



# Effects of Food Plate Size and Color on Visual Perception of Satiety in Adolescents; a New Strategy toward Weight Management

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## Abstract

**Background:** Adolescence obesity and its health consequent on adulthood is affected by various environmental factors. Recently, dishware size or color is considered as a probable critical point to manage intake and weight. We investigated visual perception effects of plate size and color on fullness sensation regarding the Body Mass Index (BMI) for age percentiles in Tehran, Iran in 2019.

**Methods:** A cross sectional study conducted on 408 students aged 13-18 year from both sexes with different socioeconomic status through convenience sampling method. Anthropometric characteristics were measured to determine BMI for Age categories based on the WHO protocol. Visual analog scale (VAS) was used to assess participants' perceived satiety when faced to images of different plate's size and color with the same food volume. SPSS 21 was used to statistical analyze.

**Results:** 41.2% of student were on >85th percentile of BMI for age. Mean of score of VAS for medium red plate was significantly lower than medium and large white plates in both sexes ( $P<0.001$ ), while mean of score of VAS for small white plate was significantly lower than large white plates only in girls ( $P<0.001$ ). The adolescents who were on >85th percentile of BMI for age, gave higher score to large white plate than medium white plate and to medium white plate than medium red plate, significantly ( $P<0.001$ ), while the scores given by the adolescent on 5th percentile of BMI, were not significant.

**Conclusion:** Considering dramatic trend of obesity in adolescents in Iran, there is an urgent need to make supportive policies. Manipulating food containers seems to be an effective and simple approach to control feeling satiety. It may be a cost-effective approach to prevent obesity in adolescents before progressing to adulthood.

**Keywords:** Plate size; Plate color; Visual satiety; Obesity

## Introduction

Overweight and obesity that are defined as abnormal or excessive fat accumulation, can be

health threatening. The global prevalence of obesity has been increased more than 300% between



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1975 and 2016 even in kids. Whereas less than 1% of children and adolescents aged 5-19 were obese in 1975, 6% of girls and 8% of boys in 2016 were reported as being obese (1). As well in Iran, a survey on high school students in 2013 showed that overweight and obesity prevalence was more than 38.5% (2). It is due to changes in dietary and physical activity patterns and in environmental and social factors associated with development and lack of supportive policies. Epidemiological studies prove these changes and their impacts on increasing trend of obesity over time. Therefore, investigation of these behavioral and environmental factors could be an effective strategy to prevent obesity (3).

Environment has fundamental effect on food choices. Moreover, perceived satiety can be defined as the extent to which a food is expected to decrease the hunger (4). Recently, the size of food packages and dishes has increased (5). In the last three decades, the average size of food containers has increased by more than 36%. Therefore, researchers have recently focused on plate's appearance as probable environmental factor involving in weight increase (6).

The larger food dishes make the amount of food seems smaller than the actual amount (7). Therefore, it is possible that people eat more than their usual consumption when food serves in a large plate (8). Plate or utensil size has a positive correlation with the amount of food consumption (7,9). Perceived volume and expected satiety act as determinants of the quantity that a person consumes (10). The perceived volume has an effect on decision about the size of the portion and consequently, on feeling satiety (11).

The appearance of the plates, may create a kind of visual image in mind, according to the "Delboeuf illusion". According to "Delboeuf illusion", when a constant amount of food put into a larger plate, it seems less than when it is placed into a smaller one, because of increased the distance between the food and the edge of the plate. Besides, serving food in larger plates, comparing with smaller ones, may lead to a delay in feeling satiety and so, more food consumption. Delboeuf illusion influences not only on the percep-

tion of plate size, but also on the perception of plate color. According to this theory, when there is a weak contrast between plate color and the color of food in it, (for example serving white rice in a white plate), food volume appears less than its actual size, so, feeling satiety occurs later. Against, when the color of the plate has a high contrast with the content of it, the food will seem larger than its actual size. Thus, the high contrast between plate and its contents, leads to over estimation of food volume. Therefore, it leads to a fast feeling satiety (12,13).

Although using colorful or/and smaller containers are suggested as an effective approach to decrease calorie intake and obesity (8), it is a controversial topic. Furthermore, there is little information about the perceived satiety. According to high prevalence of obesity in adolescents in Iran and lack of studies about the effect of plate appearance on the amount of food intake, we investigated, for the first time, the association of food plate size and color with the perceived feeling satiety and the amount of food consumption by the adolescents aged 13-18 year in Tehran in 2019.

## **Methods**

This cross-sectional study was conducted in 2019 on 408 girls and boys, aged 13-18 yr through convenience sampling method. To consider the effect of socioeconomic status, schools were selected from different districts of Municipality in Tehran, Tehran.

Information about being on a diet from the last year till the start of the study, being an athlete and consuming any effective drugs on appetite or weight was collected by face-to-face interview through a self-administered questionnaire.

### ***Anthropometric measurements***

All anthropometric measurements were done by an educated skilled dietitian. Body weights without shoes, while wearing light clothes were measured by digital scale (Beurer, Germany) to the nearest 100 grams and the heights were reported

in a standing position without shoes with the shoulders in a normal position using a non-stretch meter fixed to a wall and to the nearest 0.5 cm. BMI was calculated as weight (kg) divided by the square of height (m<sup>2</sup>). BMI/Age was categorized based on CDC growth chart through the WHO AnthroPlus software as < 5th, 5-85th, 85-95th and >95th percentile BMI/Age (14).

### Visual analogue scale (VAS) assessment

At first, two 18 and 25 cm-white flat plates without any border and an 18 cm-red flat plate were prepared. Then the same amount of cooked white rice (equal to 200 g) without any decoration (to prevent the effect of color and decoration on responses) were poured into each of these three containers. Color photograph was taken of each plate and printed, separately.

The 18 cm plate is the size of a medium plate commonly used in homes, and the 25 cm plate is the size of a large plate that is often used in restaurants. Because white is the most widely used color in both homes and restaurants dishes, white plates were used to study the effect of container size on food intake. A red plate was also used to assess the effect of dish color on the feeling of satiety.

At the time of the interview, images of large white, medium white, and medium red plates were shown to students, separately. Participants were asked “How much of this food makes you feel full” Students marked their responses on VAS for each plate, separately. Zero meant he/she will consume any amount of food, and number 10 meant he/she will consume all amount of food to feel satiety. This approach is a

reliable and sensitive method for measuring subjective hunger and satiety.

### Statistical analysis

SPSS software ver. 21 (IBM Corp., Armonk, NY, USA) was used for statistical analysis. Kolmogorov-Smirnov test was used to assess the normality distribution of variables. Parametric and nonparametric descriptive tests were used for data analysis, depend on their normal or abnormal distribution. Paired T-test was used to compare VAS score for two different size plates and two different color plates by percentile of BMI for age. Repeated measurement test was used to compare VAS score of three plates. *P* value<0.05 considered as significant level.

### Ethical considerations

The Ethics Committee of the National Nutrition and Food Technology Research Institute, Iran, approved this project with ethical code: “IR.SBMU.nnfri.Rec.1397.241”. A signed handwritten informed consent was obtained from each student before data collection.

### Results

Totally, 408 adolescents (204 girls and 204 boys) aged 13-18 took part in this study. The mean age of girls and boys was 14.87±1.8 year and 15.3±1.41 year, respectively. Chi-square test showed that being on a diet, in girls, was more than boys (about 3 times more). Table 1 shows general characteristics of participants in this research.

**Table 1:** General Characteristics of Participants by sex

		Frequency (%)			P-value*
		Total	Girls	Boys	
To be on a weight loss/gain diet currently	Yes	47 (11.5)	35 (74.5)	12 (25.5)	0.001
	No	361 (88.5)	169 (46.8)	192 (53.2)	
To be on a weight loss/gain diet from last year until 2 months ago	Yes	60 (14.7)	41 (68.3)	19 (31.7)	0.003
	No	348 (85.3)	163 (46.8)	185 (53.2)	
To be an athlete	Yes	40 (9.8)	24 (60)	16 (40)	NS
	No	368 (90.2)	180 (48.9)	188 (51.1)	

\* Significant difference between girls and boys

Distribution of adolescents among different percentiles of BMI for age showed that more than half of the students had a normal BMI for age and close to half of the students were on >85th percentile of BMI for age. Moreover, mean of VAS for 3 types of plates showed students scored lower to medium red plate (5.6) than two other medium and large

white plates (6.6 and 6.8) which were statistically different ( $P < 0.001$ ).

Figure 1 shows VAS for 3 types of plates by sex according to repeated measure test. Mean score of medium red plate was lower than two other plates in both sexes. Furthermore, mean score of medium white plate was lower than large white plate only in girls.

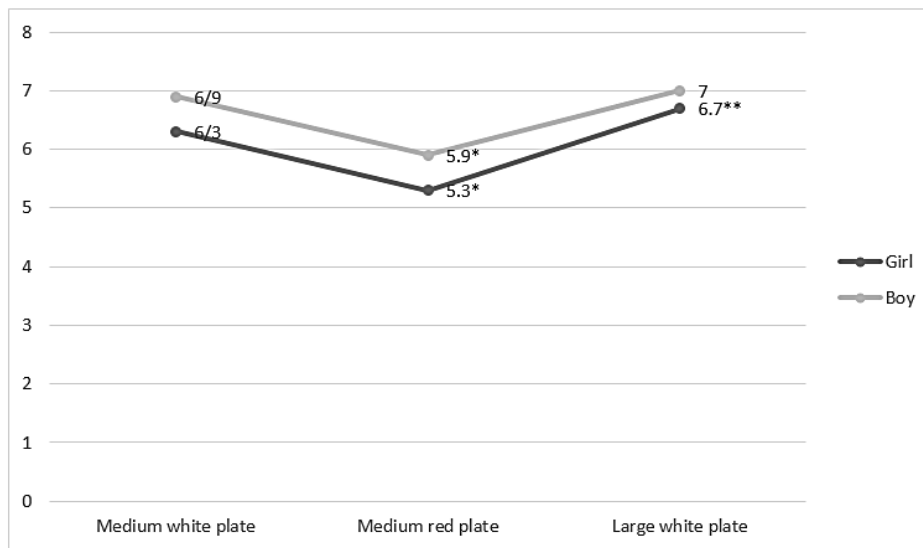


Fig. 1: Mean of VAS scores for different plates by sex

\* Significant difference with medium white plate and large white plate

\*\* Significant difference with medium white plate

To investigate the association of visualized features of food dishes and perceived satiety based on body weight, VAS for different plates were compared in different categories of BMI for age in order to paired t-test. As it showed in Table 2, the students who were on <5th percentile of

BMI for age, gave a similar score to the medium white plate and the medium red plate ( $P < 0.001$ ). Furthermore, score of large white plate was not different from the medium white plate in this BMI category ( $P < 0.001$ ).

Table 2: Visual analogue score for different plates by percentile of BMI for age

Variable	Visual analogue score (Mean ± SD)						
	Medium white plate	Medium red plate	P-value	Large white plate	Medium white plate	P-value	
BMI percentile for age	<5 <sup>th</sup>	3.5±2.5	2.9±2.8	0.1	3.5±2.5	4.4±2.3	0.1
	5 <sup>th</sup> -85 <sup>th</sup>	6.4±2.8	5.8±3	<0.001	6.4±2.8	6±2.5	0.06
	85 <sup>th</sup> -95 <sup>th</sup>	7±1.7	5.3±2.7	<0.001	7±1.7	7.9±1.5	<0.001
	>95 <sup>th</sup>	7.3±2.1	5.8±3	<0.001	7.3±2.1	8.4±1.6	<0.001

The score of medium white plate was significantly higher than medium red plate among those who were on 5th-85th, 85th-95th and >95th percentile of BMI for age ( $P<0.001$ ). Furthermore, the students who were on >85th percentile of BMI for age, gave higher score to large white plate than medium white plate, significantly ( $P<0.001$ ).

## Discussion

The current study showed that plate size and color influence the perceived satiety; such that serving food in larger white plates leads to delay in satiety feeling comparing with smaller and colored plates. Our findings, in agreement with Pollak, et al (8) showed that increase in plate size is associated with body weight. According that, the relatively larger gap (0.5 inch) between the edge of the plate size and the food in it, causes that the amount of food displays smaller than its actual amount. Therefore, the consumers may perceive the amounts of food lower than their usual requirement and compensate it by overeating.

Red dishes have been the topic of several researches focusing on role of this color on triggering avoidance motivation (13). It can be useful for diminish food intake specifically unhealthy ones. In the current study, we used two different color plates (white and red) to investigate the effect of contrast between plate and its content on perceived amounts of food intake. Our findings, in agreement with Genschow, et al (15) showed that the more contrast between food and plate color, the less perceived gap between plate's edge and food. Besides, serving food in the plates which has higher contrast with its content, displays the volume of food larger than its real bulk. Consequently, it leads to faster satiety signaling and lower food intake (16).

The effect of dish color is food type dependent to some extent. For example, Reutner, et al compared the effect of red plate on intake of dark chocolate and grapes. The results showed that consumption of grape did not decrease while

consumption of chocolate did (17). One explanation for the different impact was that grapes are perceived as healthier than dark chocolate. Although, we did not find the same results because we investigated the effect of different plates instead of different food items.

Increase in portion size over the last decade, is along with increase in containers size (18). The effect of these changes on eating behavior is considerable. Decisions on portion size depends on perception of food volume. Identifying perceptual factors is an important research question in the current rapid-changing food environment (19). Serving food in larger plates, lead to over consumption of food, regardless of the amount of appetite, satiation and food type. These kinds of behaviors usually occur without any compensating behavior for this excess energy intake. Therefore, it may be one of the reason for developing obesity worldwide (5).

Study of David et al showed a clear difference in volume of food intake in different plate sizes; so that larger plates were associated with about 24% more food intake than smaller plates (20). Manipulating food containers size may modify consumers perceive for judging about the amount of food volume in plate (4). The amount of food served on a smaller dish become overestimated and on the contrary, become underestimated when it is presented on a larger dish (19).

There are several possible mechanisms by which portion size affects food intake. The effects may be due to sensory influences (e.g., visual or olfactory cues), cognitive factors (e.g., learning and social norms), and post ingestion impacts (e.g., sensations of hunger and fullness).

Serving food in smaller plates with different contexts could be a logical strategy for limiting food and energy consumption which possibly averts obesity trend (21). However, there is not any consensus about this topic, yet. A Recent study on Western foods did not show the use of small plates as an effective strategy for reducing total energy intake (22). The effects of plate size investigated on intake of students who were in normal BMI range through VAS approach (23). Plate



size does not influence on energy intake in normal weight women. The participants consumed more vegetables and salads when the plate size is larger. Therefore, total calorie intake did not differ among different plates.

Although our findings are agreed with theirs to some extent, they are not comparable methodologically; we investigated perceived satiety through images instead of real observation. Furthermore, our participants were from different BMI categories, not just from normal BMI category. So, we cannot compare our findings with their results. According to our findings, there is an association between plate appearance and percentile 5-85, 85-95th and >95th of BMI for age, while this association did not find for students in percentile <5th. The effect of plate size and color on perceived satiety, is BMI-dependent.

On the other hand, although both sexes scored lower to medium red point than two other plates, mean score of small white plate was lower than the large one, only in girls. It may be for the reason of more attention to body weight in girls than boys, especially considering adherence to weight loss diet that was higher in girls than boys in the current study. Doing this sub-analysis, may partly explain some of the controversial results in previous studies. The effect of plate size depends on the study design (24). For example, using bowl or glass instead of plate, using snack instead of main meal, using laboratory condition instead of real setting, etc. (25).

Our study was inconsistent to Misa Shimpo that showed any significant effect of bowl size on the rice intake and fullness (26). Moreover, cultural variations can be of effective factors in perceived fullness because of diverse dining setting. For example, a study that has compared western respondents with those from the Asia concluded that individuals using the Asian dining approach are less susceptible to manipulations of plate sizes, in comparison to individuals who are accustomed to the Western dining approach (27).

In addition, when participants were unaware of being part of a food study, showed a stronger response to variations in plate size (21). Knowing Delboeuf illusion, may be useful for health-care

professionals, policy makers, dishware designers, dietitians and general population, especially those people with obesity. However, potential roles of appearance of dishware to decrease food intake have yet to receive widespread support.

Large sample size is one of the strengths of the current study. Considering adolescents, is the other strong point because of the important impact of adolescent' obesity on the rest of life cycle and of the lack of updated data on anthropometric measures in this age group in Iran. Conducting study on a homogenous sample in term of age and living area, is the other positive point of the current study.

Our study had some limitations, too. Although using plate images, instead of real plates, has been used in some of the other studies, this method may create a bias to perceive real size. If we had more budget to conduct this study in a real setting, we could have concluded more confidentially.

## **Conclusion**

Considering the high prevalence of obesity in Iranian youngsters and the association between food plate appearance and satiety feeling, especially in adolescents with overweight and obesity, more attention to this age group seems necessary to prevent occurrence of obesity and other chronic diseases in the adulthood. Manipulating the food containers may be one of the cost-effective strategies to achieve this goal. Conducting clinical trials in natural settings is suggested to investigate the exact effects of the plate appearance on perceived satiety and food intake.

## **Journalism Ethics considerations**

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

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## Conflict of interest

The authors declare that there is no conflict of interests.

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