



# Photo-Assisted Dietary Method Improves Estimates of Dietary Intake Among People with Sleeve Gastrectomy

Ebaa Al-Ozairi<sup>1,2</sup> · Manar M. AlAwadhi<sup>3</sup> · Jumana Al Kandari<sup>1,4</sup> · Etab Taghadom<sup>1,4</sup> · Mohammad Abdullah<sup>5</sup> · Carel W. Le Roux<sup>6</sup>

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## Abstract

**Introduction** Bariatric operations are effective obesity treatments because of the significant reductions in food intake after surgery, but weight regain remains a problem in a small group of patients after surgery. Estimating food intake is difficult due to dieting status, weight, gender, and challenges with estimating portion size. We aimed to evaluate the use of digital food photography in comparison to conventional methods among patients after sleeve gastrectomy.

**Methods** Participants used a mobile device (mHealth) to photo-document their dietary intake of all food and beverages consumed before and after eating. They also completed a 24 h food recall interview with a dietician.

**Results** Data from 383 eating occasions were analyzed. Food intake using 24 h recall was reported as  $972.5 \pm 77$  kcal and estimates from photographs were  $802.9 \pm 63.4$  kcal, with a difference of  $169.6 \pm 451.4$  kcal (95% confidence interval (CI) of 41.4 to 297.9 kcal,  $p = 0.005$ ). There was no difference for protein intake, but carbohydrate intake reported during the 24 h recall was  $541.2 \pm 298$  kcal and estimates from photographs were  $395.2 \pm 219.6$  kcal, with a difference of  $145.8 \pm 256.3$  kcal (95% CI of 73.2 to 218.8 kcal,  $p = 0.0001$ ).

**Conclusion** After sleeve gastrectomy, patients reported eating more total calories and calories from carbohydrates compared to estimations using photographs. The implication for patients are that tools such as mHealth might be useful to optimize food intake and calories after sleeve gastrectomy, especially for those patients that may struggle with weight regain after surgery.

**Keywords** Obesity surgery · Food photography · mHealth · Nutrition

## Introduction

The rate of obesity has nearly tripled since 1975 [1] and is projected to increase further by 2030 [2]. Bariatric surgeries are

effective treatment options for morbid obesity because the operation significantly reduces food intake, although weight regain remains a problem in a small number of patients [3, 4]. People are notoriously imprecise in estimating the energy content of foods [5–7]. This inaccuracy seems to be due to the difficulty in estimating portion size [8, 9]. There are several factors associated with inaccurately estimating food intake, such as dieting status, weight, and gender [5, 6]. Under reporting food intake is more common among women and individuals who are overweight or obese [5]. Calories tend to be underestimated for foods considered as healthy or used for weight loss, while calories are overestimated for foods considered unhealthy or associated with weight gain. People on a diet are more accurate at estimating calories of healthy foods and are more attentive to calories from fat and sugar compared to people not on a diet [6]. Furthermore, when individuals know they are being observed in a study they often alter their behavior [10].

Photo-assisted diet capture method is a technique used in which digital images are taken of all food and beverages

✉ Ebaa Al-Ozairi  
ebaa.alozairi@dasmaninstitute.org

<sup>1</sup> Dasman Diabetes Institute, Faculty of Medicine, Kuwait University, P. O. Box 24923, 13110 Kuwait City, Kuwait

<sup>2</sup> Faculty of Medicine, Department of Medicine, Kuwait University, Jabriya, Kuwait

<sup>3</sup> Faculty of Public Health, Department of Public Health Practice, Kuwait University, Jabriya, Kuwait

<sup>4</sup> Ministry of Health Kuwait, Kuwait City, Kuwait

<sup>5</sup> Royal College of Surgeon, Dublin, Ireland

<sup>6</sup> Diabetes Complications Research Centre, University College Dublin, Dublin, Ireland

consumed during the record period, and it has been validated in the general population [11–13]. The Remote Food Photography Method (RFPM) is a type of photo-assisted dietary capture that uses camera-enabled cell phones. RFPM is good for populations with low literacy who prefer photography-based applications [14], and who have difficulties estimating portions, size such as children [15]. Mobile devices have been associated with higher data quality compared to other recording methods such as paper records [16]. Mobile devices continue to increase in popularity and capability [17], and taking photos of food is not stigmatized [16].

RFPM accurately measures energy intake of individuals, and the errors associated with this method are small compared with self-reports [12]. In a validation study, comparing a handheld personal digital assistant with a 1-day weighed diet record found that digital photographs can measure individual dietary intakes for a variety of nutrients. The correlation coefficients between the nutrient intakes estimated from the two instruments ranged from 0.55 for vitamin B1 and water insoluble dietary fiber to 0.92 for vitamin B12 (median  $r = 0.78$ ) [13]. Lieffers et al. found that user satisfaction of photo-assisted dietary methods on mobile applications were generally good; however, they have difficulty capturing added fats and seasonings, and poor photographic technique and lighting was a problem encountered by the users [17].

Comparing photo-assisted dietary assessment with 24 h recall in adolescents with intellectual and developmental disabilities (IDD) showed that photo-assisted records captured significantly higher estimates of energy intake per eating occasion than regular proxy-assisted records, which is when a family member or a support person assists the participant in completing a diet record, as well as greater grams of fat, carbohydrates, and protein [18].

We aimed to measure the difference between self-reported energy and macronutrient intake and actual intake of individuals who have undergone bariatric surgery using photo-assisted diet capture methods. We investigated the feasibility of using mHealth with photographs to capture participants' meals pre- and post-consumption. We then compared the information from patients after sleeve gastrectomy to conventional dietary methods such as the 24 h recall.

## Methods

Subjects were eligible if they were aged 21 years and older, were residents in Kuwait, owned a smart mobile device, and had undergone sleeve gastrectomy. The study conformed to the ethical principles of the declaration of Helsinki (sixth amendment) and was approved by the Institutional Review Board at Ministry of Health Ethical Review Board. All participants provided written informed consent.

Fifty participants who had undergone sleeve gastrectomy more than 1 year previous were selected randomly. Each participant was asked to photograph all foods and beverages before consumption of the meal and food remaining at the end of the meal using reference objects. All photographs were taken by a smart mobile device, with built-in camera with a minimum resolution of 0.90 megapixel. Each participant was asked to send his or her data on two occasions. The food images were obtained directly from mobile networks. A reminder text message was sent to the participant on their mobile device.

Unannounced 24 h food recalls were conducted on participants by a qualified dietician detailing all the food and beverages they had consumed in the previous 24 h. The same dietician administered the recalls to all participants. The interviewer followed the Automated Multiple Pass Method (AMPM) procedures developed by the United States Department of Agriculture (USDA) [19] to solicit detailed information about everything the participants ate and drank in the past 24 h from the time of the interview. The interviewer started by asking the participants to quickly list the foods they consumed in the previous day without respect to time sequence. Then, the interviewer probed about forgotten foods from the nine commonly forgotten categories of food, in addition to time and occasion of consumption of each food and drink. More open-ended questions were asked about specific details of the foods, amounts consumed, and foods consumed between identified eating events such as snacks. Furthermore, the interviewer collected detailed information during the interview on food preparation methods, recipes, ingredients, and brand name identification of commercial products. When the participants did not provide adequate information, the interviewer probed further for necessary level of detail using open-ended questions. To facilitate memory, the interviewer collected a brief history of previous day's activities before asking questions about food intake, this helps set the stage for specific questions about foods eaten in specific settings [19]. All data were analyzed for calorie estimation and macronutrient composition by a dietician, who was blinded to the images at the time of analysis. The USDA database was used to analyze calorie, macronutrient, and micronutrient composition [20].

We analyzed the differences in total energy intake (total kcals), protein, carbohydrate, sugar, fiber, total fat, saturated fat, monounsaturated fat, polyunsaturated fat, cholesterol, and sodium by comparing the 24 h recall and photographs of meals pre- and post-consumption for each participant. The evaluation of food ingested from the 24 h recall and the photographs were from the same day. A paired *t* test was used to examine the differences in total calories and macronutrient intake variables between the 24 h recall and the photographs. Analyses were conducted with the STATA software (version 14.1 STATA Corp, College Station, TX, USA).

**Table 1** Demographic characteristics (mean and standard deviation) of study participants

Variables	<i>n</i>	Mean (SD)
Males	16%	na
Age (years)	50	38.8 ± 9.1
Current BMI (kg/m <sup>2</sup> )	50	29.2 ± 6.2
Years post surgery (years)	50	5.7 ± 1.2
BMI units lost since surgery (kg/m <sup>2</sup> )	46	15.4 ± 5.6
Smokers	16%	na

na, not applicable; SD, standard deviation

## Results

Analyses were completed on 50 observations, using 383 photographs, to determine whether there was a statistically significant difference between the estimated total energy intake from the 24 h recall and the actual total energy intake from the photographs pre- and post-consumption. Of the participants, 43 were female and 8 were male. The mean age of the participants was 38.8 ± 9.1 years, the mean body mass index (BMI) at data collection in 2017 was 29.1 ± 6.2 kg/m<sup>2</sup>, the mean years post surgery was 5.7 ± 1.2 years, the mean number of BMI units lost since surgery was 15.4 ± 5.6 kg/m<sup>2</sup>, and out of the 50 participants 8 were smokers (Table 1).

Total calories from the 24 h recall were 972.5 ± 544.4 kcal and from the digital photographs were 802.9 ± 448.0 kcal; and total calories from carbohydrate intake reported from the 24 h recall was 541.2 ± 298 kcal and estimates from photographs were 395.2 ± 219.6 kcal. We found a similar pattern of higher values reported after 24 h recall compared to photographs, for total fat, saturated fat, monounsaturated fat, polyunsaturated fat, sugar, fiber, and sodium (Table 2). The mean difference between the two methods in total calories was 169.7 kcal and a

standard deviation of 451.3 kcal (95% confidence interval (CI) of 41.4 to 297.9 kcal;  $p = 0.005$ ); and 145.8 kcal from carbohydrates and a standard deviation of 256.4 kcal (95% CI of 73.2 to 218.8 kcal) (Table 3). We did not find any statistically significant differences between the two dietary assessment methods for any other macronutrients that were analyzed.

## Discussion

We examined the diet intake of patients after sleeve gastrectomy. When we compared the participants' dietary intake from their 24 h recall with the photographs of their meal pre- and post-consumption, we found that people with sleeve gastrectomy overestimated their total calorie intake and carbohydrate intake. Our results are consistent with the literature showing individuals cannot accurately estimate energy intakes [21–24]. Energy intake reports in people with obesity or who are overweight underestimate and underreport energy intake compared with diet records of actual intakes [7, 22, 24–31]. Participants with intellectual and developmental disabilities who have not had surgery also underestimated their energy intake when comparing photo-assisted method and proxy-assisted food records [18].

Most studies find that participants underreport their actual intake, especially among individuals who are obese or overweight [22–29]. The largest source of error in estimating energy intake is from participants' poor estimation of portion size [21]. Estimating portion size remains a challenge [32]. Extensive training may help a more accurate estimation of portion size, but there still remains a large degree of variability in portion size estimates [9]. Therefore, methods should not rely on participants' portion size estimates [12]. We found that

**Table 2** Nutrient means and standard deviations from 24 h recall and photos

Nutrients <i>N</i> = 50	24 h recall mean (SD) in grams	Mean (SD) in grams	24 h recall Mean (SD) in kcal	Mean (SD) in kcal
Total calories	na	na	972.5 (544.4)	802.9 (448.0)
Protein	32.1 (20.9)	33.6 (23.4)	128.4 (83.6)	134.4 (93.6)
Carbohydrate	135.3 (74.5)	98.8 (54.9)	541.2 (298)	395.2 (219.6)
Total fat	34.3 (22.9)	29.9 (18.7)	308.7 (206.1)	269.1 (168.3)
Saturated fat	8.9 (8.1)	8.5 (6.2)	80.1 (72.9)	76.5 (55.8)
Monounsaturated fat	5.9 (4.6)	5.4 (4.7)	53.1 (41.4)	48.6 (42.3)
Polyunsaturated fat	3.6 (4.3)	2.6 (2.9)	32.4 (38.7)	23.4 (26.1)
Cholesterol	66.8 (123.0)	69.6 (101.4)	na	na
Sugar	28.1 (30.8)	23.2 (20.4)	na	na
Fiber (g)	8.5 (6.8)	7.1 (6.2)	na	na
Sodium (mg)	1119.8 (944.6)	891.9 (650.6)	na	na

na: not applicable; SD, standard deviation

**Table 3** Difference in total calories and calories from carbohydrate consumption and standard deviation of 24 h recall and photos

Nutrient	N	Mean difference	SD	95% confidence interval	p value
Total calories (kcal)	50	169.6	451.4	41.4 to 297.9	<i>p</i> = 0.005
Carbohydrate (kcal)	50	145.8	256.3	73.2 to 218.7	<i>p</i> = 0.0001

SD, standard deviation

patients after sleeve gastrectomy overestimate their intake. For example, the participants reported consuming  $\frac{1}{2}$  a package of a certain food when the photographs showed they only consumed  $\frac{1}{4}$  of the packaged food, hence the differences in calories between the 24 h recall and the photographs. This is not consistent with literature for patients who have not had an operation but who are obese. To our knowledge, there are no studies that looked at the accuracy of estimating energy intake reported from patients after sleeve gastrectomy; however, the literature does show that food preferences and behavior changes occur after sleeve gastrectomy. For example, individuals become less hungry and feel satiety earlier, and may prefer specific foods [33, 34].

Furthermore, weight loss only relying on energy restriction often promotes activation of reward areas to food stimuli in the brain [35, 36]. Ochner et al. found that after gastric bypass patients had substantial changes in neural responses to food cues in the environment, which resulted in postsurgical reductions in appetitive behavior [37, 38]. Sleeve gastrectomy patients in our study may have overestimated their intake and assumed they are consuming higher energy than their actual intake due to appetite behavior changes and feeling satiety earlier. When comparing brain responses to visual food cues in surgical vs. non-surgical groups, it was found that with similar weight loss, individuals in the non-surgical group had greater activation in the medial prefrontal cortex and perceived food cues as more rewarding compared to the surgical group [39]. This plays an importation role in food choice and may have an effect on estimating energy intake.

This novel study measured food intake after sleeve gastrectomy by 24 h diet recall and actual intake using a photo-assisted method. Digital photography appears reliable and accurate in adults in measuring energy intake in a cafeteria setting [40, 41], in addition, they can be effective for dietary assessment compared to conventional methods, such as paper records [17]. The correlation between digital photography and weighed portion sizes is very high, and mean differences between weighed foods and digital photography is very low [41]. This method is thus a strength in our study, as it measures consumption more accurately compared to other reported diet intake methods. However, our study had limitations. First, our sample size was small and both the 24 h recall and the photographs were self-reported by the participants.

## Conclusion

Individuals have difficulty estimating food intake and portion size accurately. Patients after sleeve gastrectomy overestimate their total energy intake and calorie intake from carbohydrates by inaccurately estimating their portion size when comparing 24 h diet recalls to photographs taken of meals pre- and post-consumption. This has important implications especially when food intake is considered to determine the type of interventions for those patients with weight regain after sleeve gastrectomy.

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## Compliance with Ethical Standards

**Conflict of Interest** Professor Carel Le Roux received grants from Johnson and Johnson and AnaBio. Also speaker fees from Eli Lilly, Johnson and Johnson, Sanofi Aventis, Astra Zeneca, Janssen, Bristol-Meyers Squibb, p Boehringer-Ingelheim, outside the submitted work. He is on the advisory board of NovoNordisk and GI dynamics. Professor le Roux has nothing to disclose related to this manuscript. All the other authors declare no conflict of interest

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