Validation Study of a Passive Image-Assisted Dietary Assessment With Automated Image Analysis Process

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11.0   (925) Study/Project Synopsis

11.1   * Click on the bar below and provide a synopsis of the research study addressing the following FOUR items <u>USING these numbered subheadings</u>. *Please be sure to provide enough detail that the IRB understands clearly what you propose to do, with whom, and why.*

1. **Purpose/Objectives of the Study**
2. **Study Population (including any inclusion/exclusion criteria)**
3. **Study Procedures, and**
4. **Planned Analyses**

1. PROJECT OBJECTIVES
Background and Specific Aims
Dietary assessment is used to determine the nutrient intake of individuals and groups.[1] Accurate dietary assessment is essential to nutrition research to understand how diet impacts health.[2] Currently, there is no gold standard or single method of dietary assessment that is applicable for all nutrition research questions, as the purpose, population of interest, and resources available in any investigation impact the method of assessment that can be implemented.[1] The current dietary assessment methods have limitations that can affect accuracy of dietary data. Currently, subjective dietary assessment methods are widely used in research. However, these subjective methods are prone to errors due to issues of accuracy of capturing all foods and beverages consumed as a consequence of recall errors and determining portion sizes of foods and beverages consumed due to poor estimation or inaccurate measurements.[3,4] Self-reported dietary data also appears to have a systematic bias, in which populations with obesity are more likely to underreport intake.[5-12] Subjective methods are also labor-intensive in regards to data collection and/or analysis.[1,13] Objective dietary assessment can limit human errors and provide objective dietary information. However, few objective methods are available in free-living situations, and objective methods can be costly and difficult to use in studies with large samples.[1,13,14] The incorporation of technology into dietary assessment, such as image-assisted dietary assessment, has been investigated by researchers to improve accuracy in collecting dietary information in free-living situations.[15] The active dietary assessment methods, which is self-administered and requires individuals to manually capture images or videos with digital cameras, smartphones, and other devices with picture-capturing function,[15] had improved accuracy and provided comparable accuracy of dietary information when compared with objective dietary

assessment methods.[16,17] However, the active dietary assessment methods still rely on humans to manually capture images, which does not eliminate human errors. Passive dietary assessment methods, which images or videos automatically capture dietary intake through the use of wearable devices or other tools, can reduce human errors as the process of collecting dietary information by reducing the effort and training needed to obtain imagery.[15] The results of reviewed passive dietary assessment methods showed improved accuracy in assessing dietary information.[18-21] However, all the image-assisted dietary assessment methodologies at this time involve manual image analysis processes, which increases cost. Thus, there is a need for a wearable device that has the function of passive image capturing, with complete automated image analysis software to provide accurate and inexpensive dietary information.

Therefore, the purpose of this investigation is to validate a passive image-assisted dietary assessment method using images taken by Sony Smarteyeglass and an automatic image analysis software, DietCam, to identify food items and estimate portion sizes. The specific aims of this investigation are: 1) to determine the accuracy of DietCam in identifying foods in different shapes (Regular vs Irregular) and complexities (Single food vs Mixed food); and 2) to determine the accuracy of DietCam to estimate food volumes comparing with weighed food intake measured from plate waste method.

2. STUDY POPULATION
Study Design
To validate the accuracy of DietCam in analyzing food images taken by Sony Smarteyeglass in food recognition and volume estimation, a 2x2x2x2x3 mixed factorial design will be used, with a between-subject factor of the order of meals (Order 1 and 2) and within-subject factors of food shapes (Regular and Irregular), food complexities (Single food and Mixed food), meals (Meal A and B), and methods of measurement (DietCam, weighed food intake [WFI], and 24-hour dietary recall) (see Table 1). Individuals will be randomized into one of the two orders of meals. In each meal, participants will be given a meal that includes a regular-shaped single food (i.e., cookie), an irregular-shape single food (i.e., ice cream), a regular-shaped mixed food (i.e., sandwich), and irregular-shaped mixed food (i.e., pasta dish). Dependent variables will be the identification of foods and amount of foods consumed.

Table 1. Description of Study Design

Order	Meal Session 1	Meal Session 2
1 (n=15)	Meal A: **Turkey & Provolone Cheese Sandwich** (*Regular-shaped mixed food*) **Chicken and Wild Rice** (*Irregular-shaped mixed food*) **Chocolate Chips Cookie** (*Regular-shaped single food*) **Potato Chips Original** (*Irregular-shaped single food*)	Meal B: **Ham and Cheddar Cheese Wrap** (*Regular-shaped mixed food*) **Pasta with Broccoli in Alfredo Sauce** (*Irregular-shaped mixed food*) **Red Seedless Grapes** (*Regular-shaped single food*) **Chocolate Ice-cream** (*Irregular-shaped single food*)
2 (n=15)	Meal B: **Ham and Cheddar Cheese Wrap** (*Regular-shaped mixed food*) **Pasta with Broccoli in Alfredo Sauce** (*Irregular-shaped mixed food*) **Red Seedless Grapes** (*Regular-shaped single food*) **Chocolate Ice-cream** (*Irregular-shaped single food*)	Meal A: **Turkey & Provolone Cheese Sandwich** (*Regular-shaped mixed food*) **Chicken and Wild Rice** (*Irregular-shaped mixed food*) **Chocolate Chips Cookie** (*Regular-shaped single food*) **Potato Chips Original** (*Irregular-shaped single food*)

Participants
Thirty men and women will be invited to participate in the validation study. Eligibility of this investigation will be based upon the following criteria: 1) between the ages of 18 and 65 years; 2) body mass index (BMI) 18.5 to 24.9 kg/m^2; 3) no food allergies/intolerance to foods used in the investigation; 4) report not having a dietary plan or dietary restrictions that prevents consumption of the foods used in the investigation; 5) report a favorable preference for the foods served in the meal (listed in Table 2), with participants rate each food item $\geq$ 3 on a Likert

scale during the phone screen; 6) able to complete all two meal sessions within four weeks of the screening session; 7) are not legally blind without corrected lenses; and 8) are able to eat a meal while wearing the Sony Smarteyeglass. Participants will be excluded if they wear electronic medical devices such as pacemakers and implantable defibrillators.

Recruitment

Participants will be recruited from the University of Tennessee, Knoxville campus by posting flyers around campus and handing out flyers around campus and sending emails through University electronic mailing lists. Participants will be asked to contact the Healthy Eating and Activity Laboratory (HEAL) by phone and will be given information about a study that investigates dietary assessment via digital images. Interested participants will be screened over the phone and scheduled for a face-to-face screening session. Participants who sign the consent form at the screening session and meet eligibility criteria will be randomized to one of two orders.

3. STUDY PROCEDURES

Procedures

All participants will be asked to come to HEAL for 1, 30-minute screening session, and then for 2, 40-minute meal sessions, with approximately one week occurring between each session. Sessions will be scheduled between 11:00am and 5:00pm, Monday to Friday. During the screening session, interested participants will sign the consent form. After signing the consent from, eligibility will be confirmed by taking height and weight measures. Participants will also be given questionnaires related to demographics. Prior to the start of the first meal session, eligible participants will be randomized to one of the two orders described in Table 1, using a random numbers table. Participants will be instructed for the meal sessions to stop eating a minimum of two hours prior to the scheduled meal sessions and only consume water during that period. During both meal sessions, instructions on how to use Sony Smarteyeglass will be provided to participants. These instructions will include how to wear and use the eyeglasses. Participants will be instructed that, after putting on the Smarteyeglass, to initiate the recording via the controller of the Sony Smarteyeglass. After the recording is initiated and prior to starting to eat, participants will be instructed to look at each provided food at the table. Then, participants will also be instructed to turn their head toward the left shoulder, look at each food from the side, and then repeat the same step for turning their head toward the right shoulder. Participants will be asked to start the meal by taking one bite of each provided food. For the first bite of each food, participants will be instructed to hold the food, either in their hand or on a fork or spoon (depending on the food), approximately 12 inches in front of the eyeglasses and to look at the food. Following taking the first bite of each provided food, participants will be instructed to eat normally until satisfied. Participants will be given 30 minutes to eat. The investigator will leave the room while the participant is eating. The investigator will check in with participants every 10 minutes. At the end of 30 minutes, participants will be instructed to again look at each provided food on the table at three different angles (looking straight at each food, from left side and the right side) following the exact same procedure at the beginning of the meal. The second meal session will follow the same procedure as the first session.

On the day following each meal session, participants will be called to complete a 24-hour dietary recall, which will take 20 minutes to complete. Instructions will be provided to participants at the end of each meal session about how to complete the dietary recall and a two-dimensional visual aid will be provided to aid participants in estimating the consumed portions for each food and beverage item consumed.

At the end of second meal session, participants will be asked to complete a questionnaire to provide feedback on their use of the Sony Smarteyeglass. After the second session is completed, the participants will be thanked for their participation and given a $20 gift card to compensate for their time in the study.

For the first and second meal session, the meals will contain foods that are categorized into two food shapes (Regular and Irregular) and two food complexities (Single food and Mixed food). Each meal will contain four foods (see Table 2 for detailed description of foods), with the four foods representing the four potential food categories (regular-shaped single food, irregular-shaped single food, regular-shaped mixed food, irregular-shaped mixed food). Along with the four foods, participants will be given 20oz of water in each meal session. Foods will be weighed prior to being provided to participants and the amount provided to participants will be within +/- 3g of the amount described in Table 3. Mixed foods will be broken down into their individual food components and measured. Each meal will provide approximately 50% of daily estimated energy need for each sex. The Estimated Calories Needed Per Day for males and females aged 19 to 35 years are 2450 kcal/day and 1900 kcal/day, respectively.[22] Thus, each meal will provide approximately 1225 kcal for males and 950 kcal for females. Each food will provide approximately 25% of the energy for each meal.

Table 2. Detailed Description of Provided Foods

Food	Brand	Serving	Calories per Serving	Calories per Gram
Cookie	Nabisco Chips Ahoy! Original	33g	160	4.85

Grapes	Red Seedless Grapes	161g	104	0.65
Potato chips	Food Club Classic Potato Chips	28g	160	5.71
Ice-cream	Blue Bell Dutch Chocolate	72g	160	2.22
Chicken	Tysonâ Fully Cooked Chicken Breast Fillets	98g	110	1.12
Wild Rice	Minute Ready-to-serve Brown & Wild Rice	125g	230	1.84
Sandwich Bread	Nature's Ownâ 100% whole wheat bread	26g	60	2.30
Turkey Deli	Oscar Mayer Delifresh Smoked Turkey Breast	56g	50	0.89
Provolone Cheese	Food Club Not Smoked Provolone Cheese	23g	80	3.48
Tomato	Fresh Tomato Medium	50g	8	0.16
Lettuce	Fresh Lettuce	75g	6	0.08
Tortilla	OLE Mexican Foods High Fiber Low Carbs Tortilla	45g	50	1.11
Ham Deli	Oscar Mayer Delifresh Smoked Ham	56g	50	0.89
Cheddar Cheese	Food Club Mild Cheddar Cheese (Thin Sliced)	32g	130	4.06
Spring Mix	Fresh Spring Mix	142g	35	0.25
Dressing	Food Club Fat Free Ranch Dressing	29g	25	0.85
Pasta	Barilla Ready Pasta Fully Cooked Penne	121g	210	1.74
Broccoli	Food Club Broccoli Spears	89g	30	0.34
Alfredo Sauce	Ragu Classic Alfredo	61g	90	1.48

Table 3. Detailed description of meal sessions

Meals	Food		Female Amount Served	Female Calories Served	Male Amount Served	Male Calories Served
A	Turkey & Provolone Cheese Sandwich	Whole Wheat Bread	52g	120	52g	120
		Turkey	70g	62	133g	118
		Provolone Cheese	23g	80	23g	80
		Tomato	50g	8	50g	8
		Lettuce	45g	4	45g	4
		Total:	240g	274	303g	330
	Chicken and Wild Rice	Chicken	98g	110	98g	110
		Wild Rice	71g	131	107g	197
		Total:	169g	241	205g	307
	Chocolate Chips Cookies		44g	213	60.5g	293
	Potato chips Original		39g	223	52g	297
Total Meal A Calories			**951**		**1227**	
B	Ham and Cheddar Cheese Wrap	Tortilla	45g	50	45g	50
		Ham Deli	76g	68	103	92
		Cheddar Cheese	21g	85	32g	130
		Spring Mix	36g	9	36	9
		FF Ranch Dressing	29g	25	29g	25
		Total:	207g	237	247g	306
	Pasta with Broccoli and Alfredo Sauce	Pasta	91g	158	121g	210
		Broccoli	66g	22	66g	22
		Alfredo Sauce	38g	56	50g	74
		Total:	195g	236	237g	306
	Chocolate Ice-cream		107g	238	138g	306
	Red Seedless Grapes		365g	237	471g	306
Total Meal B Calories			**948**		**1224**	

Measures
All measures will be collected at HEAL by trained research assistants.

Anthropometrics: Weight, height, and BMI- During the initial phone screen height and weight will be asked by the phone screener and BMI calculated from those values. During the initial screening session, weight will be assessed by an electronic scale, and height will be assessed using a stadiometer, using standard procedures, with participants wearing light clothing, without shoes.[23] BMI (kg/m^2) will be calculated from these measures. A BMI between 18.5 and 24.9 is required to be eligible for this study.

Demographics- At the initial screening session, basic demographic information (e.g., gender, age, education level) will be obtained.

Sony Smarteyeglass – Digital images will be recorded during each meal session using Sony Smarteyeglass. Number of blurred images and times that Sony Smarteyeglass fail to capturing images will be documented.

Weighed Food Intake- Before and after each meal session, each food items will be weighed to the nearest tenth of a gram using an electronic food scale. The weight of the containers will also be measured. The total grams of each food items will be recorded and total food consumed will be calculated by subtracting plate waste weight from the pre-meal weight. Results of total grams of each food items and total food consumed will be entered into Nutrition Data System for Research (NDS-R) dietary software developed by the Nutrition Coordinating Center, University of Minnesota, Minneapolis, Minnesota.

DietCam- DietCam is developed by Dr. JinDong Tan and colleagues[24] and is an application designed to automatically recognize foods and estimate volumes of a meal from images or videos. DietCam has an algorithm called multi-view food classification that recognizes foods and beverages in images or videos and estimates volumes without any reference objects.[24] DietCam has the average accuracy rate of 84% in recognizing regular shape food items.[24] DietCam will be used to analysis digitial images taken by the Sony Smarteyeglass in the study to identify food items and estimate volumes of food intake. In this investigation, DietCam will be used to identify food items with different shapes (Regular vs Irregular) and complexities (Single food vs Mixed food). DietCam will also be used to estimate volume of foods in the unit of cubic meters (m^3). Results of volume estimation of foods from DietCam will be entered to NDS-R to convert to commonly used measurements.

24-hour Dietary Recall- On the following day of each meal session, the investigator will ask the participant to recall their dietary intake by having the participant reporting all foods and beverages consumed and the time in which they consumed these items within the past 24 hours. Participants will be asked what time of day the foods and beverages were consumed and will be shown two-dimensional food shapes to help with estimating portion sizes. Only dietary intake for the meal session will be entered into NDS-R to convert to commonly used measurements.

Participants' Feedback- At the end of last meal session, participants will be asked to complete a questionnaire regarding their experience on using Sony Smarteyeglass. A total of six structured questions will be included in the questionnaire and each question will be associated with an open-ended question. Structured questions will consist of a five-scale rating regarding ease of use, clearness of instructions, satisfaction, likelihood, and comfortableness. Percentages of participants answering in responses to each structured question will be tabulated and open-ended questions will be summarized.