating the physical environment, may be recommended because one can easily and instantly reach larger groups of people [15]. According to Roy et al. [7] and Thorndike et al. [23], simple environmental interventions in food settings can lead to healthier food choices among (young) adults. Recently, environmental interventions in food settings are becoming very popular in the form of nudge and choice architecture studies [5, 24–27]. However, in order to have a chance of success, behavioural approaches must generally be ‘easy’ by reducing the effort to participate to a minimum [28].

A relatively easy environmental intervention, which has the potential to control people’s energy intake is portion size modification [29, 30]. Rolls et al. [31], for example, showed that portion size is positively related to daily energy intake. Beside the fact that (in general) people are consuming more kilocalories than they are expending [30], today’s portions of high-caloric foods

contain larger quantities than recommended by dietary guidelines, even in Europe [32]. These findings raise the argument to decrease portion sizes in the battle against overweight and obesity.

Rolls et al. [31] proved that a reduction in portion size of 25% of all foods on two consecutive days led to a reduced food intake of approximately 10%. In their study, however, participants (i.e. randomly recruited young women) were invited in a laboratory setting, where the portion sizes and energy density of the foods of daily menus were changed. From a scalability and public health point of view, it is clear that confirmation by real-life setting trials is needed. To our knowledge, only one US study reduced the portion size of a calorie-dense food product (i.e. French fries) served in an on-campus university restaurant, presented in plain paper bags [33]. This experiment showed that reducing the portion size of French fries by 50% resulted in a 30% decrease in French fries consumption per consumer as well as 31% reduction in plate waste per consumer [33]. In an intercept survey, 70% of the 322 questioned French fries consumers indicated they did not notice the change in portion size [33]. In the latter study, consumers consisted primarily of US freshmen while dietary intake, and thus also dietary compensational effects during the rest of the day were not assessed. So, from this study we cannot conclude that portion size reduction will lead to reduced food intake, as the 50% reduction in French fries consumption may have been compensated for later on the day. In the laboratory experiment by Rolls et al. [34], ratings of hunger decreased as the size of the package containing potato chips increased, but this did not lead to a reduced energy intake at the subsequent dinner later that day. Such possible adjustments were also checked in a study by Jeffery et al. [35], where unannounced 24-h dietary recalls were conducted by phone after a 50% reduction of pre-packaged lunches in a naturalistic setting. Results showed that mean 24-h energy intake decreased with 278 kcal/day when a small lunch was served in comparison with a large one [35]. A British study investigating the effects of reducing breakfast both on hunger feelings and subsequent energy intake, showed no influence on subsequent energy intake but did show a significance difference in hunger feeling after reducing the portion with 40%. However, this study was conducted in an overweight population in a laboratory setting [36].

In summary, no real-life experimental studies including portion size modification assessed level of satiety and dietary compensational behaviour during the hours immediately after consumption. Since European research about portion size reduction is limited and US results cannot be extrapolated due to the different eating habits between both continents [37–39], more European

studies are desirable. Therefore, the primary aim of the present study was to investigate the effect of a French fries portion size reduction on French fries consumption and plate waste among university students and employees in a Belgian on-campus university restaurant setting. Secondly, we aimed to investigate the effect of the intervention on level of satiety and caloric intake during the afternoon. Thirdly, we aimed to evaluate consumers' perceptions about the portion size reduction.

## Methods

### Participants and design

The study was conducted in the on-campus restaurant of the Vrije Universiteit Brussel (Brussels, Belgium). The restaurant operates by a free-flow system which gives consumers the ability to choose daily between six different types of menus (i.e. menu 1 (generally meat dish), menu 2 (generally meat dish), fish-menu, vegetarian/vegan-menu, pasta menu, wok menu) or the salad bar. Consumers are free to choose a starchy side dish (French fries, mashed potatoes, boiled potatoes, or rice) when choosing one of the first four menus. Next to the main dish, a typical menu consists of soup of the day and a dessert (i.e. choice between fruit, yoghurt, pudding, cookies, or ice cream) and costs €5 for students and employees of the university, visitors pay a non-sponsored price (€10). French fries were chosen as the food of interest for the current study because it is high in calories, frequently chosen by students and employees, and relatively easy to manipulate in terms of portion sizes. Participants were university students and employees consuming one of the above mentioned menus as lunch at the on-campus restaurant during the experimental period. The on-campus restaurant is open on weekdays (Monday–Friday) from 11:30 a.m. till 1:45 p.m. and only serves lunch meals. Approximately 1200 to 1300 meals are served every day in the on-campus restaurant and all students and employees visiting the free-flow system of the on-campus restaurant were exposed to the experiment.

The study consisted of a real-life experiment during which French fries consumption and French fries plate waste were measured in 2056 consumers during baseline week and 2175 consumers during intervention week. In addition, a convenient subsample of as much students and employees as possible ( $n = 296$ ) was recruited on the spot to voluntarily participate in face-to-face and telephone interviews assessing level of satiety and dietary intake during lunch and later in the afternoon. Dietary intake was measured by means of a 4-h dietary recall. Dietary recall has been validated against a 4-day food record and provides a good overall ranking of intake [40]. These assessments were performed during both the pre-intervention and intervention week. Post

intervention, students and employees who consumed French fries during the intervention week were asked about their perception of the portion size reduction in a post-intervention week. Figure 1 represents how the experiment was conducted. This study was approved by the medical ethics committee of the university hospital (Vrije Universiteit Brussel, Brussels, Belgium, B.U.N. 143201732012).

### Procedure

The experimental study took place over a two times (i.e. baseline and intervention week) 4-day period (Tuesday–Friday) during the opening hours of the on-campus restaurant (11:30 a.m. to 1:45 p.m.).

The course of the intervention was visually presented by Fig. 1. During the first (i.e. baseline) week, baseline data were collected of French fries consumption by registering the amount of portions of French fries (served in the usual porcelain bowls) purchased, the amount of French fries produced, and by weighing the wasted amount of French fries. Further, level of satiety shortly after completing lunch and caloric intake of the lunch were assessed using face-to-face interviews in a conveniently chosen group of students and employees immediately after having completed their lunch meal. Four hours after finishing these face-to-face interviews (between 4 and 6 p.m.), level of satiety of that exact moment and caloric intake and physical activity (as control for compensational behaviour for the larger/smaller portion) during the afternoon were assessed during telephone interviews within the same subgroup of students and employees who participated earlier that noon.

The second and third week were used as intermediate weeks during which no manipulations or assessments were carried out. This was due to the Easter holiday, during which the on-campus restaurant was less visited by students and employees.

During the fourth (i.e. intervention) week, French fries portion sizes were reduced by replacing the usual porcelain bowl containing approximately 200 g of French fries by smaller volume paper bags containing approximately 160 g French fries (Fig. 2), which corresponds to a reduction of 20%. Similar to the baseline week, French fries consumption, the amount of French fries produced and French fries plate waste were measured. Using telephone interviews, level of satiety and caloric intake were again assessed twice (right after lunch, and 4 h later) in the same subgroup of students and employees as in the baseline week. Because not everyone ate in the on-campus restaurant again, a part of this subgroup dropped out. At the end of the intervention week, two groups (French fries consumers and non-French fries consumers) were formed based on the side dish choice of the consumers. To avoid meal bias (i.e. some main