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Reproducibility of an in-laboratory test meal to assess *ad libitum* energy intake in adolescents with obesity

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ABSTRACT

Aim: The aim of the present work was to test the reproducibility of a personalized in-laboratory *ad libitum* buffet meal in assessing energy and macronutrient intake in obese adolescents.
Methods: Twelve 13.5 ± 1.5 years old obese adolescent girls were asked to complete three identical experimental sessions during which an *ad libitum* buffet meal was presented at lunch time. The buffet was personalized based on food preference questionnaires, presented usually consumed food items and excluded preferred foods. Total energy intake and the energy ingested derived from each macronutrient were assessed by investigators using the Bilnuts nutritional software.
Results: Mean body mass was 87.0 ± 13.7 kg and mean BMI was 32.2 ± 4.9 kg/m^2. Mean FM percentage was 39.1 ± 4.4% and FFM was 50.6 ± 7.7 kg. There was no significant difference between total energy intake, the percentage of intake related to fat, protein or Carbohydrates (CHO) between the three sessions. The Intraclass Correlations (ICC) observed for total energy intake was 0.99. ICC for Protein, Fat and CHO were 0.38; 0.96 and 0.81 respectively. The Bland & Altman visual analysis revealed an important agreement between meals.
Conclusion: The proposed personalized in-laboratory *ad libitum* test meal produces is a reproducible methods to assess energy and macronutrients intake in obese adolescent girls.

1. Introduction

Investigating eating behaviors and food intake is of main importance in obesity research, however it remains particularly difficult to measure and methodologically debated (Schoeller et al., 2013). Employing a reproducible method to accurately assess energy intake is of particular importance, especially when it comes to energy balance studies that tend to identify the effect of acute stimuli on food intake. Indeed, many studies have been questioning the impact of several acute stimuli (exercise, sedentary behaviors, cognitive tasks, etc) on subsequent energy intake but this rests on the hypothesis that food consumption remains stable in absence of the stimulus, which remains uncertain in children and adolescents.

In healthy adults, *ad libitum* test meals have been shown to be a reproducible method to assess in-laboratory energy intake and macronutrient preferences, with food consumption remaining stable from one session to the other (Arvaniti, Richard, & Tremblay, 2000). Similarly, McNeil and collaborators lately showed the reproducibility of a multi-choice menu (62-food items) to measure in-laboratory energy and macronutrient intakes in healthy adults (McNeil, Riou, Razmjou, Cadieux, & Doucet, 2012). In a recent study, Chaput et al. also showed the reproducibility of an in-laboratory 74-item menu in healthy adolescents, independently of gender and body mass index (Chaput et al., 2016). Although such menus

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proposed a multitude of choices, it may sometimes be difficult for researchers to employ such extensive buffets and this might also lead to food wastage. Moreover, such menus do not consider participants' food preferences, which may induce some bias in the subsequently measured energy intake.

Many energy balance related researchers have been measuring the nutritional responses (total energy and macronutrient consumptions) to different physical (Bellissimo et al., 2008; Thivel, Metz, Julien, Morio, & Duche, 2014) or sedentary activities (Chaput et al., 2015; Thivel et al., 2013) with some of them proposing *ad libitum* buffets based on *a priori* food choices such as yogurts or pizzas (Bellissimo, Thomas, Pencharz, Goode, & Anderson, 2008). Although Bellissimo and collaborators showed the reproducibility of their pizza-based buffet in healthy adolescent boys (Bellissimo, Thomas, et al., 2008), the high palatability of such items may influence the participants' consumption, leading them to eat above satiety (Thivel, Duché, & Morio, 2012). When such a meal is used to investigate the nutritional response to an acute stimulus (such as exercise or sedentary behaviors), the subsequently assessed energy intake might be more affected by the degree of palatability of the proposed food than the real effects of the studied stimulus.

The aim of the present work was to test the reproducibility of a personalized in-laboratory *ad libitum* buffet meal in assessing energy and macronutrient intake in obese adolescents.

2. Material and methods

2.1. Participants

Twelve adolescent girls aged 12–16 years old (Tanner stages 3–5) with obesity (as defined by Cole, Bellizzi, Flegal, & Dietz, 2000 (Cole et al., 2000)) took part in this study. The adolescents were recruited through pediatric consultations (Clermont-Ferrand University Hospital and Romagnat Children Medical Center, France). To be included in the study, participants had to be free of any medication that could interact with the protocol and had to take part in less than 2 h of physical activity per week. All adolescents and their legal guardian received information sheets and signed consent forms as requested by the ethical authorities (Local Human Protection Committee, CPP Sud Est VI, agreement AU1178).

2.2. Study design and procedure

After the medical inclusion, anthropometric measurements were obtained and body composition was assessed. A digital scale was used to measure weight to the nearest 0.1 kg and height to the nearest 0.5 cm using a stadiometer. Body mass index was calculated as BM (kg) divided by height squared (m^2). Fat-Mass (FM) and Fat-Free Mass (FFM) were assessed using DXA (QDR4500A scanner, Hologic, Waltham, MA, USA).

Participants then took part in three identical experimental sessions in our laboratory separated by at least seven days. They were asked to maintain a similar balanced diet prior to the three sessions and to avoid any intensive physical activity for the prior 48 h (a member of the investigation team contacted the adolescents and their legal representative two days before each session to remind them to keep to this balanced diet and to avoid intensive exercise). The three experimental days were similar: the adolescents arrived between 08:00 a.m. and 08:30 a.m. in the laboratory in a fasting state and received a standardized breakfast of 500 kcal (as previously detailed (Thivel et al., 2014),). They were then asked to remain quiet in the laboratory until lunch time. In the mean time they were allowed to perform their homework or read but no electronic or video devices were allowed. They were required to remain seated quietly without any physical or cognitive (reading, watching TV, doing their homework) activity for the last hour of the morning, right before lunch that was proposed *ad libitum* at 12:00.

The content of the buffet meal was composed based on a food preference questionnaire filled in by the adolescents, assisted by the investigator, before the experimental sessions. This questionnaire documents the type of food the participant cannot eat because of allergies, cultural issues, or just because they do not like the food. The type of food preferred was also identified with the questionnaire. By identifying and then excluding preferred and not consumed items, under- and over-consumptions were avoided. The adolescents were then asked to rate food items from a list of about 75 usually served at lunch (from 1 to 5, (1 meaning "don't like" and 5 "like very much") (listed food items were adapted from previously published ones (Chaput et al., 2016; McNeil et al., 2012)). The adolescents were also asked to indicate if they were used to eating each remaining item, then rarely consumed items that were indicated as liked by the adolescents were not included in the buffet to avoid "occasional eating". Employing this food preference questionnaire, an *ad libitum* buffet meal was composed, including usually consumed foods but not preferred types of food. Two choices were available at each meal course. The Table 1 gives an example of a buffet meal for one of the participants.

The adolescents were asked to eat until satisfied, but were not informed that the aim of the study was to assess their food consumption. The adolescents received their meal and ate on separate tables. All the items were individually offered at the same time in large platters (plate-warmers were used to keep some items warm). No mixed food was presented to the adolescents. The content of the buffet was known before lunch by the investigators and each remaining items was weighted after lunch using a digital kitchen scale (Tristar Europe, Firminy, France) to assess the adolescent's intake. Total intake (in kcal) and intake relative to each macronutrient was assessed using the nutritional software Bilnuts (4.0 SCDA, Nutrisoft, Software, France).

2.3. Statistical analyses

Statistical analysis was performed using Stata software version 13 (StataCorp, College Station, US). Quantitative variables were expressed as mean and standard deviation (SD). The assumption of normality was checked by the Shapiro-Wilk test. To measure the concordance for total energy intake and the energy derived from each macronutrient (Fat, Carbohydrate and Protein) between the three methods, Pearson and Spearman correlation coefficients were estimated according to statistical distribution. This study of correlation was completed by estimation of Lin concordance coefficients and the Bland-Altman graphical representations. Finally, random-effect regression models were performed to complete these usual analyses taking into account within and between subject variability (random-effects). Following these models, the intra-class correlation coefficients (ICC) were expressed to evaluate the reproducibility of methods (Bonett, 2002; Kottner et al., 2011). Concordance was considered satisfactory according to usual rules and recommendations. A value greater than 0.9 indicated a high concordance (Barnhart, Song, & Haber, 2005; Lin, Hedayat, Sinha, &

Table 1
Buffet meal example.

Food items	
Ham and Turkey	Cheese and yogurts
Salads and crudities	Fruits and compotes
Mashed potatoes and beans	Bread
Mincemeat and chicken	