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

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To the Graduate Council:

I am submitting herewith a thesis written by Tsz-Kiu Chui entitled "Validation Study of a Passive Image-Assisted Dietary Assessment Method with Automated Image Analysis Process." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Nutrition.

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

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ABSTRACT

Background: Image-assisted dietary assessment is being developed to enhance accuracy of dietary assessment. This study validated a passive image-assisted dietary assessment method, with an emphasis on examining if food shape and complexity influenced results.

Methods: A 2x2x2x2x3 mixed factorial design was used, with a between-subject factor of meal orders, and within-subject factors of food shapes, food complexities, meals, and methods of measurement, to validate the passive image-assisted dietary assessment method. Thirty men and women (22.7 ± 1.6 kg/m^2, 25.1 ± 6.6 years, 46.7% White) wore the Sony Smarteyeglass that automatically took images while two meals containing four foods representing four food categories were consumed. Images from the first 5 minutes of each meal were coded and then compared to DietCam for food identification. The comparison produced four outcomes: DietCam identifying food correctly in image (True Positive), DietCam incorrectly identifying food in image (False Positive), DietCam not identifying food in image (False Negative), or DietCam correctly identifying that the food is not in the image (True Negative). Participants' feedback about the Sony Smarteyeglass was obtained by a survey.

Results: A total of 36,412 images were coded by raters and analyzed by DietCam, with raters coding that 92.4% of images contained foods and DietCam coding that 76.3% of images contained foods. Mixed factorial analysis of covariance revealed a significant main effect of percent agreement between DietCam and rater's coded images [(F (3,48) = 8.5, p < 0.0001]. The overall mean of True Positive was 22.2 ± 3.6 %, False Positive was 1.2 ± 0.4%, False Negative was 19.6 ± 5.0%, and True Negative was 56.8 ± 7.2%. True Negative was significantly (p < 0.0001) different from all other percent agreement categories. No main effects of food shape or complexity were found. Participants reported that they were not willing to wear the Sony Smarteyeglass under different types of dining experiences.

Conclusion: DietCam is most accurate in identifying images that do not contain food. The platform from which the images are collected needs to be modified to enhance consumer acceptance.

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CHAPTER I: LITERATURE REVIEW

DIETARY ASSESSMENT

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]

SUBJECTIVE DIETARY ASSESSMENT

Subjective dietary assessment is obtained through self-report methods. These methods of dietary assessment are widely used in free-living situations. Three common self-report dietary assessment methods include 24-hour dietary recall, food record, and food frequency questionnaires (FFQ).[3]

The 24-hour dietary recall, with at least three days (two non-consecutive weekdays and one weekend day), is considered close to the gold standard.[4] A 24-hour dietary recall is a dietary assessment tool in which an individual reports on all foods and beverages consumed (including portion sizes) in a previous 24-hour period during a recall interview conducted in person, by phone, or by using a computer interface.[1,5,6] In-person and phone methods require a trained interviewer with knowledge of foods available in the community, as well as commonly used cultural dietary practices to obtain dietary information.[1,5] The interview contains structured questions to aid the individual to remember all the foods and portion consumed in the past 24 hours.[5] The 24-hour dietary recall not only provides detailed dietary information on foods and beverages consumed on a specific day and the total amount of each food and beverage consumed, it also provides contextual information, such as meal and snack patterns, food preparation, and timing and location of meals.[7]

The Automated Multiple Pass Method (AMPM) is designed by the United States Department of Agriculture (USDA) to enhance the accuracy of 24-hour dietary recall and reduce respondent burden.[8] The AMPM is a five-step computerized method to collect dietary data by interviewer.[8] The five-step approach includes the following steps: 1) collecting a list of foods and beverages consumed; 2) obtaining forgotten foods; 3) describing the time and eating occasion; 4) acquiring detailed information of consumed foods and beverages; and 5) collecting any additional missing information.[8] The AMPM has been used in the United States National Health and Nutrition Examination Survey yearly since 2002.[8]

One strength of 24-hour dietary recall is that it reduces literacy barriers (unless using a computer interface in which a participant inputs information).[1,3] The 24-hour dietary recall is also less burdensome to individuals as compared to a food record.[5] In addition, 24-hour dietary recall is less likely to influence dietary intake as compared to non-recall methods, as collection of information on dietary intake happens after eating has occured.[5] However, there are limitations associated with 24-hour dietary recall that might affect the accuracy of dietary data and create bias. The 24-hour dietary recall relies on memory and knowledge to report food consumption and estimate portion sizes.[3,5] Another limitation of 24-hour dietary recall is that it can be labor-intensive regarding what is required for data collection and analysis.[9] Due to the high cost of interviewer-administrated 24-hour dietary recall, this method may not be feasible for use in large scale studies.[5] Furthermore, studies have shown that 24-hour dietary recall has problems of underreporting, when reported intake is compared to weighed dietary assessment methods and biological markers, with issues of underreporting more prevalent in populations with obesity.[10-13]

A food record, also called food diary, requires individuals to record all foods and beverages and their amounts consumed, immediately following consumption, for at least three consecutive days.[1,5] The recording can be done by hand or electronically.[14] Individuals need to receive adequate training to accurately describe foods and beverages and learn how to weigh and measure foods and beverages to report portion sizes consumed.[1,5] Similarly to 24-hour dietary recall, food records can also assess contextual information, such as meal and snack patterns, food preparation, and timing and location of meals.[14]

A strength of food records is that it does not rely on individuals' memory to report dietary intake, which can eliminate memory errors.[1,3] If foods and beverages are weighed or measured at each eating episode, errors from portion size estimation can be minimized.[5] A disadvantage of food records is that study samples need to be literate, which limits the method being used in some specific populations, such as new immigrants or low literacy groups.[1,3,5] Another disadvantage of food records is that there is limited generalizability of dietary intake information obtained from food records.[1] As completing food records in the recommended method is highly burdensome, individuals who complete food records as foods and beverages are being consumed are usually highly motivated and dedicated, making the data hard to be used to represent the general population.[1] The third disadvantage is that data analysis process of food records is labor-intensive, especially if dietary data are entered manually.[1,9] This makes the food records difficult to administer in large population studies.[1] Another disadvantage of food records is underreporting. Studies have shown that individuals tend to underreport and underestimate dietary intake when using food records compared to biological markers, especially in populations with obesity.[12,15] In addition, food records may alter dietary intake, thus not providing information on current intake.[1,9] Rebro and colleagues[16] studied the effect of writing food records on eating behaviors among women aged 50 to 79 years old.[16] A sample of 176 four-day food records were randomly selected and analyzed.[16] Investigators found that the food items, food components, and snacks recorded on day four were significantly less than those on day one.[16] Thus, the investigators interpreted that individuals might decrease food consumption and reduce the complexity of the foods consumed to finish the food records.[16] The increase awareness of what is being consumed when writing food records may also alter intake.[1]

A FFQ assesses typical frequency of consumption of foods and beverages during a specific time interval (usually about six months) using a list of foods and beverages.[5,6] The semi-quantitative FFQ includes questions with standard portion sizes listed for each item[17] while the quantitative FFQ allows individuals to choose their own portion sizes consumed.[1] The FFQ can be collected via a questionnaire provided as a hard copy or as a questionnaire provided electronically. The FFQ can be self-administered or administered by a trained interviewer.[1] Currently, there are many developed FFQ instruments for different populations and purposes and these instruments are often linked to a database for nutrient intake estimation based on individuals' answers.[5] Commonly used FFQs include the Harvard Willett FFQ developed by Willett and colleagues,[18,19] the Block FFQ developed by Block and colleagues,[20] and the Diet History Questionnaires developed by Thompson and Subar.[13,21-23]

A strength of FFQ is that it collects individuals' usual dietary intake over a long period.[3,5] Unlike other subjective dietary assessment methods, FFQ can be used to avoid sudden changes in recent diet (i.e., due to illness or disease) by collecting dietary information prior to that period.[5] Also, FFQ is less burdensome to collect dietary information for the respondent and staff.[17] Compared to 24-hour dietary recalls and food records, FFQ is often used to assess usual dietary intake from large numbers of people (i.e., over 100 individuals).[17] Weaknesses of FFQ include that it relies on individual's ability to report the frequency of food patterns and portions over a long period of time.[3] Also, the nutrient intake estimation of FFQ is not as accurate as compared to 24-hour dietary recalls and food records.[5] When validated with doubly labeled water (DLW), FFQ is found to underestimate energy intake by up to 38% in women and 36% in men.[13] The difference in accuracy is believed to be due to the use of incomplete lists of foods, errors in frequency and portion size estimation.[5] In addition, FFQ does not collect detailed dietary information including food preparation, specific foods and beverages consumed, and contextual information, such as meal and snack patterns, and timing and locations of meals.[24] In terms of literacy level, the self-administered FFQ requires higher literacy level than interviewer-administered FFQ.[5]

The accuracy of traditional self-reported dietary assessment methods has been questioned by many researchers due to concerns of measurement errors that lead to inaccurate dietary data.[2,3,6,25] The main challenges in accuracy of dietary data with subjective dietary assessment methods include reliance on memory (which might create bias), inability to accurately quantify portion sizes consumed, cost, and alteration of dietary behaviors as data are being collected. Although when weighed food records are completed as food is being consumed, thus not involving memory, it still relies on individuals to weigh and measure all foods and beverages prior to and after consumption and to record this information, which can still introduce human errors. These challenges indicate that objective methods that reduce reliance of procedures on individuals are needed to minimize bias and estimation issues to enhance the accuracy of dietary assessment.

Technology advancement has led to the development of new methods to address many limitations previously described in self-reported dietary assessment conducted in free-living situations. Initial use of technology focused on internet-based platforms without the use of images accessible by computers, personal digital assistants (PDAs), or smartphones.[26] These technologies without the use of images focused on reducing the time needed to collect and process data, thereby reducing participant and staff burden.[26,27] An example of this is the National Cancer Institute's Automated Self-Administered 24-hour recall (ASA24), which is a self-administered 24-hour dietary recall completed on an internet-based platform.[28] Even though these new technology-based dietary assessment methods without the use of images reduced participant and staff burden, this type of technology does not appear to impact on reducing inaccuracy of the data caused by memory recall or inability to correctly quantify portion sizes consumed.[29-31]

OBJECTIVE DIETARY ASSESSMENT

Objective dietary assessment collects dietary intake using methods that do not involve self-report. The most commonly used objective dietary assessment methods include weighed food intake (WFI) and biomarkers that reflect dietary intake. One of the most commonly used biomarkers for assessing energy intake via determining energy expenditure is DLW.[1]

WFI, also called "plate waste," can only be used when all foods and beverages consumed can be weighed before and after consumption by a second person in which the dietary assessment is not being conducted.[9] WFI is usually obtained in a controlled environment, such as laboratory or cafeteria-like setting.[9] In these settings, the items that can be selected to consume are controlled (or set due to a menu) and participants usually eat in the setting, allowing for everything to be measured prior to and after consumption.[9] A strength of WFI is that quantity of foods and the items consumed can be objectively determined.[17] Even though accurate dietary information can be obtained from WFI, the controlled environment where eating occurs does not necessarily represent food consumption in free-living situations.[9]

DLW is the gold standard method to determine energy expenditure in free-living situations.[1] It is a biomarker used to calculate carbon dioxide production indirectly, and the carbon dioxide production is used to calculate energy expenditure by the use of standard equations for indirect calorimetry.[1] DLW is applicable to a wide range of protocols and has been used as a validation tool to estimate energy intake in a free-living environment.[1,9] However, DLW only provides information about energy intake (assuming that participants are weight stable so that the calculated energy expenditure represents energy intake).[1] Other disadvantages of DLW include its high cost and the need for technical skills to perform the analysis.[1,9,32]

USE OF IMAGE-ASSISTED TECHNOLOGY TO ADDRESS DIETARY ASSESSMENT ACCURACY

To reduce the errors encountered in subjective dietary assessment in free-living situations and allow collection of detailed dietary intake in free-living situations, researchers have developed image-assisted dietary assessment, which is a new method of using technology to enhance dietary assessment acuracy.[33] This type of dietary assessment is defined as any method that incorporate images or videos of dietary intake to enhance self-reported dietary intake or to obtain dietary intake. Image-assisted dietary assessment is categorized into two types: active and passive.[33]

ACTIVE IMAGE-ASSISTED DIETARY ASSESSMENT

Active image-assisted dietary assessment is self-administered and requires individuals to manually capture images or videos with digital cameras, smartphones, and other devices with picture-capturing function.[33] Images are taken before and after each eating episode and are usually taken with measurement references for manual or automated image analysis processing.[33] The studies reviewed below focused on active image-assisted dietary assessment that is validated in comparison with objective dietary assessment methods, such as DLW or WFI.

Rollo and colleagues[34] conducted a pilot study to validate Nutricam Dietary Assessment Method (NuDAM) in adults with type 2 diabetes. NuDAM consisted of Nutricam, a mobile phone application, and a follow-up phone call to the participants the next day. Nutricam was an image-based food record application on mobile phones that allowed users to capture foods before and after eating episodes, with images captured at a 45-degree angle. Participants also recorded audio to describe the photographs and provide specific information about location, meal occasion, and consumed foods (such as brand names and preparation methods). A reference card (9 cm x 5 cm) was placed next to the food items to assist with estimating portion sizes. A prompt card with instructions for recording intake was also attached to the mobile phone to remind users of the instructions for dietary assessment. Images and audio recordings were then sent to a website and analyzed by a dietitian. On the next day, dietitians called participants to collect additional intake information for the NuDAM record, as well as any potential unreported foods.[34]

Ten participants with type 2 diabetes and no recent weight loss between 18 to 70 years old were asked to participate in the study.[34] Participants recorded their dietary intake with NuDAM in the first week and food records in the second week for three nonconsecutive days (one weekend day and two weekdays). DLW was used as the reference method to determine total energy expenditure for two weeks. Anthropometric data (height and weight) were collected at day 0, 8, and 15 to assess weight changes, and dietary restraint was also measured at baseline to account for any factors that may cause misreporting of dietary intake. Participants were asked to complete questionnaires on their experience with NuDAM and food records at the end of each week. Dietary information from NuDAM and food records were analyzed by three dietitians. To analyze NuDAM records, dietitians first identified food items, and then quantified the items with a portion size estimation tool developed by the investigators' research team. The tool consisted of different reference images of foods, serving tools, and food shapes. For the food records, the dietary information was entered directly into nutrition analysis software called FoodWorks program.[34]

A low level of dietary restraint was found in participants and no significant weight changes were found in participants during the two-week investigation period.[34] Investigators reported that the overall mean energy intake from NuDAM (8.8 ± 2.0 MJ/day) and the food records (8.8 ± 1.8MJ/day) were significantly lower than the mean total energy expenditure calculated from DLW (11.8 ± 2.3 MJ/day). The percentage of underreporting compared to the total energy expenditure was -23.7% in NuDAM and -23.9% in food records. Eight out of ten participants underreported their intake in either NuDAM, food records, or both. None were found to be over-reporting of energy intake. For the results of questionnaires, investigators found that all participants preferred to use NuDAM to record dietary intake instead of food records. However, the questionnaires revealed that changes in eating behaviors were reported when using both methods (nine participants with NuDAM and six with the food records). Another limitation of the study was that the same dietitian was used to clarify intake data and estimate intake. The familiarity with the participants' dietary intake may affect the results of intake estimation. In addition, investigators did not provide any information on the quality of the pictures taken by participants or how many pictures could not be used for analysis.[34]

Martin and colleagues[35] validated a dietary assessment method called Remote Food Photography Method (RFPM) to estimate energy and nutrient intake in free-living adults. RFPM allowed individuals to use cell phones with cameras to capture images of foods prior to and after consumption, with a reference card placed next to the plates. Customized prompts were sent to remind participants to capture images of food selections and foods that was remaining after consumption. Food images were then sent to a computer program (Food Photography Application) through a wireless network to estimate food types and grams amount consumed. The images were analyzed semi-automatically, in which a dietitian was responsible to review all computer-analyzed results and make changes on estimated food portions manually when necessary. Fifty adults between 18 to 65 years of age with a stable weight were asked to capture images of foods before and after eating for six days under free-living conditions and in two laboratory-based buffet meals. DLW was used as a reference to determine energy expenditure in the free-living conditions. In the laboratory-based buffet meals, two lunches were provided two days apart and consisted of sandwiches, pretzels, cookies, fruit cocktail and a beverage. User-satisfaction was also assessed with participants rating at the end of the study.[35]

The investigators found no significant difference of the estimated energy intake between RFPM and DLW.[35] During laboratory-based buffet meals, the energy and nutrient contents estimated from RFPM did not show a significant difference when compared to weighed intake. RFPM underestimated energy intake by 152 ± 694 kcal/day under free-living conditions and 4 ± 73 kcal for laboratory-based buffet meals. Investigators also noted that there was no significant change of eating behaviors (overeating or undereating) while using RFPM. In terms of user satisfaction, the results showed that participants were satisfied with RFPM and the ease of use. Investigators did not provide any information on how many images were included and usable for analyzing dietary intake. Also, investigators did not provide any information regarding errors of the automated computer analysis and how often the dietitian was needed to review the computer program and manually make changes to dietary data.[35]

Boushey and colleagues[36] investigated the accuracy and usability of the Mobile Food Records (mFR), an application which allows individuals to capture images manually to record food intake on mobile phone to yield energy and nutrient intake, in community dwelling individuals as compared to DLW. Forty-five men and women, who were between the ages of 21 and 65 years and resided in a rural county in the Midwest, were included in the study. Participants were asked to attend three visits at Purdue University campus during the study period. The second and third visits were approximately seven days apart. At the second visit, participants received instructions on using mFR to capture images prior to and after eating episodes, and also practiced using mFR on food models. Participants were asked to start recording dietary intake using mFR when a practice meal was provided at the second visit. Participants were then asked to continue recording all eating episodes using mFR for 7.5 days until the third visit. Pre-packed and weighed foods, based on estimated energy requirement for each participant, were provided to participants during all the remaining 7.5 days. Participants were required to return all foods that were not consumed for plate waste purpose. Aside from the pre-packed foods provided, participants could also consume additional foods and beverages.[36]

For the instruction of capturing images of dietary intake, participants were asked to capture the images with a provided reference marker with known dimensions next to the foods and at certain angles for the purpose of food identification and portion estimation.[36] Acceptable images taken by participants would automatically be uploaded to the central server for automatic image analysis, which was trained on the foods and beverages that were provided in the pre-packed foods prior to the investigation. After the automatic food identification, participants were able to review and confirm the results, and made necessary changes to complete food records through a list of foods in the system. All images taken by participants prior to and after eating episodes were also reviewed by three trained analysts to either identify and estimate food items (both provided pre-packed and not provided) in the images using standard protocol. The three analysts also used the Food and Nutrient Database for Dietary Studies developed by the USDA to estimate the reported energy intake of each participant from mFR. The plate waste method was used to determine the difference between provided pre-packed foods and the leftover returned from the participants to estimate the presumed energy intake.[36]

Boushey and colleagues[36] found a statistical difference of mean energy intake of 579 kcal/day between reported energy intake from mFR (2353kcal/day) and total energy expenditure estimated by DLW (2932 kcal/day). When comparing the reported energy intake from mFR and the presumed energy intake, the investigators found a mean difference of 20 kcal/day between two methods. The investigators also found 53% of participants underreported food intake and 2% overreported. In term of usability of mFR, the majority of participants reported being willing to use mFR, but some reported that the automatic food identification was slow and the accuracy of it was low.[36]

The results of the above studies suggest that using active image-assisted dietary assessment can provide relatively comparable measures of energy intake as compared to WFI or DLW. However, the main challenge is that these methods still rely on individuals to manually capture images and thus would increase the possibility of missing meals (no information found for the above studies). Missed eating episodes may lead to inaccurate energy and nutrient calculation. These active dietary assessment methods usually require users to take images at certain angles and with references placed next to the foods. Images with blurry quality, incorrect angles, insufficient lights, and without references cannot be analyzed manually by human or automatically via computer software. No information was provided in the studies regarding the frequency of occurrence of these issues.

PASSIVE IMAGE-ASSISTED DIETARY ASSESSMENT

In passive image-assisted dietary assessment methods, images or videos automatically capture dietary intake through the use of wearable devices or other tools that do not rely on individuals to actively capture images.[33] It is believed that removing the need for participants to "remember," either via memory to engage in directions for capturing images (i.e., actively take pictures, use correct angle for taking images, place marker close to foods in images, etc.), will enhance accuracy as compared to active image-assisted dietary assessment.[3] The studies reviewed below focused on validating wearable devices in comparison to objective dietary assessment methods such as DLW or WFI.

Image-Diet Day, a dietary assessment system developed by Arab and colleagues[37], used a wearable camera-phone to automatically capture and transmit images. Image-Diet Day consisted of two components – a mobile phone (model Nokia N80) with a three-mega pixel camera and the computer-assisted, multi-pass 24-hour recall. The mobile phone was designed to be worn around the neck and capture images every ten seconds. Battery life of the mobile phone was managed by a specific application to balance power savings and performance. Maximum 100 images could be saved in each mobile phone. Poor quality images were filtered, and key images were saved chronologically in groups for review. In terms of privacy, participants could review images and delete any images that they did not want to share with the investigators. The images were then used as a memory aid for the users to complete the web-based 24-hour recall called DietDay.[37]

Arab and colleagues[37] conducted a study to test the feasibility of the Image-Diet Day to enhance the self-reported dietary assessment. Fourteen healthy participants (non-Hispanic Caucasian and African American adult men and women), who had enrolled in another biomarker-based validation study, were recruited in the study. Participants were asked to wear the mobile phone around their neck for one week and turn on the camera prior to each eating episode. Total energy expenditure determined by DLW was used as a reference. A total of 110 eating episodes were recorded and 11,090 images were uploaded. Investigators found that the estimated intake calculated from Image-Diet Day (2359 kJ) was closely matched to the total energy expenditure determined by DLW (2377 kJ), with only 18 kJ of underestimation from the Image-Diet Day. Acceptability and feasibility of Image-Diet Day were also assessed. A total of 71% of participants reported having difficulty on wearing the device and 21% encountered technical problems with the device. Participants' comments regarding the Image-Diet Day were related to the need to recharge the device and increased self-consciousness of wearing the device in public, which might lead to alteration of dietary behaviors. However, 57% of participants found that the images were helpful in reporting dietary intake. The results suggested that passive imaging was a promising method to collect dietary intake information.[37]

Although Image-Diet Day included a mobile device to automatically capture images of foods, the main limitation was that the system required participants to manually enter their dietary intake online using the captured images. The requirement of participants to enter foods and portions consumed manually not only increased the burden of the participants, but also introduced the possibility of human errors; thus, these problems might affect the accuracy of dietary data. With the wearable mobile phone, the main technical issue was the short battery life, which was not adequate to capture images for the entire day.[37] This technical issue was also the concern for some participants as stated in post-study interview.[37] During the technical feasibility test, some devices required a replacement of battery.[37] The second technical issue was the slow imaging frequency (about 6 images per minutes). This might not capture all the foods and portions consumed during meal time and thus might introduce the problem of underreporting. However, battery life should also be enhanced to increase imaging frequency.[37] The third technical issue was the appearance of the wearable mobile phone. As indicated from the participants' feedback, the current appearance of the device increased participants' self-consciousness of wearing it in public, which might lead to change in dietary behaviors.[37]

Another wearable camera, SenseCam, was developed by Microsoft and was intended to be worn around the neck to passively capture images every 20 seconds in response to changes in motion, light and temperature.[38] SenseCam internal storage was sufficient for one week and battery was enough for 12 to 16 hours per day. A privacy button on SenseCam was designed to temporarily stop capturing images when necessary and SenseCam would automatically re-start the capturing function after seven minutes.

Gemming and colleagues[38] conducted a study to validate SenseCam-assisted 24-hour recall on measuring energy intake while comparing to total energy expenditure estimated by DLW. Forty adults (20 males and 20 females) aged between 18 to 64 years with mean body mass index (BMI) of 27 kg/m^2 were asked to wear SenseCam before eating episodes for four set days (one test day and three actual data collection day) over a 15-day period. Participants were also asked to wear SenseCam throughout the day while awake with the option to remove it anytime when they felt uncomfortable. On the day after wearing SenseCam, participants completed the paper-based multiple pass 24-hour recall (MP24) with a trained dietitian in person with tools to help the participants to estimate portion sizes, such as standard household measure, example crockery and glassware, and portion size guide. After completion of MP24, participants could view the images privately and delete any images that they did not wish to disclose with the records to be seen by the researchers. The dietitian then reviewed the SenseCam images with the participants. Participants could confirm, modify, or add any information to MP24 that was collected prior to the review of the SenseCam images, and this method was identified as MP24 plus SenseCam images. DLW was used to assess the total energy expenditure during four data collection appointments for each participant. Before DLW, resting energy expenditure was measured via indirect calorimetry to aid in determining total energy expenditure during the investigation period.[38]

Investigators reported that one participant was noncompliant to wear the SenseCam and six devices malfunctioned during study period.[38] The results of total energy expenditure measured by DLW and energy intake assessed by MP24 and MP24 with SenseCam images were compared. In male participants, mean energy intake reported in MP24 only underestimated 17% and MP24 plus SenseCam images underestimated 9% when compared to total energy expenditure measured by DLW. In female participants, the results of mean energy intake reported in MP24 underestimated 13% and MP24 plus SenseCam images underestimated 7%. Investigators reported that the use of SenseCam images with MP24 significantly reduced underreporting for both males and females when compared to MP24 alone. No significant difference of energy intake was found between MP24 with SenseCam images and total energy expenditure from DLW. Investigators did not report any mean energy intake results for combined sex.[38]

The main limitation of the study was the manual image analysis process particularly only a single dietitian was used in both dietary assessment and image review. These procedures were not audited during the study period, which might potentially introduce human errors and bias. Second, the option for the participants to review and delete any images that they did not want to disclose on records might be another limitation. Participants might delete any food images during private screening, which then might result in underreporting.

Gemming and colleague[38] suggested that SenseCam significantly reduced the underreporting in typical 24-hour recall. However, there are several limitations of SenseCam that need to consider. Under insufficient light, the quality of images captured by SenseCam can be relatively poor. Also, SenseCam has a slow capturing frequency that is insufficient to capture all the consumed foods. These issues might result in production of useless images that might affect the effectiveness of using SenseCam images during dietary assessment. Another limitation is that SenseCam has a relatively short battery life (12 to 16 hours) as a device that is intended to be worn throughout the day to capture dietary intake passively.[38]

Pettitt and colleagues[39] developed another wearable device (currently called wearble micro-camera) and conducted a pilot study to evaluate its ability to improve dietary assessment accuracy. The wearable micro-camera was designed to be worn on the ear and had a wide-angle lens (170-degree view angle) to take audiovisual recordings during eating episodes. The length of each eating episode could also be measured using the audiovisual recording feature. Six healthy participants between the ages of 24 to 30 with moderate to high activity levels were recruited and asked to wear the wearable micro-camera during meal times for three study days (two weekdays and one weekend day). Participants were instructed to turn on the wearable micro-camera before each eating episode. Participants were also asked to complete 14-day food records with instructions provided by a trained researcher at baseline. The 14-day food records and micro-camera images were analyzed by a dietitian. Standard portion size estimations were used if details were not provided. No additional information was provided on how the micro-camera images were being analyzed. DLW was used to determine total energy expenditure over 14-day study period. At baseline, anthropometric data were collected. Resting metabolic rate was measured at each visit using indirect calorimetry. Estimated energy intake from 14-day food records and food records plus micro-camera images were compared to total energy expenditure determined from DLW.[39]

The investigators reported that only two days (out of three-day attempted recording) worth of eating episodes were recorded due to short battery life of the camera.[39] When compared to total energy expenditure determined from DLW, results from two-day food records alone showed a significant difference of estimated energy intake with 34% (-3912kJ) underreporting. Two-day food records plus micro-camera images had 30% (-3507kJ) underreporting, which was also found significant, when compared to total energy expenditure from DLW. The mean estimated energy intake calculated from 14-day food records resulted in closer values to total energy expenditure determined from DLW when compared to the results of both two-day food records with or without micro-camera images. A reduction in energy intake was noted in the two-day food records when the camera was in use as compared to the 14-day food records, which led the investigators to indicate that the wearable micro-camera might affect eating behaviors. Feedback from participants confirmed that the device did affect their activities and they also felt uncomfortable wearing it in the public. There was no information reported on the quality of the micro-camera captured images and how many poor quality images were eliminated during the analysis process.[39]

The results of this study suggested that dietary images with food records did improve the underreporting rate when compared to the food records alone collected for the same amount of days.[39] However, the errors was still significantly different from the actual total energy expenditure determined from DLW.[39] The main limitation of this study that might contribute to this high error rate was the manual image analysis process.[39] Human errors and bias remained as a major challenge in this manual analysis process.

There are limitations with the wearable micro-camera. The main limitation is the short battery life. In the study conducted by Pettitt and colleagues,[39] the issue of insufficient battery caused the study to only have two days worth of dietary data instead of planned three days. Due to the short battery life of the device, the users need to turn the camera on to begin recording process and regularly charge the device.[39] Thus, the user bias remain as an issue that would potientially lower the accuracy of the dietary data.[39] Another limitation is the appearance of the device. Participants' feedback from the validation study revealed that most participants did not want to wear the micro-camera in public.[39] The unwillingness to wear the device might introduce another user error, potentially increasing underreporting, as the users might not record all the eating episodes.

eButton, a wearable computer with camera, was developed by Sun and colleagues[40] and was designed to be worn on the chest. eButton captures images passively every one to five seconds. Circular dinning plate/bowl with known sizes (diameter and depth) and shapes were required to be placed in the image for portion size estimation. Captured images were saved to the micro SD card in the device and were analyzed semi-automatically when downloaded. All images were first automatically segmented into groups of similar images and key frames were then chosen as the representative images. For privacy protection, all images were automatically processed to recognize human faces and block them before being reviewed. At eButton's current stage of development, identification of food items was required to be done manually. However, eButton could segment each food item and estimate volumes of each food automatically. After food recognition and portion size estimation, the name of foods and portion sizes were to be sent to USDA's food database to determine energy and nutrient information.[40]

Jia and colleagues[41] evaluated the accuracy of portion size estimation by eButton when compared to human raters' estimation and actual food volume. Seven participants were recruited from the investigators' laboratory and received instructions on how to use the eButton before the study. No further information was provided on participants' characteristics for the study. Investigators examined 105 foods (Asian and Western foods) with 78 of them amorphous in shape and 22 being non-amorphous. No liquids were included in the study. Foods were either prepared by participants or purchased from fast-food restaurants. Participants were asked to wear eButton during eating occasion. Foods were wrapped in plastic film and then submerged in a pool of millet seeds to determine the volume of the foods (i.e. the difference in volume of millet seeds before and after submerging). Selected food images were analyzed by eButton and three raters (a dietitian, a volunteer, and a lab member) to estimate the portion size of each consumed food. For the result of volume estimated by eButton, 15% of the food volume estimation had over 30% errors. The mean relative errors of estimated volumes between eButton and the actual food volume was -2.8% among all food samples. When compared to the actual food volume, three raters' volume estimation had higher mean relative errors with the error range between -15.5% to -78.8%. The result suggested that eButton had less errors in portion size estimation when compared to human raters.[41]

eButton provided higher accuracy in volume estimation when compared to estimation completed by human manually.[40,41] However, there are several issues needed to be addressed in eButton. First, the main issue is that the food recognition process is done manually.[40] This might potentially introduce human errors and bias, and thus affecting the accuracy of the dietary data. Second, eButton currently has low battery support which can only last four to eight hours depending on the sensors and capacity of the rechargeable battery.[40] Poor battery life is a disadvantage for a device that is designed to be worn continuously during eating episode. Also, it will be very burden and challenged for users to charge the device multiple times during the day, which might potentially miss capturing all the eating episodes. Third, a known reference is required to present in the picture to aid in volume estimation.[41] Sizes of reference objects must be provided before volume estimation.[41]

In sum, the validation studies showed that wearable devices that passively capture images/videos could help in increase the accuracy of dietary assessment and provide objective dietary information.[37-39,41] However, there are technical issues of the reviewed devices, which include insufficient battery life, poor quality images, slow capturing frequencies, and insufficient memory. None of the reviewed passive image-assisted dietary assessment methods have fully automated image analysis capabilities for both food identification and volume estimation without reference objects. Thus, human errors and bias remain as an major issue with these wearable devices.

The current dietary assessment methods have limitations that can affect the 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.[3,5] Self-reported dietary data also appears to have systematic bias, in which populations with obesity are more likely to underreport intake.[10-13,15,42-44] Subjective methods are also labor-intensive in regards to data collection and/or analysis.[1,9] Technology-integrated, but not image-assisted, self-reported dietary assessment methods do not address the forementioned issue of human errors and bias in traditional self-reported dietary assessment since humans are still involved in the process of recalling and collecting dietary data.[45] Objective dietary assessment can limit human errors and provide objective dietary information.[1,17] However, few objective dietary assessment methods are available in free-living situations, and these objective methods can be costly and difficult to be used in studies with large samples.[1,9,32] The incorporation of image technology into dietary assessment (image-assisted dietary assessment) has been investigated by researchers to improve accuracy in collecting dietary information in free-living situations.[33] Reviewed studies validated different methods in using image-assisted dietary assessment. For active image-assisted dietary assessment methods, the overall results suggested that these methods had improved accuracy and provided comparable accuracy of dietary information when compared with reference methods such as DLW and WFI.[34-36] However, the active image-assisted dietary assessment methods still rely on humans to manually capture images, which does not eliminate human errors. Passive image-assisted dietary assessment methods can reduce human errors as the process of collecting dietary information reduces the effort and training needed to obtain imagery.[33] The results of reviewed passive image-assisted dietary assesment methods showed improved accuracy in assessing dietary information.[37-39,41] However, all the passive image-assisted dietary assessment methodologies at this time involve manual image analysis processes for either food identification or volume estimation with reference objects, which increases cost. Thus, there is a need for a wearable device that has the function of passive image capturing, with automated image analysis software for food identification and volume estimation that requires no reference objects, to provide accuate and inexpensive dietary information.

Therefore, the purpose of this investigation was 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. The specific aims of this investigation were: 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.

CHAPTER II: MANUSCRIPT

INTRODUCTION

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] There are two types of dietary assessment methods: subjective and objective. 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]

Current dietary assessment methods have limitations that can affect the accuracy of dietary data. Subjective dietary assessment methods, obtained through self-reported methods, are widely used to assess dietary intake in free-living situations. Three common self-report dietary assessment methods include 24-hour dietary recall, food record, and food frequency questionnaires (FFQ).[3] 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.[3,5] Subjective methods are also labor-intensive in regards to data collection and/or analysis.[1,9] Self-reported dietary data also appear to have systematic bias, in which populations with obesity are more likely to underreport intake.[10-13,15,42-44] To begin to address these issues, technology-integrated, but not image-assisted, self-reported dietary assessment methods were developed. These initial efforts included uses of computers, personal digital assistants (PDAs), and smartphones, and focused on reducing the time needed to collect and process data, thereby reducing participant and staff burden.[26,27] An example of this is the National Cancer Institute's Automated Self-Administered 24-hour recall (ASA24), which is a self-administered 24-hour dietary recall completed on an internet-based platform. These initial technology-integrated, but not image-assisted, self-reported dietary assessment methodology still do not appear to address the inaccuracy of the data caused by memory recall or the inability to correctly quantify portion sizes consumed.[29-31]

Objective dietary assessment methods collect dietary intake without involving self-report methods. These methods include weighed food intake (WFI) and biomarkers such as doubly labeled water (DLW) that reflect intake. These objective dietary assessment methods can limit human errors and provide objective dietary information.[1,17] However, few objective dietary assessment methods are available in free-living situations, and these objective methods can be costly and difficult to be used in studies with large samples.[1,9,32]

The incorporation of technology via images into dietary assessment (image-assisted dietary assessment) has been investigated by researchers to improve accuracy in collecting dietary information in free-living situations.[33] Dietary assessment using images can be divided into active and passive methods. Research on active image-assissted dietary assessment methods, which are self-administered and require individuals to manually capture images or videos with digital cameras, smartphones, and other devices with picture-capturing function,[33] suggested an improved accuracy and provided comparable accuracy of dietary information when compared with objective dietary assessment methods.[34-36] However, the active image-assisted dietary assessment methods still rely on humans to manually capture images, which does not eliminate human errors. Passive image-assisted dietary assessment methods, in 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 requires less effort and training than the active image-assisted dietary assessment.[33] The results of reviewed passive image-assisted dietary assessment methods showed improved accuracy in assessing dietary information.[37-39,41] However, all the passive image-assisted dietary assessment methodologies at this time involve manual image analysis processes to determine food identification or volume estimation 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 was 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 volume consumed. The specific aims of this investigation were: 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.

STUDY DESIGN AND METHODOLOGY

STUDY DESIGN

To validate the accuracy of DietCam in analyzing food images taken by Sony Smarteyeglass in food identification and volume estimation, a 2x2x2x2x3 mixed factorial design was used, with a between-subject factor of the order of meals (Meal 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 were randomized into one of the two orders of meals. In each meal, participants were given a meal that included 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 were the identification of foods and amount of foods consumed (grams). The study was approved by the Institutional Review Board at the University of Tennessee-Knoxville (UTK IRB) and was registered at ClinicalTrials.gov (NCT03267004).

PARTICIPANTS

Thirty men and women were invited to participate in the validation study. The study was advertised as an investigation of dietary assessment via digital images. To recruit participants, flyers were posted around the University of Tennessee, Knoxville (UTK) campus. Individuals who were interested in participating in the research study were asked to contact the Healthy Eating and Activity Laboratory (HEAL) for more information and were screened over the phone for eligibility. Participants were enrolled until 30 had been recruited and completed the study.

Eligibility criteria of this investigation included:

1. Between the ages of 18 and 65 years
2. Body mass index (BMI) between 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 rating each food item ≥ 3 on a Likert scale during phone screen
6. Able to complete all two meal sessions within four weeks of the screening session
7. Not legally blind without corrected lenses
8. Able to eat a meal while wearing Sony Smarteyeglass

Participants were excluded if they wore electronic medical devices such as pacemakers and implantable defibrillators as the controller of Sony Smarteyeglass emits radio waves that would affect the medical devices according to the Sony Smarteyeglass Reference Guide.[46]

A total of 54 individuals were interest in participating in the investigation. Of these initially interested individuals, three were no longer interested in participating after initial phone screenings with details provided regarding the study, and eleven were unable to be reached for phone screenings. Of the remaining that were phone-screened for eligibility, eight became ineligible for the following reasons: five reported a BMI outside the eligible range, one reported being legally blind without corrected lenses, one reported disliking the foods provided in the study, and one reported having food allergies or dietary restriction. After being phone screened, all eligible individuals attended the screening session and signed the informed consent. After the screening session, two more participants were excluded due to BMI outside the eligible range. Thus, a total of 30 eligible participants participated in this study (see Appendix 1, Figure 1, for the flow of study participants).

SONY SMARTEYEGLASS

Sony Smarteyeglass is developed by Sony Corporation and is an eyeglass that is intended to be operated as an Android system mobile device.[47] Sony Smarteyeglass has a display, built-in camera, sensors, and a touch-sensitive controller and keys.[47] Sony Smarteyeglass is designed to be worn as usual eyeglasses, and the user is able to operate the eyeglasses via the touch-sensitive controller.[47] The controller can also be connected to an Android system device wirelessly.[47] In this study, Sony Smarteyeglass was connected to an Android system tablet, which was used by researchers to review the recordings during meal sessions.

PROCEDURES

SCREENING SESSION

At the completion of the phone screen, 32 eligible participants were scheduled to come to HEAL for one, 30-minute face-to-face screening session. All screening sessions were scheduled between 11:00am and 5:00pm, Monday to Friday. During the screening session, eligible participants signed a consent form. After signing the consent form, eligibility was confirmed by taking height and weight measures. Participants were also asked to fill out a demographic questionnaire. Prior to the start of the first meal session, eligible participants were randomized to one of the two orders described in Appendix 1, Table 1. Participants were 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.

MEAL SESSIONS

After the screening session and randomization, participants were scheduled for two 40-minute meal sessions, with approximately one week occurring between each session. All meal sessions were scheduled between 11:00am and 5:00pm, Monday to Friday.

During both meal sessions, instructions on how to use Sony Smarteyeglass were provided to participants. These instructions included how to wear and use the eyeglasses. Participants were instructed that, after putting on the Smarteyeglass, to initiate the recording via the controller of the Sony Smarteyeglass. After the recording was initiated and prior to starting to eat, participants were instructed to look at each provided food at the table. Then, participants were also instructed to turn their head toward their left shoulder, look at each food from the side, and then repeat the same step by turning their head toward to the right shoulder. Participants were then asked to start the meal by taking one bite of each provided food. For the first bite of each food, participants were instructed to hold the food, either in their hand or on a fork or a 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 were instructed to eat normally until satisfied. Participants were then given 30 minutes to eat. The investigator then left the room while participants were eating. The investigator checked in with participants every 10 minutes. At the end of 30 minutes, participants were instructed to again look at each provided food on the table at three different angles (looking straight at each food, from the left side and the right side) following the exact same procedure at the beginning of the meal. The second meal session followed the same procedure as the first meal session.

On the day following each meal session, participants were called to complete a 24-hour dietary recall. Instructions were provided to participants about how to complete the dietary recall at the end of each meal session and a two-dimensional visual aid was provided to aid participants in estimating the consumed portions for each food and beverage item consumed. A total of 29 participants completed all 24-hour dietary recalls, with one recall missed from one participant due to being unable to contact participant on the day following the meal session.

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

MEAL DESCRIPTION

The meals that were served for this investigation contained foods that were categorized into two food shapes (Regular and Irregular) and two food complexities (Single food and Mixed food). Each meal contained four foods (see Appendix 1, 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 were given 20 oz. of water in each meal session. Foods were weighed prior to being provided to participants and the amount provided to participants were within +/- 3g of the amount described in Appendix 1, Table 3. Mixed foods were broken down into their individual food components and measured. Each meal provided 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.[48] Thus, each meal provided approximately 1225 kcal for males and 950 kcal for females. Each food provided approximately 25% of the energy for each meal.

MEASURES

ANTHROPOMETRICS

During the screening session, height and weight were assessed using a stadiometer and an electronic scale, respectively. Standard procedures were used to collect the measurements. Participants were asked to remove their shoes, jackets, and any other items in their pockets. BMI (kg/m^2) was calculated from collected height and weight for each participant to confirm eligibility of this study.

DEMOGRAPHICS

Basic demographic information, such as gender, age, race, ethnicity, and education level, were collected via demographic questionnaire during the screening session after consent form is obtained.

CONSUMPTION

WEIGHED FOOD INTAKE

Before and after each meal session, each food item was weighed to the nearest tenth of a gram using an electronic food scale. The weights of the containers were also measured. The total grams of each food item were recorded, and total food consumed were calculated by subtracting plate waste weight from the pre-meal weight. The food consumption of pasta and alfredo sauce were weighed together to yield more accurate weight due to inability to separate each ingredient after mixing.

DIETCAM

DietCam, developed by Dr. JinDong Tan and colleagues,[49] 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.[49] DietCam has the average accuracy rate of 84% in recognizing regular shape food items.[49] DietCam was used to analyze images taken by the Sony Smarteyeglass in the study to identify food items. In this investigation, DietCam was used to identify food items with different shapes (Regular vs Irregular) and complexities (Single food vs Mixed food). While volume estimation of foods in the unit of cubic meters (m^3) was initially proposed for this project, as the analysis process for volume estimation was not at a stage that allowed completion of determining this variable, these results are not reported. Thus, reported methodology and results focus on food identification only.

After data collection, two levels of food identification (classification and subclass identification) were completed using DietCam. First, images of both meal sessions from 10 participants were selected as training images for DietCam system. For the first level of training (classification), 14 images were randomly selected from each meal, a total of 28 images from each of the 10 selected participants. Each food in the selected image was framed and annotated with general food categories (e.g. sandwich, cookie, wrap, grapes etc.) using MATLAB version R2017b with coded program written by a research staff, Yan Li, from Dr. JinDong Tan's laboratory (see Appendix 1, Figure 2, for example). Each framed and annotated food category was then cropped out into small image patches for data augmentation by adding additional external images for training and generalization purpose. The version 2012 dataset from the PASCAL Visual Object Classes (VOC)[50] with over 17,000 images was used for the data augmentation during training. For the first level of food identification, classification, the training achieved an average of 97% accuracy. After the training, all the food images from the remaining 20 participants were input into the DietCam for automatic image analysis. Each image was analyzed individually through DietCam with the model developed at training. After the automatic image analysis, processed food images were labeled with names of the food categories appearing in the image, with a rectangle frame around the identified foods, and provided in a text file with a list of foods identified in each image (see Appendix 1, Figure 3, for example).

To determine accuracy of food identification by DietCam, after images from 20 participants were analyzed by DietCam, the images captured in the first 5 minutes of each meal session, with the 5-minute period starting when the first food image appeared in the meal, were selected. This first 5-minute period captured the period at the start of the meal when participants were instructed to capture images of the food from several angles before starting to eat. The selected images were coded by raters into one of the three codes for each food (100% of food available and visible on the serving plate, less than 100% of food available and visible on the serving plate, or food in the image but not on the plate (being consumed [held in hand or on utensil]), or two other codes (blurry image and no food at all in the image). Images were coded into all possible codes, meaning one image could include more than one image code (see Appendix 1, Figure 4, for example). To capture inter-rater reliability, 33% of all coded images were coded by two raters. All raters coded one meal until 90% agreement was achieved. Once 90% agreement was achieved, raters coded meals independently.

After all images were coded, the results of the coding were compared to the results of DietCam food identification (first level classification). The comparison produced four outcomes: DietCam identifying food correctly in image (True Positive: coded image result and DietCam result both identify the food in the image), DietCam incorrectly identifying food in image (False Positive: coded image result does not identify food in the image while DietCam identifies the food in the image), DietCam not identifying food in image (False Negative: coded image result identifies the food in the image while DietCam does not identify the food in the image), or DietCam correctly identifying that the food is not in the image (True Negative: coded image result and DietCam result both do not identify the food in the image).

For the second level of food identification (subclass identification), 4 images were selected from each meal, a total of 8 images, from each of the 10 selected participants with each image represented one food category (i.e. sandwich, cookie, wrap etc.). Microsoft Paint was used to color-code each visible individual ingredient in the image with a specific set of color codes (Blue, Red, Green codes) assigned to each ingredient (see Appendix 1, Figure 5 and 6, for examples). A list of color codes was created for all the ingredients for both meals. While subclass identification of foods was initially proposed for this project, as the analysis process for subclass identification was not at a stage that allowed completion of this variable, these results are not reported.

24-HOUR DIETARY RECALL

On the following day of each meal session, the investigator asked 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 were provided a two-dimensional food shapes to help with estimating portion sizes. Only dietary intake for the meal sessions were entered into Nutrition Data System for Research (NDS-R) dietary software developed by the Nutrition Coordinating Center, University of Minnesota, Minneapolis, Minnesota.

All data extracted from NDS-R were merged into one file for analysis. For mixed food (details refer to Table 1), the portion consumed (grams) of each individual food components were combined and recoded into its own food category (i.e. wrap, chicken and rice, sandwich, and pasta dish).

PARTICIPANTS' FEEDBACK

At the end of second meal session, participants were asked to complete a questionnaire regarding their experience using Sony Smarteyeglass. A total of six structured questions were included in the questionnaire and each question was associated with an open-ended question. Structured questions consisted 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 were tabulated and open-ended questions were summarized.

PARTICIPANTS' EXPERIENCES

Three questions were included in this section regarding participants' overall experience with the Sony Smarteyeglass. One question asked about the ease of use of Sony Smarteyeglass. Responses for this question were based on a five-scale rating ranging from extremely easy to extremely hard (extremely easy, easy, neither hard or easy, hard, and extremely hard). For participants who rated ease of use as hard or extremely hard, they completed an opened-ended question so that they could describe why they responded with their response. The second question asked about the clearness of instructions for using Sony Smarteyeglass. Responses for this question were also based on a five-scale rating ranging from extremely clear to extremely unclear (extremely clear, clear, neither unclear or clear, unclear, and extremely unclear). For participants who rated the clearness of instructions as unclear or extremely unclear, they completed an opened-ended question so that they could describe why they responded with their response. The last question of this section asked about participants' satisfaction with their experience using Sony Smarteyeglass. Responses were on a five-scale rating ranging from extremely satisfied to extremely unsatisfied (extremely satisfied, satisfied, neither unsatisfied or satisfied, unsatisfied, and extremely unsatisfied). For participants who rated satisfaction as unsatisfied or extremely unsatisfied, they completed an opened-ended question so that they could describe why they responded with their response.

LIKELIHOOD AND COMFORTABLENESS OF WEARING SONY SMARTEYEGLASS

Three questions were included in this section of the questionnaire regarding the likelihood and comfortableness of wearing Sony Smarteyeglass. All responses to the structured questions were based on a five-scale rating. An open-ended question was associated with each question asking participants to describe the reasons why they chose unlikely/uncomfortable or extremely unlikely/uncomfortable. The first question asked about the likelihood of wearing Sony Smarteyeglass during dining episodes in different situations. The second question asked about the likelihood of participants remembering to put on Sony Smarteyeglass and start the recording before eating. Responses for the first and second questions ranged from extremely likely to extremely unlikely (extremely likely, likely, neither unlikely or likely, unlikely, and extremely unlikely). The last question asked about participants' comfortableness of using Sony Smarteyeglass if it captures images other than their eating. Responses for this question ranged from extremely comfortable to extremely uncomfortable (extremely comfortable, comfortable, neither uncomfortable or comfortable, uncomfortable, and extremely uncomfortable).

VALIDATION OF QUESTIONNAIRE

The questionnaire was validated for its content via cognitive interviewing and pilot testing. For cognitive interviewing, five students at UTK were randomly selected and asked to read each question in the questionnaire and rephrase each question in their own words. Responses of each question were recorded to identify any unclear questions. In this step, one out of five responses were different from the original meaning of the questions asking about the ease of use of Sony Smarteyeglass and comfortableness of participants using Sony Smarteyeglass if it captures images other than eating. All other responses were similar to the meaning of the original questions. No revision was made to the questionnaire.

For pilot testing, another five students at UTK were randomly selected and asked to complete the questionnaire. They were also asked if there was anything on the questionnaire that was unclear or misleading after they completed the questionnaire. Responses were documented and reviewed. Based on the answer and the responses to the question regarding the clearness of the questionnaire, there were no unclear or misleading questions in the questionnaire; as a result, no revision was made to the questionnaire.

STATISTICAL ANALYSIS

The data were analyzed using SPSS version 22.0 for Windows (SPSS Inc., Chicago IL). Quantitative data on participant characteristics were described with summary statistics. For interval/ratio data, independent sample t-tests, and for nominal/ordinal data, Chi-square tests, with the between-subject factor of meal orders, were conducted to examine the difference between meal orders on participant characteristics. Due to a statistically significant difference between meal orders for race and ethnicity, these two variables were used as covariates in subsequent analyses. For all analyses on intake, Mixed foods were analyzed using their food categories (e.g. sandwich, pasta dish, chicken and rice, and wrap). Percent agreement between the raters was calculated. Percent agreement for food identification between the DietCam and provided foods was analyzed using a 2x2x2x2x4 mixed analysis of covariance, with a between-subject factor of meal orders (Meal 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 percent agreement between outcomes (True Positive, False Positive, False Negative, True Negative), with covariates of ethnicity and race. Mauchly's Test of Sphericity indicated that the assumption of sphericity had been violated for percent agreement, χ^2 (5) = 81.3, $p < 0.0001$. Greenhouse-Geisser corrections was used to adjust for sphericity. Post hoc pairwise comparisons using Bonferroni corrections were made to determine which groups differed in percent agreement between DietCam and provided foods. A 2x2x2x2x2 mixed analysis of covariance, with a between-subject factor of meal orders (Meal 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 (WFI and 24-hour dietary recall), and covariates of ethnicity and race, was conducted for the amount of food consumed. For significant outcomes, alpha was set at 0.05. Quantitative and qualitative data from the questionnaire were summarized.

RESULTS

PARTICIPANT CHARACTERISTICS

Participant characteristics by meal order are presented in Appendix 1, Table 4. Participants were aged 25.1 ± 6.6 years with a BMI of 22.7 ± 1.6 kg/m^2. The participants were 56.7% female and 43.3% male. No statistical significant differences were found between Meal Order 1 and 2 for age (p = 0.68) and BMI (p = 0.59). No statistical significant differences were found between meals orders and sex (χ^2 (1, N = 30) = 1.2, p = 0.27), education level (χ^2 (3, N = 30) = 5.3, p = 0.15), and marital status (χ^2 (1, N = 30) = 0, p = 1.00). Over 96.6% of participants had some college education and 86.7% of participants were never married. For race, participants were predominately White (46.7%) and Asian (46.7%). Statistically significant differences were found between meal orders for race [χ^2 (3, N = 30) = 13.7, p = 0.003] with 80.0% of participants in Meal Order 1 identifying as Asian and 73.3% of participants in Meal Order 2 identifying as White. Statistically significant differences were also found between meal orders for ethnicity [χ^2(1, N = 30) = 6.0 p = 0.01] with 100% of participants identifying as non-Hispanic or Latino in Meal Order 1 and 66.7% identifying as non-Hispanic or Latino in Meal Order 2.

FOOD IDENTIFICATION

<u>PROVIDED FOOD: IMAGES CODED BY RATER</u>

Thirteen meals were double-coded to determine percent agreement between raters. The overall mean percent agreement between raters was 84.5 ± 3.7% (n=13), and the percent agreement for individual meal was 85.3 ± 3.4% for Meal A (n=6) and 83.9 ± 4.0% for Meal B (n=7).

Summary of coded images by meals is presented in Appendix 1, Table 5. A total of 36,412 images were coded (18,344 in Meal A and 18,068 in Meal B). A total of 33,376 (91.6% of total images) images were coded with foods, with 16,599 (49.7% of images coded with foods) in Meal A and 16,735 (50.1% of images coded with foods) in Meal B. In Meal A, 49.9% of images were coded as cookies, 53.6% were coded as chips, 32.2% were coded as chicken and rice, and 30.6% were coded as sandwich. Of those coded images in Meal A, the largest percentage of images for cookies and chips were coded as 100% of food available and visible on the serving plate (cookie = 26.4%, chips = 26.9%), while the largest percentage of images for chicken and rice and sandwich were coded as less than 100% of food available and visible on the serving plate (chicken and rice = 22.4%, sandwich = 20.1%). In Meal B, 52.9% images were coded as ice-cream, 58.2% were coded as grapes, 30.6% were coded as pasta dish, and 25.1% were coded as wrap. Of those coded images in Meal B, 36.6% of images with ice-cream, the largest percentage of images, was coded as 100% of food available and visible on the serving plate. For grapes, 32.5%, the largest percentage of images, was coded as less than 100% of food available and visible on the serving plate. For the pasta dish, 22.0%, the largest percentage of images, was coded as less than 100% of food available and visible on the serving plate. For the wrap, 11.4%, the largest percentage of images, was coded as 100% of food available and visible on the serving plate. When the images for Meal A and Meal B are combined, 2,778 images (7.6% of total images) were coded as having no food at all in the image and 2,101 images (5.8% of total images) were coded as blurry images.

DIETCAM

Results of DietCam in food identification (classification) are presented in Appendix 1, Table 6. DietCam identified foods in 27,781 images (76.3%), with 14,077 in Meal A and 13,704 in Meal B. In Meal A, 38.5% of images were identified with cookies by DietCam, 21.4% were identified with chips, 18.8% were identified with chicken and rice, and 17.7% were identified with sandwich. In Meal B, 12.2% of images were identified with ice-cream, 43.3% were identified with grapes, 18.7% were identified with pasta dish, and 16.2% were identified with wrap.

PERCENT AGREEMENT FOOD IDENTIFICATION: DIETCAM VS. PROVIDED FOOD

Results of food identification (classification) for each food for DietCam vs. coded image are shown in Appendix 1, Table 7. The overall mean of True Positive was 22.2 ± 3.6 %, False Positive was 1.2 ± 0.4%, False Negative was 19.6 ± 5.0%, and True Negative was 56.8 ± 7.2%. After adjusting for race and ethnicity, a statistically significant main effect of percent agreement was found [(F (3,48) = 8.5, $p < 0.0001$]. The pairwise comparisons for the main effect of percent agreement indicated statistically significant differences between True Positive and False Positive ($p < 0.0001$), True Positive and True Negative ($p < 0.0001$), False Positive and False Negative ($p < 0.0001$), False Positive and True Negative ($p < 0.0001$), and False Negative and True Negative ($p < 0.0001$). Furthermore, there was no statistically significant difference found between True Positive and False Negative ($p = 0.22$). No other statistically significant main effects or interactions were found for shapes, complexities, and meals.

PARTICIPANTS' FEEDBACK

All participants (n=30) completed the questionnaire regarding their experience using Sony Smarteyeglass at the second meal session. Summary tables of responses to all questions showed in Appendix 1, Tables 8-13.

PARTICIPANTS' EXPERIENCE

The majority, 83.4%, of participants reported that it was either easy or extremely easy to use Sony Smarteyeglass, and one participant reported it was hard to use Sony Smarteyeglass. The one participant reporting that it was hard to use the glasses commented on the "annoying user-interface set-up of the Sony Smarteyeglass and hard to find menu." For responses to the clearness of the instructions provided to use Sony Smarteyeglass, all of the participants found the instructions were either clear or extremely clear. Over 70% of participants reported being satisfied with using the Sony Smarteyeglass and 10% were unsatisfied. For those who reported being unsatisfied, participants reported the Sony Smarteyeglass was hard to wear and not suitable for people who wear eyeglasses due to the heaviness and large size of the Sony Smarteyeglass.

LIKELIHOOD AND COMFORTABLENESS OF WEARING SONY SMARTEYEGLASS

Regarding the likelihood of wearing Sony Smarteyeglass during dining episodes in different situations, the responses of unlikely and extremely unlikely regarding wearing Sony Smarteyeglass were more frequently reported for dining situations when eating alone at home (43.4%), at restaurant (76.7%), and at work (56.7%). Similar results were found when participants were eating with friends or family at home (66.6%), at restaurant (90%), at work (76.6%), and at party (76.7%). In particular, over half of the participants (56.7%) reported they would be extremely unlikely to wear Sony Smarteyeglass at a party eating with family or friends.

Participants generally had concerns regarding privacy and the appearance and weight of the Sony Smarteyeglass.

Regarding the likelihood of participants remembering to put on Sony Smarteyeglass and start the recording before eating, over half of participants reported either being likely or extremely likely to remember to complete these steps. However, participants (16.7%) who responded either unlikely or extremely unlikely to remember reported that it would be difficult to develop the habit to wear Sony Smarteyeglass and start recording before each eating episode. For the comfortableness of Sony Smarteyeglass capturing images other than eating, most responses were reported with 40% of participants reported either comfortable or extremely comfortable and 36.7% reported either uncomfortable or extremely uncomfortable. For those who reported being uncomfortable or extremely uncomfortable, participants again expressed concerns regarding invasion of privacy and potentially affecting others around them.

FOOD VOLUME

<u>WFI VS 24-HOUR DIETARY RECALL</u>

Results of each food category is shown in Appendix 1, Figures 2 to 5. Overall, no statistical significant main effect was found for food shapes [(F (1,25) = 0.2, p = 0.70], food complexities [(F (1,25) = 3.6, p = 0.70], meal orders [(F (1,25) = 0.7, p = 0.41], or methods of assessing intake [(F (1,25) = 2.4, p = 0.14], after adjusting for race and ethnicity. The overall mean WFI (n=30) for single food was 354.4 ± 126.2g, mixed food was 682.9 ± 191.7g, regular-shaped food was 599.8 ± 208.5g, and irregular-shaped food was 437.5 ± 118.4g. For 24-hour dietary recall (n=29), the mean intake for single food was 302.6 ± 132.6g, mixed food was 739.3 ± 264.9g, regular-shaped food was 556.0 ± 209.6g, and irregular-shaped food was 632.7 ± 265.7g.

DISCUSSION

The purpose of the study was 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 volume consumed. This study was designed to determine the accuracy of DietCam in identifying foods of differing shapes (Regular vs Irregular) and complexities (Single vs Mixed food). Additionally, this study was to determine the accuracy of DietCam in determining food volume consumed as compared to WFI measured from plate waste method.

The results of the analyses for food identification, classification, indicate that DietCam has the best accuracy in determining when a food is not present. DietCam also has a low mis-identification (identifying a specific food when it is not in the image) rate, 1.2 ± 0.4%. However, no significant difference was found between True Positive and False Negative, indicating that there was no difference in DietCam's ability in correctly identifying the provided foods when the foods are present in images and not identifying the provided foods when the foods are present in images. This would mean that within any given image with a food, the food would miss being identified just as frequently as being correctly identified. The findings also suggest that there was no difference in DietCam's ability in identifying Regular- and Irregular-shaped foods, and Single and Mixed foods.

Only one other recent study has examined how well an automated system identifies food in images, but this system only identified if any food is in the image or if the image does not contain any food. Thus, it appears that this system does not have the capacity to identify a specific food in the image. In this study conducted by Jia and colleagues,[51] participants used a wearable device, eButton, to collect the images. Only the results of two meals sessions were reported in the study. The investigators found that in the first meal session, the system identified food as being in the image in 92.6% of the images that did contain food.[51] It incorrectly identified that an image did not contain food in 7.4% of images that did contain food.[51] It incorrectly identified an image as containing a food in 9.6% of images that actually did not contain a food.[51] It correctly identified images as not containing food in 90.4% of images that did not contain a food.[51] In the second meal session, the system correctly identified food in the image in 79.4% of images that did contain food.[51] It incorrectly identified that an image did not contain a food in 20.6% of images that did contain a food.[51] It incorrectly identified that food was present in 7.0% of images that did not contain a food, and correctly identified that an image did not contain a food in 93% of images without food.[51] When the data in the present study are examined as identification being food present in an image or not (rather than a specific food identified in an image or not), DietCam correctly identified food in an image in 82.1% of images with food present in images. It incorrectly identified that an image did not contain food in 17.9% of images that contained food. It incorrectly identified that food was present in 12.8% of images that did not contain a food, and correctly identified that an image did not contain food in 87.2% of the images without food. The findings in the present study show that DietCam is similar in accuracy to the previous study for identifying food in images that contain foods but may be less accurate when identifying that food is not in an image when food is truly not in images. This difference in results may be a consequence of sampling (the previous investigation was providing information per meal for only two meals, while this study is presenting summary statistics on 40 meals), or potentially due to DietCam trying to identify specific foods in images (rather than just if food is present), which may create more error in saying a food is present in an image when no food is present.

The findings of food identification, classification, in the present study are novel as no current passive image-assisted dietary assessment methods possesses the ability to automatically identify specific food items. Previous studies[37-39,41] validating different passive image-assisted dietary assessment methods either rely on participants to identify food items consumed or rely on raters to recognize food items from images taken by the passive methods. With the manual food identification process, these passive methods validated in previous studies did not eliminate the possibility of human errors and bias. However, the present study completely eliminated human effort in the process of identifying food items from images taken by Sony Smarteyeglass. A previous study validating an active image-assisted dietary assessment method, mobile Food Record (mFR), has the automatic image analysis to classify food items and estimate portion sizes.[36] However, there was no information reported on the accuracy of mFR in identifying food items from the images taken by participants.[36] Although mFR has the function of automatic food identification, it requires a specific colored fiducial marker to facilitate the identification of foods and beverages in captured images.[52] DietCam used in the present study does not require any reference objects to facilitate the food identification process.

Feedback from participants suggest that the Sony Smarteyeglass was easy to use and clear instructions were provided. This finding is inconsistent with a previous study[37] validating Image-Diet Day system, a passive image-assisted dietary assessment method that included a wearable mobile phone. Arab and colleagues[37] found that 71% of participants had difficulty using the wearable mobile phone. Participants in the present study did have negative feedback on the likelihood and comfortableness of wearing the Sony Smarteyeglass at different dining situations. This feedback, combined with participants' concerns regarding privacy and the appearance and weight of the Sony Smarteyeglass, suggest that it would be unlikely for participants to wear the Sony Smarteyeglass at meal times. These findings are consistent with the findings of the wearable mobile phone used in Image-Diet Day system. In the study conducted by Arab and colleagues,[37] participants reported the wearable mobile phone was heavy to wear and too large in size.

The finding in the present study that there was no significant difference in the volume consumed between the 24-hour dietary recalls and WFI is inconsistent with the literature that has found underreporting of dietary intake using self-reported dietary assessment.[10-13,53] The previous studies[10-13,53] were conducted in free-living situation, while the present study was in a controlled laboratory setting and required participants to really examine their food both at the start and the end of the meal due to the instructions provided to capture the images with the Sony Smarteyeglass. Thus, the extended time of looking at each provided foods may potentially increase the participant's awareness of the portion consumed. Studies have found that increased training on portion sizes improves the accuracy of portion size estimation as people were more familiar with the portions.[54-56]

The study has a number of limitations and strengths. The first limitation is that the subclass identification and food volume estimation were not completed as proposed since they were not at a stage that allowed completion of these variables. Future research is needed for these steps of image analyses. Second, this study only included the results from text files to perform analysis of the food identification (classification) of DietCam. The text files used for analysis in the present study did not specify whether if the rectangle frame was correctly placed on the identified foods or not. For example, the text file may indicate that cookies were in the image, but the actual image may have a rectangle frame around the chips and label the frame cookies (so frame around the wrong food) and miss having a rectangle frame around the cookies in the image. Thus, the food identification generated by DietCam in the text files used for analysis may have additional errors than what is reported. Third, the present study had a limited number of images for training from each participant (28), which could have resulted in incomplete training for the DietCam. The images captured a wide variety of different angles of the foods, and the small number of training images might not have captured all the angles required to completely train the DietCam system to identify each food item. Lastly, there were limited numbers of foods included in the present study. Thus, it is not clear how well DietCam would accurately identify items consumed in eating occasions with greater variety of foods or across several eating occasions in a day.

For strengths, the present study examined DietCam's ability to identify food items differing in shape and complexity, which has not been done in previous studies investigating passive image-assisted dietary assessment.[37-39,41] Second, the present study was the first to validate a passive image-assisted dietary assessment with a complete automatic food identification process by food items. Third, the present study included a larger and more diverse sample as compared to previous studies investigating passive image-assisted dietary assessment.[37,39,41]

To better enhance understanding of the accuracy of food identification by DietCam, future research should further investigate what types of images (100% of food available and visible on the serving plate, less than 100% of food available and visible on the serving plate, or food in the image but not on the plate (being consumed [held in hand or on utensil]) would impact the accuracy of food identification. By understanding what types of images lower the accuracy of identification, potentially those types of images could be eliminated from the analyses of identification. Second, future studies should further examine the number of images that are needed for food identification in dietary assessment. For example, the passive image-assisted dietary assessment collects many more images as compared to the active image-assisted dietary assessment (thousands of images vs. two images). Thus, in the passive image-assisted dietary assessment, for food identification, potentially images need to be analyzed until no new additional foods are identified. For this type of process, analyses of images do not need to be 100% accurate (i.e., a food would not need to be correctly identified in every image), as if a food was identified in at least one image, it would be considered to be an item consumed. Most importantly for accuracy in dietary assessment, the analyses from the images should not identify a food in an image that actually was not there, and thus not consumed. Moreover, since the participants reported that they were not willing to wear the Sony Smarteyeglass under different dining episodes, future studies should investigate the feasibility of other wearable devices that are smaller in size to decrease the noticeable appearance and/or increase the comfortableness of the devices. Lastly, to address privacy concerns, future studies should incorporate automatic processes to remove images with human faces before analysis, which has been previously done by Sun and colleagues[40] in one of the passive image-assisted dietary assessment methods.

Overall, while DietCam shows promise with its automatic food identification system, when the analyses are about identifying specific foods consumed, it is most accurate in identifying images that do not contain food. However, when identification is only about if an image contains a food, rather than a specific food, DietCam shows a high degree of accuracy of identifying that food is in an image. Furthermore, from a consumer perspective, the platform from which the images are collected needs to be modified to enhance consumer acceptance. Future research is needed to enhance DietCam’s ability to identify components of foods consumed, rather than just broad categories of food, and its ability to estimate volume of food consumed; to incorporate a smaller and unnoticeable wearable device for the platform from which to collect images; and to examine the feasibility of this system in free-living situation.

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APPENDICES

APPENDIX 1 – TABLES & FIGURES

Table 1. Description of study design.

Meal 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 Chip 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 Chip Cookie (*Regular-shaped single food*) Potato Chips Original (*Irregular-shaped single food*)

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	Tyson® 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 Own® 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.

<table>
<tr><th rowspan="2">Mea
ls</th><th rowspan="2" colspan="2">Food</th><th colspan="2">Female</th><th colspan="2">Male</th></tr>
<tr><th>Amount Served</th><th>Calories Served</th><th>Amount Served</th><th>Calories Served</th></tr>
<tr><td rowspan="11">A</td><td rowspan="6">Turkey & Provolone Cheese Sandwich</td><td>Whole Wheat Bread</td><td>52g</td><td>120</td><td>52g</td><td>120</td></tr>
<tr><td>Turkey</td><td>70g</td><td>62</td><td>133g</td><td>118</td></tr>
<tr><td>Provolone Cheese</td><td>23g</td><td>80</td><td>23g</td><td>80</td></tr>
<tr><td>Tomato</td><td>50g</td><td>8</td><td>50g</td><td>8</td></tr>
<tr><td>Lettuce</td><td>45g</td><td>4</td><td>45g</td><td>4</td></tr>
<tr><td>Total:</td><td>240g</td><td>274</td><td>303g</td><td>330</td></tr>
<tr><td rowspan="3">Chicken and Wild Rice</td><td>Chicken</td><td>98g</td><td>110</td><td>98g</td><td>110</td></tr>
<tr><td>Wild Rice</td><td>71g</td><td>131</td><td>107g</td><td>197</td></tr>
<tr><td>Total:</td><td>169g</td><td>241</td><td>205g</td><td>307</td></tr>
<tr><td colspan="2">Chocolate Chips Cookies</td><td>44g</td><td>213</td><td>60.5g</td><td>293</td></tr>
<tr><td colspan="2">Potato chips Original</td><td>39g</td><td>223</td><td>52g</td><td>297</td></tr>
<tr><td colspan="3">Total Meal A Calories</td><td colspan="2">951</td><td colspan="2">1227</td></tr>
<tr><td rowspan="12">B</td><td rowspan="6">Ham and Cheddar Cheese Wrap</td><td>Tortilla</td><td>45g</td><td>50</td><td>45g</td><td>50</td></tr>
<tr><td>Ham Deli</td><td>76g</td><td>68</td><td>103</td><td>92</td></tr>
<tr><td>Cheddar Cheese</td><td>21g</td><td>85</td><td>32g</td><td>130</td></tr>
<tr><td>Spring Mix</td><td>36g</td><td>9</td><td>36</td><td>9</td></tr>
<tr><td>FF Ranch Dressing</td><td>29g</td><td>25</td><td>29g</td><td>25</td></tr>
<tr><td>Total:</td><td>207g</td><td>237</td><td>247g</td><td>306</td></tr>
<tr><td rowspan="4">Pasta with Broccoli and Alfredo Sauce</td><td>Pasta</td><td>91g</td><td>158</td><td>121g</td><td>210</td></tr>
<tr><td>Broccoli</td><td>66g</td><td>22</td><td>66g</td><td>22</td></tr>
<tr><td>Alfredo Sauce</td><td>38g</td><td>56</td><td>50g</td><td>74</td></tr>
<tr><td>Total:</td><td>195g</td><td>214</td><td>171g</td><td>284</td></tr>
<tr><td colspan="2">Chocolate Ice-cream</td><td>107g</td><td>238</td><td>138g</td><td>306</td></tr>
<tr><td colspan="2">Red Seedless Grapes</td><td>365g</td><td>237</td><td>471g</td><td>306</td></tr>
<tr><td colspan="3">Total Meal B Calories</td><td colspan="2">948</td><td colspan="2">1224</td></tr>
</table>

Table 4. Participant characteristics.

	Meal Order 1 (n=15)[b]	Meal Order 2 (n=15)[b]
Age (years)[a]	25.3 ± 6.2	24.8 ± 7.1
Sex (%)	53.3 (Male) 46.7 (Female)	33.3 (Male) 66.7 (Female)
BMI (kg/m^2)[a]	22.6 ± 1.6	22.8 ± 1.7
Marital Status (%)		
Married	13.3	13.3
Never Married	86.7	86.7
Education Status (%)		
High school (10-12 years)	6.7	0
Some College (< 4 years)	6.7	33.3
College/University Degree	40.0	46.7
Graduate/Professional Education	46.7	20.0
Race (%)*		
American Indian/Alaskan Native	0	6.7
Asian	80.0	13.3
White	20.0	73.3
Other	0	6.7
Ethnic Heritage (%)*		
Hispanic/Latino	0	33.3
Not Hispanic/Latino	100	66.7

[a] Mean ± SD

[b] See Table 1 for description of Meal Orders.

* Significant were found between Meal Orders

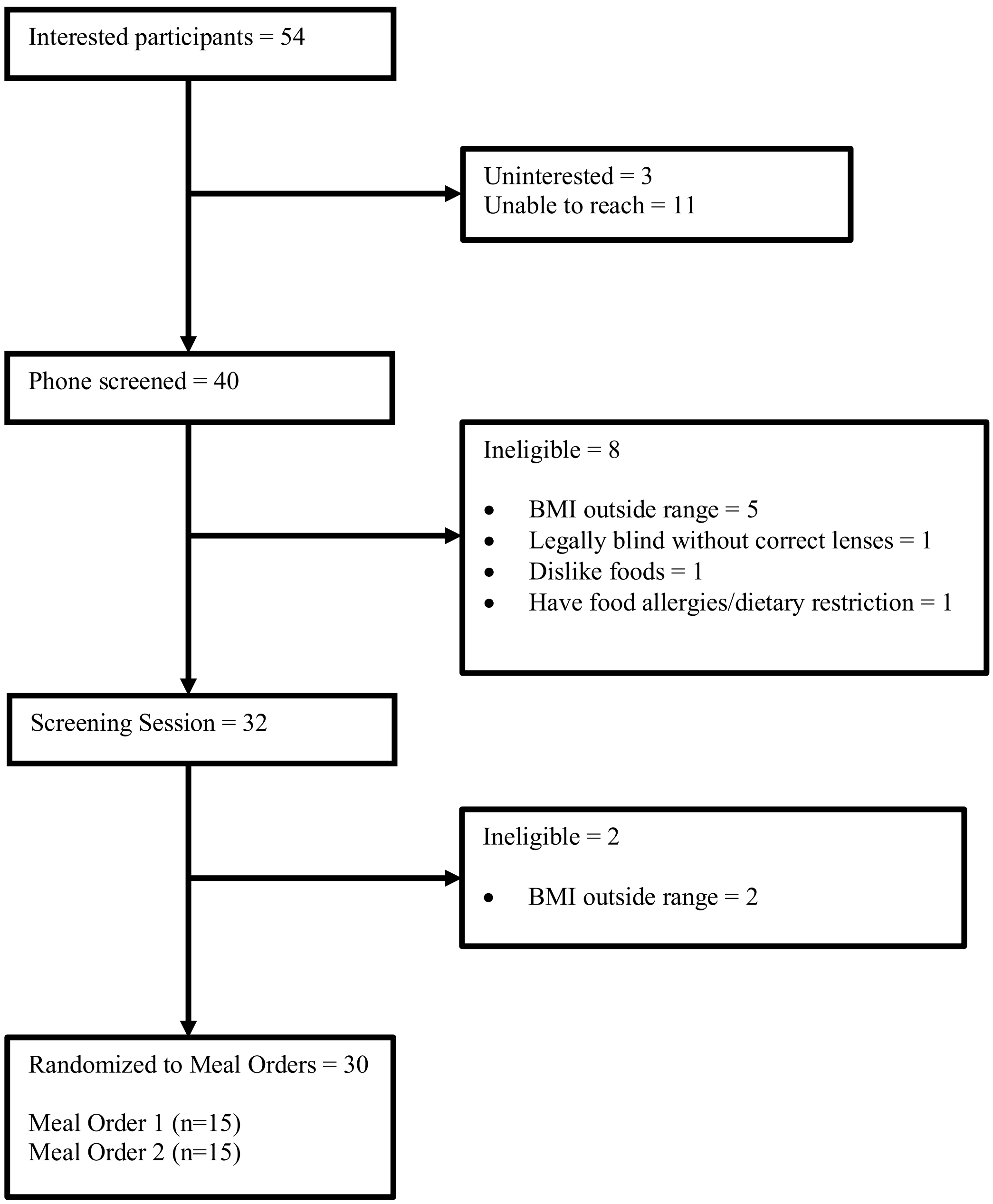


Figure 1. Flow of study participants.

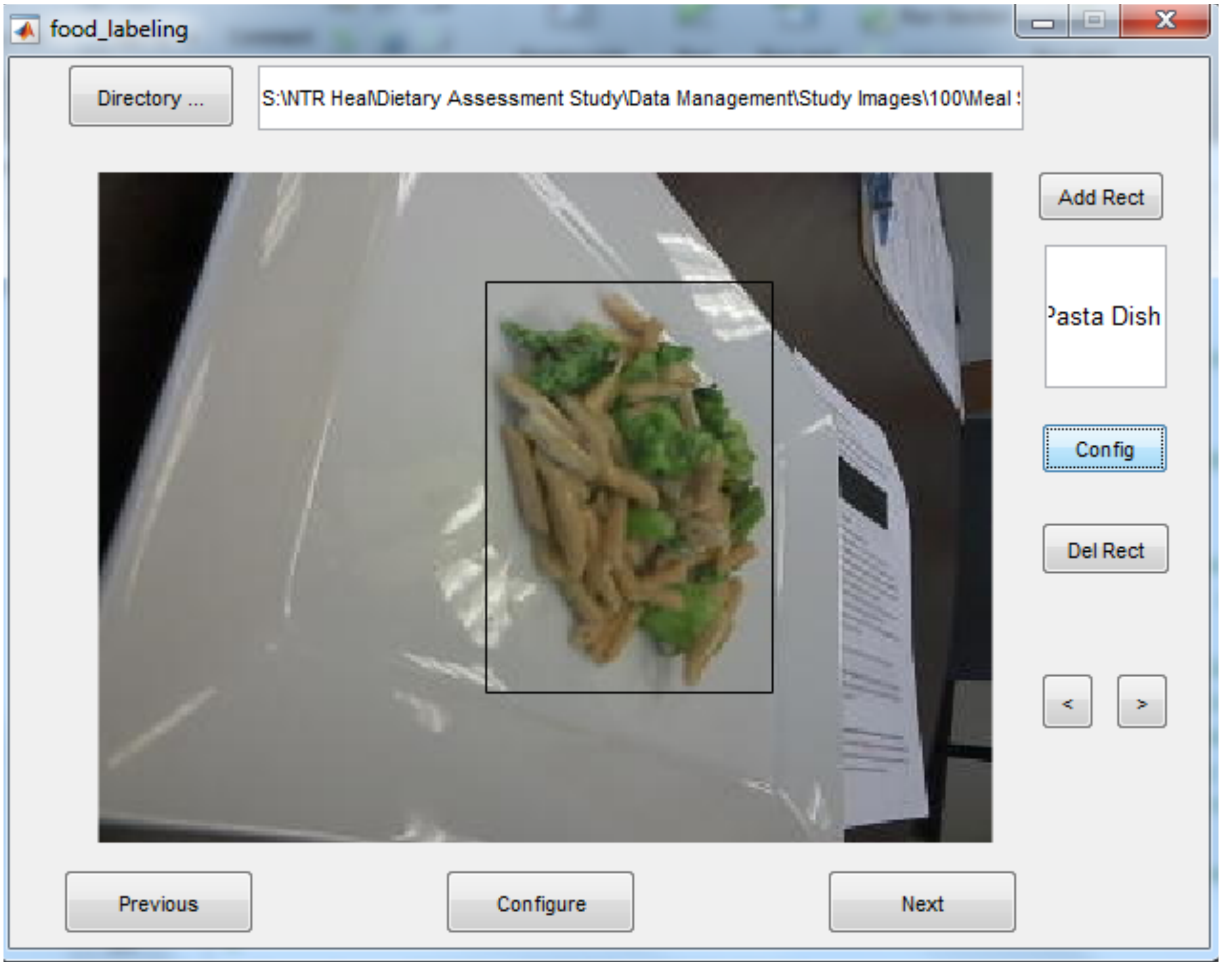
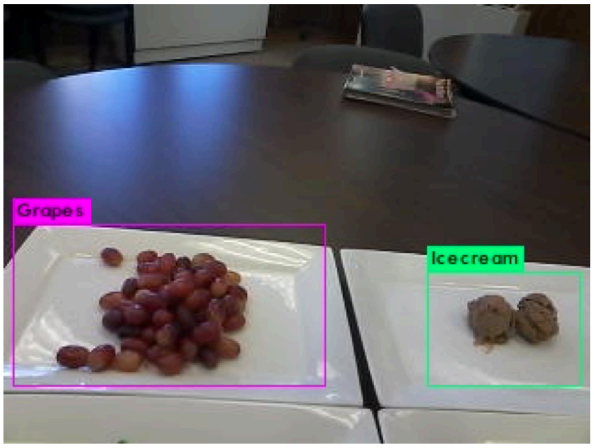


Figure 2. First level of training DietCam for food identification, classification.

For training DietCam at first level of food identification, classification, pasta dish in this image was framed and annotated as "pasta dish".

Processed Image:



Text File:

	A	B	C	D
669	0668.jpg			
670	0669.jpg			
671	0670.jpg		Grapes	
672	0671.jpg		Icecream	Grapes
673	0672.jpg		Grapes	Grapes
674	0673.jpg		Icecream	Grapes
675	0674.jpg		Grapes	
676	0675.jpg		Grapes	
677	0676.jpg		Grapes	
678	0677.jpg		Grapes	

Figure 3. Results of DietCam food identification at first level, classification.

On the left, a processed image by DietCam is shown, with each rectangle frame representing one food identification, which also appears on the associated text file showed on the right and is highlighted.

Figure 4. Example image coded by raters.

This image was coded by raters as: grapes 100% available and visible on the serving plate; ice-cream 100% available and visible on the serving plate; pasta dish less than 100% available and visible on the serving plate; and pasta dish in the image but not on the plate.

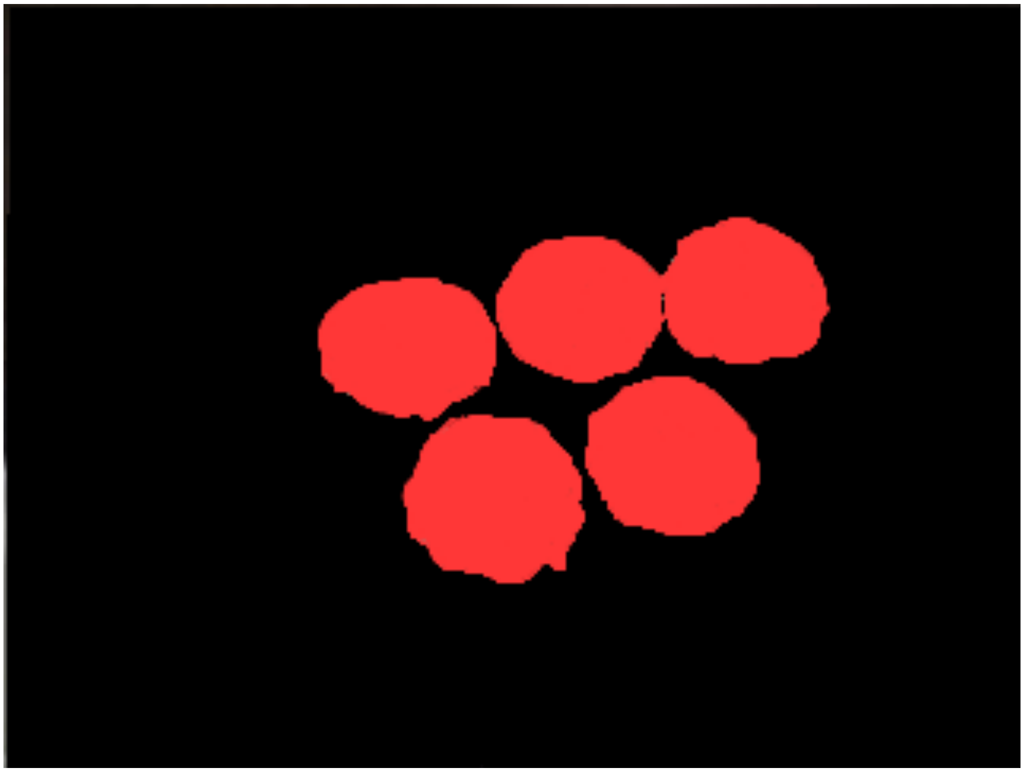


Figure 5. Second level of training DietCam for food identification, subclass identification: Single food.

For training DietCam at the second level of food identification, subclass identification, this particular color was assigned for cookie.

Figure 6. Second level of training DietCam for food identification, subclass identification: Mixed food.

For training DietCam at the second level of food identification, subclass identification, a specific color was assigned to each ingredient in the sandwich.

Table 5. Summary of images coded by raters: Meal A and Meal B.

		Numbers of Images ***n*** **(%)**
Meal A (n=18,344)		
Chocolate Chip Cookies	Item 100% on the plate	4,843 (26.4)
	Item partially on the plate	4,257 (23.2)
	Item in the image but not on the plate	391 (2.1)
Potato Chips	Item 100% on the plate	4,935 (26.9)
	Item partially on the plate	5,096 (27.8)
	Item in the image but not on the plate	383 (2.1)
Chicken & Wild Rice	Item 100% on the plate	1,601 (8.7)
	Item partially on the plate	4,116 (22.4)
	Item in the image but not on the plate	867 (4.7)
Turkey and Provolone Cheese Sandwich	Item 100% on the plate	1,754 (9.6)
	Item partially on the plate	3,692 (20.1)
	Item in the image but not on the plate	1,153 (6.3)
No Food at all		1,590 (8.7)
Blurry		1,062 (5.8)
Meal B (n=18,068)		
Chocolate Ice-cream	Item 100% on the plate	6,612 (36.6)
	Item partially on the plate	2,921 (16.2)
	Item in the image but not on the plate	313 (1.7)
Grapes	Item 100% on the plate	4,644 (25.7)
	Item partially on the plate	5,853 (32.5)
	Item in the image but not on the plate	316 (1.7)
Pasta with Broccoli & Alfredo Sauce	Item 100% on the plate	1,307 (7.2)
	Item partially on the plate	3,978 (22.0)
	Item in the image but not on the plate	1,155 (6.4)
Ham & Cheddar Cheese Wrap	Item 100% on the plate	2,061 (11.4)
	Item partially on the plate	1,944 (10.8)
	Item in the image but not on the plate	740 (4.1)
No Food at all		1,188 (6.6)
Blurry		1,039 (5.8)

Table 6. Results of DietCam food identification.

	Numbers of Images in which Item was Identified ***n* (%)**
Meal A (n=18,344)	
Chocolate Chip Cookies	7,061 (38.5)
Potato Chips	3,931 (21.4)
Chicken & Wild Rice	3,445 (18.8)
Turkey and Provolone Cheese Sandwich	3,238 (17.7)
No food at all	4,267 (23.3)
Meal B (n=18,068)	
Chocolate Ice-cream	2,203 (12.2)
Grapes	7,830 (43.3)
Pasta with Broccoli and Alfredo Sauce	3,386 (18.7)
Ham & Cheddar Cheese Wrap	2,922 (16.2)
No food at all	4,364 (24.2)

Table 7. Results of food identification (classification): DietCam vs provided food.

		Numbers of Images *n* (% per total image in meal)
Meal A (n=18,344)		
Chocolate Chips Cookies	Correctly Identified (True Positive)[a]	6681 (36.4)
	Incorrectly Identified (False Positive)[b]	380 (2.1)
	No Identification (False Negative)[a]	2503 (13.6)
	Not in image (True Negative)[c]	8780 (47.9)
Potato Chips	True Positive[a]	3836 (20.9)
	False Positive[b]	95 (0.5)
	False Negative[a]	6244 (34.0)
	True Negative[c]	8169 (44.5)
Chicken & Wild Rice	True Positive[a]	3284 (17.9)
	False Positive[b]	161 (0.9)
	False Negative[a]	2589 (14.1)
	True Negative[c]	12310 (67.1)
Turkey and Provolone Cheese Sandwich	True Positive[a]	3075 (16.8)
	False Positive[b]	163 (0.9)
	False Negative[a]	2694 (14.7)
	True Negative[c]	12312 (67.7)
Meal B (n=18,068)		
Chocolate Ice-cream	True Positive[a]	2070 (11.5)
	False Positive[b]	133 (0.7)
	False Negative[a]	7489 (41.4)
	True Negative[c]	8376 (46.4)
Grapes	True Positive[a]	7532 (41.7)
	False Positive[b]	289 (1.6)
	False Negative[a]	2980 (16.5)
	True Negative[c]	7267 (40.2)
Pasta with Broccoli & Alfredo Sauce	True Positive[a]	3226 (17.9)
	False Positive[b]	160 (0.9)
	False Negative[a]	2303 (12.7)
	True Negative[c]	12379 (68.5)
Ham & Cheddar Cheese Wrap	True Positive[a]	2572 (14.2)
	False Positive[b]	350 (1.9)
	False Negative[a]	1957 (10.8)
	True Negative[c]	13189 (73.0)

Means with different superscripts were significantly different ($p < 0.05$).
True Positive: coded image result and DietCam result both identify the food in the image
False Positive: coded image result does not identify food in the image while DietCam identifies the food in the image
False Negative: coded image result identifies the food in the image while DietCam does not identify the food in the image
True Negative: coded image result and DietCam result both do not identify the food in the image

Table 8. Questionnaire results: Easiness of using Sony Smarteyeglass.

	Percent % (*n*) *n*=30
Extremely Hard	0 (0)
Hard	3.3 (1)
Neither Hard or Easy	13.3 (4)
Easy	66.7 (20)
Extremely Easy	16.7 (5)

Table 9. Questionnaire results: Clearness of instructions for using Sony Smarteyeglass.

	Percent % (*n*) *n*=30
Extremely Unclear	0 (0)
Unclear	0 (0)
Neither Unclear or Clear	0 (0)
Clear	56.7 (17)
Extremely Clear	43.3 (13)

Table 10. Questionnaire results: Satisfaction with experience using Sony Smarteyeglass.

	Percent % (*n*) *n*=30
Extremely Unsatisfied	0 (0)
Unsatisfied	10 (3)
Neither Unsatisfied or Satisfied	13.3 (4)
Satisfied	53.3 (16)
Extremely Satisfied	23.3 (7)

Table 11. Questionnaire results: Likelihood of wearing Sony Smarteyeglass while eating at different dining situations.

	Percent % (*n*) *n*=30				
	Extremely Unlikely	**Unlikely**	**Neither Unlikely or Likely**	**Likely**	**Extremely Likely**
At home eating alone?	16.7 (5)	26.7 (8)	26.7 (8)	20 (6)	10 (3)
At home eating with family/friends?	33.3 (10)	33.3 (10)	6.7 (2)	23.3 (7)	3.3 (1)
At a restaurant eating alone?	40 (12)	36.7 (11)	10 (3)	10 (3)	3.3 (1)
At a restaurant eating with family/friends?	46.7 (14)	43.3 (13)	6.7 (2)	0 (0)	3.3 (1)
At work eating alone?	26.7 (8)	30 (9)	20 (6)	20 (6)	3.3 (1)
At work eating with family/friends?	43.3 (13)	33.3 (10)	10 (3)	10 (3)	3.3 (1)
At a party eating with family/friends?	56.7 (17)	20 (6)	16.7 (5)	3.3 (1)	3.3 (1)

Table 12. Questionnaire results: Likelihood to remember to wear Sony Smarteyeglass before eating.

	Percent % (*n*) *n*=30
Extremely Unlikely	6.7 (2)
Unlikely	10 (3)
Neither Unlikely or Likely	30 (9)
Likely	46.7 (14)
Extremely Likely	6.7 (2)

Table 13. Questionnaire results: Comfortableness to use Sony Smarteyeglass if it captures images other than eating.

	Percent % (*n*) *n*=30
Extremely Uncomfortable	6.7 (2)
Uncomfortable	30 (9)
Neither Uncomfortable or Comfortable	23.3 (7)
Comfortable	33.3 (10)
Extremely Comfortable	6.7 (2)

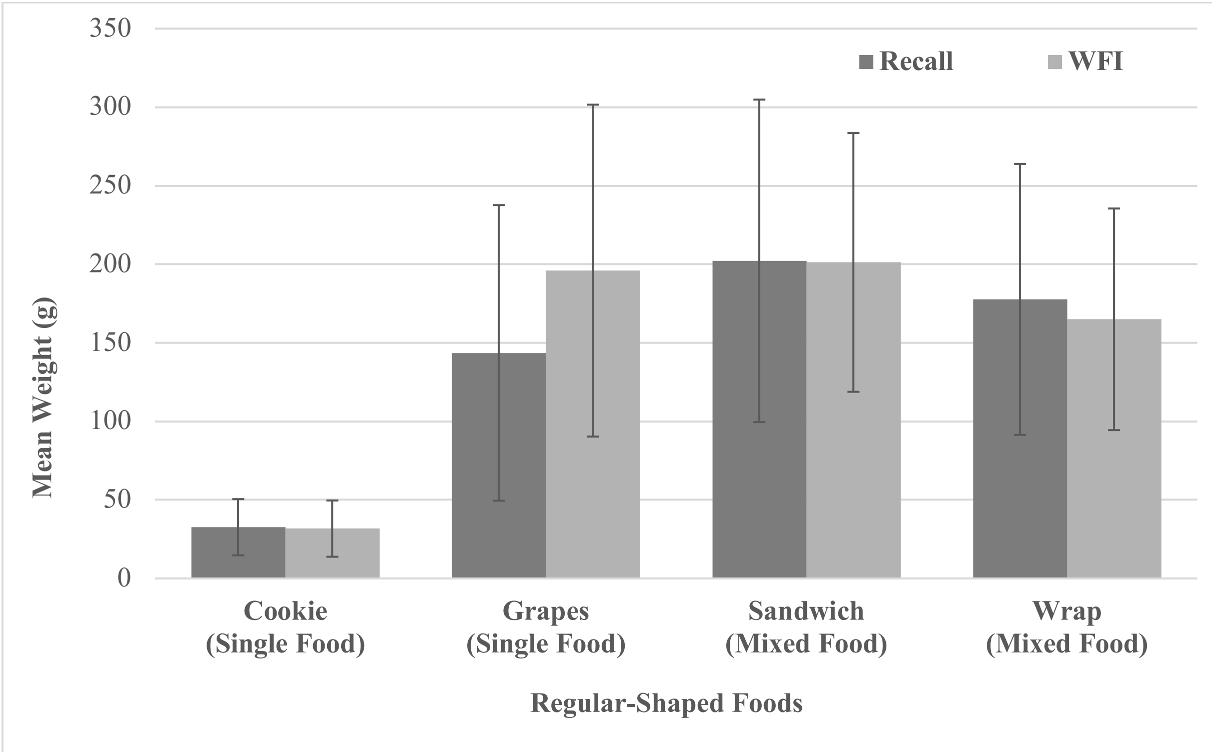


Figure 7. Mean weight of Regular-shaped foods: 24-hour Dietary Recall vs. WFI.

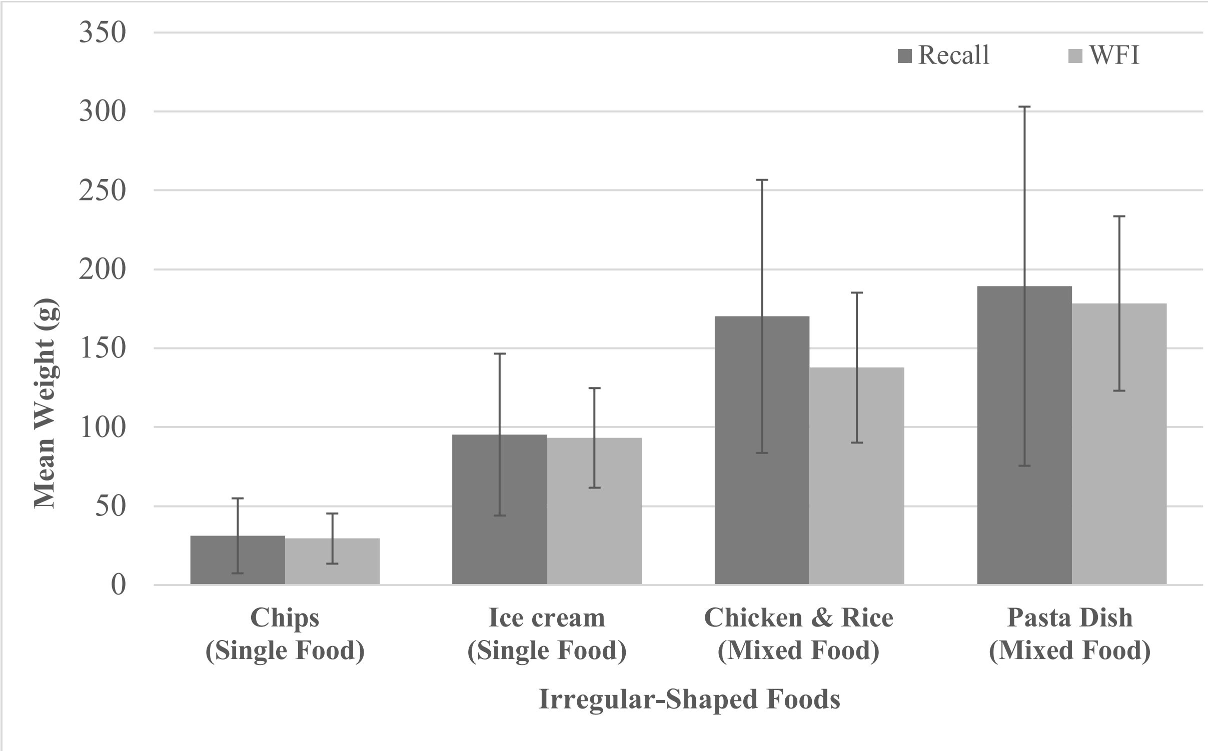


Figure 8. Mean weight of Irregular-shaped Foods: 24-hour Dietary Recall vs. WFI.

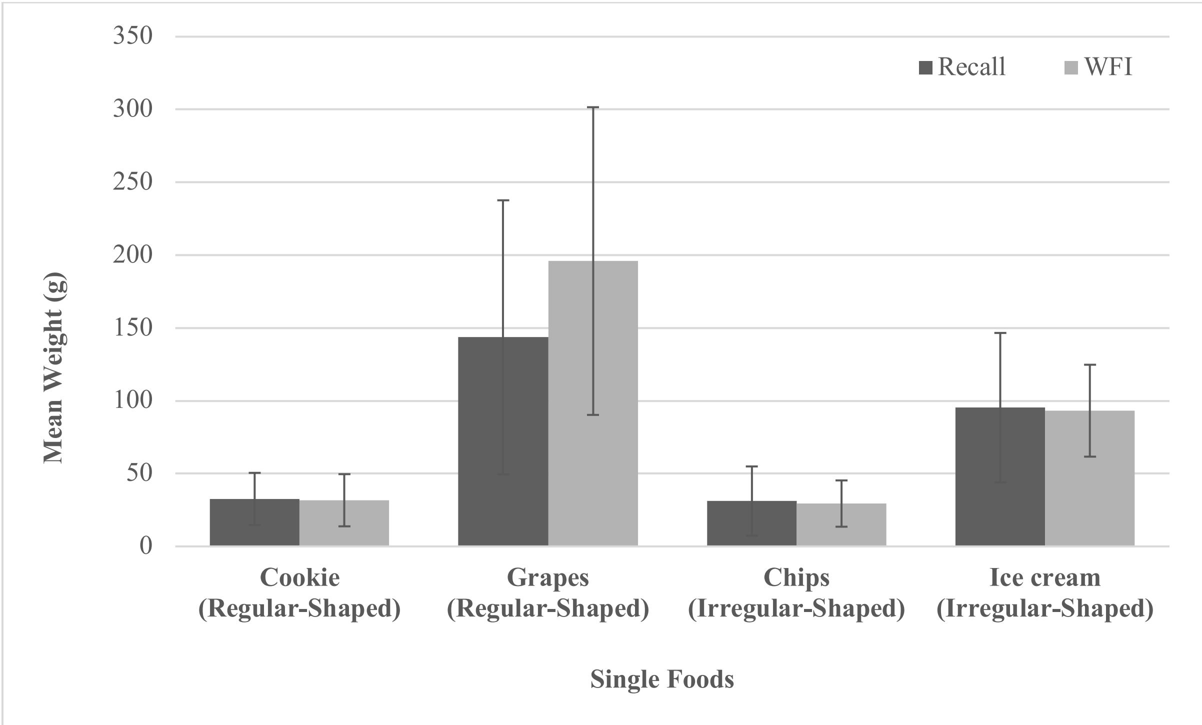


Figure 9. Mean weight of Single foods: 24-hour Dietary Recall vs. WFI.

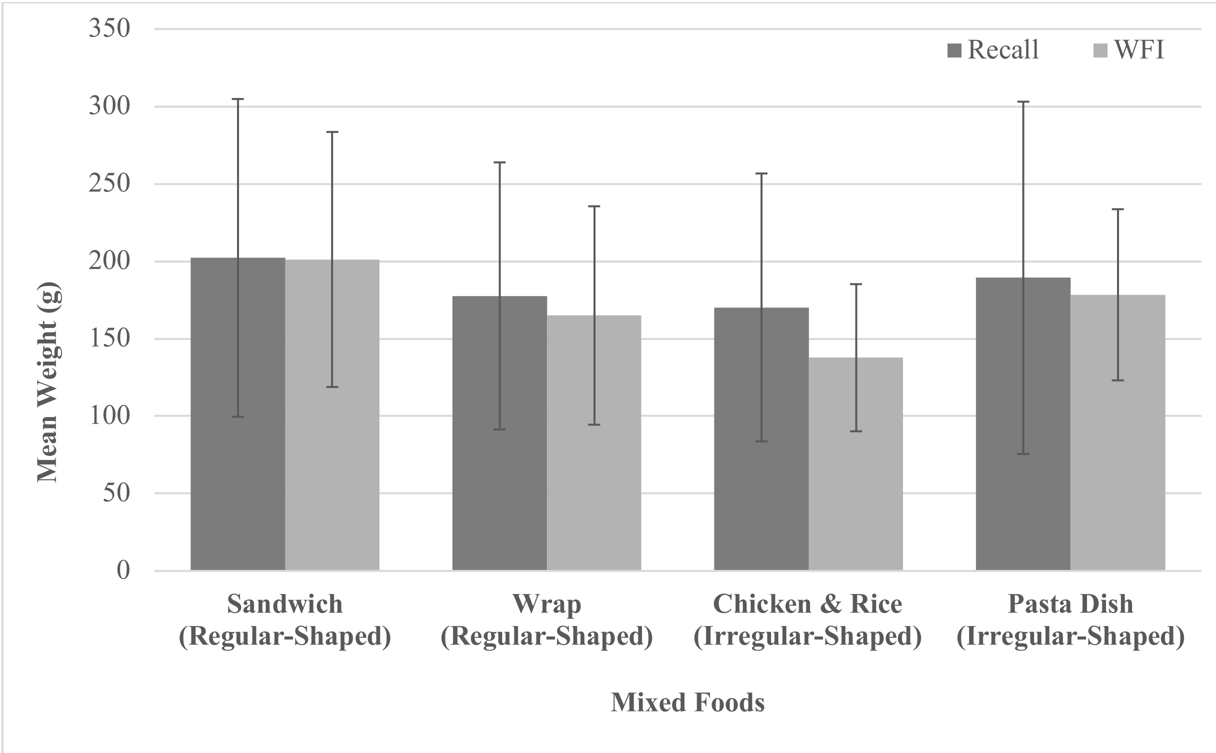


Figure 10. Mean weight of Mixed foods: 24-hour Dietary Recall vs. WFI.

APPENDIX 2 – IRB FORM B

FORM B APPLICATION

All applicants are encouraged to read the Form B guidelines. If you have any questions as you develop your Form B, contact your Departmental Review Committee (DRC) or Research Compliance Services at the Office of Research.

FORM B

IRB # ______________________________

Date Received in OR _________________

THE UNIVERSITY OF TENNESSEE

APPLICATION FOR REVIEW OF RESEARCH INVOLVING HUMAN SUBJECTS

I. IDENTIFICATION OF PROJECT

1. **Principal Investigator:**
   Tsz-Kiu Chui, RD (Principal Investigator)
   Jessie Harris Building Room 229
   1215 W. Cumberland Avenue
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   Faculty Advisor:
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   Jessie Harris Building Room 229
   1215 W. Cumberland Avenue
   Knoxville, TN 37996-1920
   974-6259
   hraynor@vols.utk.edu

   Department:
   Nutrition

2. **Project Classification: Research project**

3. **Title of Project: Validation Study of a Passive Image-Assisted Dietary Assessment with Automated Image Analysis Process**

4. **Starting Date: Upon IRB Approval**

5. **Estimated Completion Date: December 2018**

6. **External Funding** ***(if any):*** N/A

    - **Grant/Contract Submission Deadline:**
    - **Funding Agency:**
    - **Sponsor ID Number** *(if known)*:
    - **UT Proposal Number** *(if known):*

II. 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.

III. DESCRIPTION AND SOURCE OF RESEARCH PARTICIPANTS

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 Description of Study Design). 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.

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 Chip 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 Chip 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 ≥ 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.

IV. METHODS AND 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 Detailed Description of Provided Foods 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 Detailed Description of Meal Sessions. 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.

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	Tyson® 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 Own® 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

Detailed Description of Meal Sessions

Meals	Food		Female		Male	
			Amount Served	Calories Served	Amount Served	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 digital 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.

Statistical Analyses

The data will be analyzed using SPSS version 22.0 for Windows (SPSS Inc., Chicago IL). Quantitative data on participant characteristics and responses for the questionnaire regarding participants' feedback will be described with summary statistics. Qualitative data from the questionnaire will be summarized. For all analyses, mixed foods will be broken into their food categories (e.g. sandwich, pasta dish, etc.) and also into their individual food components (e.g., whole wheat bread, turkey, provolone cheese, etc.), with analyses conducted using both methods for coding mixed foods. Percent agreement for food identification between the DietCam and provided foods will be determined for irregular- and regular-shaped foods and single and mixed foods. Inter-rater agreement on food identification between the DietCam and provided foods for irregular- and regular-shaped foods and single and mixed foods will be determined using Cohen's kappa coefficient. For food volume, percent amount agreement will be described by dividing the DietCam consumed amount by actual consumed amount, and then multiplying by 100 for irregular- and regular-shaped foods and single and mixed foods. A 2x2x2x2x3 mixed analysis of variance, with a between-subject factor of orders (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, WFI, and 24-hour dietary recall) will be conducted for amount of food consumed. For significant outcomes ($p<0.05$), post hoc pairwise comparisons using Bonferroni corrections were made to determine which groups differed in total grams and energy consumed. The Greenhouse-Geisser corrections were used when appropriate for repeated measures to adjust for sphericity.

V. SPECIFIC RISKS AND PROTECTION MEASURES

<u>Human Subjects Research and Protection from Risk</u>

<u>Risks to Subjects</u>

Human Subjects Involvement and Characteristics. Participants will be 30 healthy weight men and women, 18 to 65 years old recruited from the University of Tennessee campus. Participants will be eligible if they meet 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 ≥ 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.

Rationale for Exclusion of Children and Adolescents. These groups may respond differently to the use and the instructions of the Sony Smarteyeglass. The first step in validating this approach for dietary assessments is to determine if this approach works with adults.

Source of Materials. Participants will provide weight, dietary intake, and questionnaire data specifically for research purposes. Participants will be given a unique identification number that will be used on all documents and electronic data files with no references to individual names, addresses, or phone numbers. Hard copies of data will be stored in locked file cabinets in locked rooms in which only project staff will have access (Jessie Harris Building [JHB], room 102) and electronic files will be password protected. No personal identification information including participants' names, addresses, or phone numbers will be digitally recorded by Sony Smarteyeglass during sessions. Videos/images will be downloaded directly to the university server weekly and saved as electronic data files with a unique identification number assigned to each documents and files. Only project staff will have access to the electronic copies of videos/images. Videos/images will only be analyzed by the project staffs using the DietCam software.

Potential Risks. The risks of this investigation are considered minimal. Participants could be allergic to the foods used in the investigation; however, all participants will be screened for food allergies prior to consuming the meal. Videos/images taken by Sony Smarteyeglass may capture things other than served foods during the meal sessions; however, all meal sessions will be conducted in HEAL (JHB 102) with only one participant at each scheduled time period. In addition, no personal identification information will be digitally recorded during sessions. Other possible risks related to the research may include loss of confidentiality, discomfort (such as eye strain, fatigue, nausea, or motion sickness) while using the Sony Smarteyeglass, and the use of Sony Smarteyeglass may affect the performance of electronic medical device such as cardiac pacemakers and implantable defibrillators.

Adequacy of Protection against Risk

Recruitment and Informed Consent. 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 contact HEAL and will receive a description of the study over the telephone. Interested participants will be screened over the phone and scheduled for an in-person screening session. Interested participants who meet eligibility criteria will sign a consent form approved by the Institutional Review Board of the University of Tennessee during the first appointment.

Protection against Risk. The confidentiality of all participants will be protected in the following ways: 1) participants will be given a unique identification number that will be used on all documents with no references to individual names, addresses, or phone numbers; 2) all hard copy data will be stored in locked cabinets in the locked rooms of JHB 102; 3) videos/images taken by Sony Smarteyeglass containing no identifiable data will be downloaded directly to the university server weekly and saved as electronic data files, and only analyzed by project staff with DietCam software for research purposes; 4) all electronic data files will be password protected and backed-up; 5) these procedures will be approved by the University of Tennessee's Institutional Review Board to ensure that they meet the standards for the protection of human subjects.

Data and Safety Monitoring Plan

Data Collection, Storage, and Quality Control. All staff involved in data collection will be trained by the PI and must demonstrate competence in administering all questionnaire measures. The research assistant will review all questionnaire data for accuracy and completion. Participants will be re-contacted to provide missing data or to clarify responses. Range checks will be built into the data entry procedure to alert staff to data that should be clarified. Under the supervision of the PI, a complete double-entry verification procedure will be used to ensure that all data entry is correct. Furthermore, Tsz-Kiu Chui will conduct error checking and preliminary analyses of all data to ensure accuracy. Hard copies of data will be stored in a locked filing cabinet and electronic data files will be password protected and backed-up. Data will be stored in JHB 102 and will be retained indefinitely. Videos/images taken by Sony Smarteyeglass will be downloaded directly to the university server weekly and saved as electronic data files to prevent loss of data. Videos/images will be analyzed by project staff with DietCam software. The files will be retained indefinitely.

Participant Confidentiality. All participant records and assessment data from this study will be treated as confidential, including participants' names and the fact they are participating in the study. The records and questionnaires collected will be safeguarded according to the policy of the University of Tennessee, a policy that is based on Tennessee law and which promotes the protection of confidential health information.

Adverse Event and External Review for Data Safety. Adverse events reported during the course of the study will be documented by research staff and reported to the University of Tennessee's Institution Review Board.

VI. BENEFITS

Potential Benefits of the Proposed Research to the Subjects and Others. There are no benefits for participating in this study.

Importance of Knowledge Gained. The potential for minimal risk to human subjects is considered reasonable in relation to the importance of the knowledge that is expected to result from this study. We believe this project is significant because it validates a new passive image-assisted dietary assessment with automated image analysis process, which eliminates human errors in the process of data collection and analysis process. Moreover, the findings of this study will have important applications for future refinement of the automated image analysis software, DietCam, and further development of the passive image-assisted dietary assessment.

VII. METHODS FOR OBTAINING "INFORMED CONSENT" FROM PARTICIPANTS

The study will be described individually to each interested adult during the initial telephone call and then in more detail during the first in-person appointment at HEAL on the University of Tennessee, Knoxville campus. Interested, eligible participants will sign a consent form approved by the Institutional Review Board at the University of Tennessee during the first appointment. Signed consent forms will be stored in locked file cabinets in JHB 102 with participants receiving a copy.

VIII. QUALIFICATIONS OF THE INVESTIGATOR(S) TO CONDUCT RESEARCH

The Principal Investigator will be led by a faculty advisor (Dr. Hollie Raynor), who has extensive research and experience in designing, implementing, and evaluating randomized controlled trials with experience in conducting dietary assessment. Tsz-Kiu Chui is a registered dietitian with three years of work experience in nutrition counseling and dietary assessment.

IX. FACILITIES AND EQUIPMENT TO BE USED IN THE RESEARCH

Research space in JHB will be used for this investigation. The space is in room 102 (Healthy Eating and Activity Laboratory), is 768 square feet, and includes a group meeting room, two offices, a reception area, a storage closet, and a kitchen. Data will be stored in locked filing cabinets and in password-protected files in HEAL.

All equipment to be used is courtesy of HEAL. The following equipment will be used in the research study: a food scale (Denver Instruments SI-8001, Fisher Scientific); a portable digital scale (Healthometer Professional, Sunbeam Product Inc. Raton, FL); and a portable stadiometer (SECA, ITIN Scale Company, Brooklyn, NY). Hard copies of data will be stored in a locked filing cabinet and electronic data files will be password protected and backed-up. Data will be analyzed using NDS-R and the statistical program, SPSS for Windows.

X. RESPONSIBILITY OF THE PRINCIPAL/CO-PRINCIPAL INVESTIGATOR(S)

The following information must be entered verbatim into this section:
By compliance with the policies established by the Institutional Review Board of The University of Tennessee the principal investigator(s) subscribe to the principles stated in "The Belmont Report" and standards of professional ethics in all research, development, and related activities involving human subjects under the auspices of The University of Tennessee. The principal investigator(s) further agree that:

1. **Approval will be obtained from the Institutional Review Board prior to instituting any change in this research project.**

2. **Development of any unexpected risks will be immediately reported to Research Compliance Services.**

3. **An annual review and progress report (Form R) will be completed and submitted when requested by the Institutional Review Board.**

4. **Signed informed consent documents will be kept for the duration of the project and for at least three years thereafter at a location approved by the Institutional Review Board.**

XI. SIGNATURES
ALL SIGNATURES MUST BE ORIGINAL. The Principal Investigator should keep the original copy of the Form B and submit a copy with original signatures for review. Type the name of each individual above the appropriate signature line. Add signature lines for all Co-Principal Investigators, collaborating and student investigators, faculty advisor(s), department head of the Principal Investigator, and the Chair of the Departmental Review Committee. The following information should be typed verbatim, with added categories where needed:

Principal Investigator: Tsz-Kiu Chui, RD

Signature: __________________________ Date: ____________________

Co-Principal Investigator:

Signature: _________________________ Date: ______________________

Co-Investigator:

Signature: _________________________ Date: ______________________

Student Advisor (if any): Dr. Hollie Raynor, PhD, RD, LDN

Signature: ___________________________ Date: ___________________

XII. DEPARTMENT REVIEW AND APPROVAL
The application described above has been reviewed by the IRB departmental review committee and has been approved. The DRC further recommends that this application be reviewed as:

[X] Expedited Review -- Category(s): ________4______________

OR

[ ] Full IRB Review

Chair, DRC: Katie Kavanagh, PhD

Signature: _____________________________ Date: _________________

Department Head: Jay Whelan, PhD

Signature: _____________________________ Date: _________________

Protocol sent to Research Compliance Services for final approval on (Date) : ___________
Approved:
Research Compliance Services
Office of Research
1534 White Avenue

Signature: _____________________________ Date: _________________

For additional information on Form B, contact the Office of Research Compliance Officer or by phone at (865) 974-3466.

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APPENDIX 3 – RECRUITMENT FLYER

Dietary Assessment Study

Interested in participating in a study investigating a new dietary assessment method using images taken by Sony Smarteyeglass? This study may be for you!

You may be eligible if you are...

- between the ages of 18-65 years
- of a healthy weight
- free of dietary restrictions

If interested, contact the Healthy Eating and Activity Laboratory at 865-974-0752.

Receive a $20 Gift Card for participating

Dietary Assessment Study 865-974-0752

Dietary Assessment Study 865-974-0752

Dietary Assessment Study 865-974-0752

Dietary Assessment Study 865-974-0752

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Dietary Assessment Study 865-974-0752

APPENDIX 4 – PHONE SCRIPT

<u>Dietary Assessment via Digital Images Phone Script</u>

Hello, this is ____________. Thanks for calling about the **Dietary Assessment via Digital Images** Study. Let me tell you about the study so that you can decide if you are interested in participating. The purpose of this study is to evaluate a new dietary assessment method using images taken by Sony Smarteyeglass. This study includes a screening appointment in the Healthy Eating and Activity Laboratory (HEAL) and two scheduled meal sessions in HEAL. The screening appointment, which will take approximately 30 minutes to complete, will involve completing informed consent, height and weight measurements and a demographic questionnaire. After the screening appointment, you will be scheduled for two meal session appointments, which will take approximately 40 minutes. These appointments will need to be scheduled between 11 am and 5 pm Monday-Friday. Before each meal session appointment, you will be asked stop eating for a minimum of two hours and only consume water during that period. At the start of each meal session appointment, instructions on how to use Sony Smarteyeglass will be provided to you before we serve a meal to you. Next, a meal will be served to you and you will be asked to put on the Sony Smarteyeglass. After putting on the Smarteyeglass, you will be instructed to start the digital recording of the eyeglass. You will then follow the instructions to use Sony Smarteyeglass and eat the meal until you are satisfied. The meal will either include a turkey & provolone cheese sandwich, chicken and wild rice, chocolate chip cookie, and potato chips; or a ham & cheddar cheese wrap, pasta with broccoli in Alfredo sauce, red seedless grapes, and chocolate ice-cream. On the following day of each meal session, you will be called to complete a dietary recall in which you will report all the foods and beverages consumed within the past 24 hours. The phone call will take approximately 20 minutes to complete. Instructions on how to complete the phone call will be provided to you at the end of each meal session and a visual tool will be provided to you at the end of first meal session to help you in estimating consumed portions. The second meal session will follow the same procedure as the first meal session. At the end of the second meal session, you will be asked to complete a questionnaire regarding your experience using Sony Smarteyeglass. Upon completion of all sessions, you will receive a $20 gift card. If you are interested in participating in this study, I have some questions to ask you to determine your initial eligibility. This will take about 10 minutes.

Go to Screening Form.

SCREENING FORM

1) Gender: ☐ F ☐ M
2) a) Age:________________ b) Date of birth: ___/___/___ **(must be between 18 and 65)**

If age is not between 18 and 65: I am sorry, but the age range we're recruiting for is 18-65. Since you are _____yrs old, you are not eligible for this study. Thank you very much for your time.

3) a) Current weight:_________lbs. b) Height: ____ft ______inches
c) Current BMI: __________ **(must be between 18.5 and 24.9)** **BMI= kg/m² or (lbs/in²) x 703**

If BMI is below 18.5 or above 24.9: I'm sorry, but because your height and weight are not within the range for this study, you aren't eligible for this study. Thank you very much for your time.

Now I have some diet-related questions.
4) Do you have any food allergies or dietary restrictions?
☐ No ☐ Yes → Explain _______________ (**INELIGIBLE** if cereal proteins [wheat, rice, gluten], nuts, milk, or egg protein)

If YES to Q4: I am sorry, but due to the fact that you are allergic to ___________, you are not eligible for this study because the meal contains ____________. Thank you for your time.

5) Do you have a health condition that influences eating or requires a therapeutic diet?
☐ No ☐ Yes **(INELIGIBLE)**

If YES to Q5: I am sorry, but due to the fact that you have a health condition that influences eating, you are not eligible for this study. Thank you for your time.

6) Are you legally blind without corrected lenses?
☐ Yes **(INELIGIBLE)** ☐ No

If NO to Q6: I am sorry, but due to the fact that you are legally blind without corrected lenses, you are not eligible for this study. Thank you for your time.

7) Will you be able to eat a meal while wearing the Sony Smarteyeglass, which looks like a regular eyeglass with a plastic frame and a controller attached to it via an electronic cord?
☐ No **(INELIGIBLE)** ☐ Yes

If NO to Q7: I am sorry, but due to the fact that you would not be able to eat a meal while wearing the Sony Smarteyeglass, you are not eligible for this study. Thank you for your time.

8) Would you be able to complete all the sessions required for this study within 4 weeks of starting the screening session?
☐ No **(INELIGIBLE)** ☐ Yes

If NO to Q8: I am sorry, but due to the fact that you would not be able to complete all sessions within 4 weeks of starting the screening sessions, you are not eligible for this study. Thank you for your time.

9) Do you wear any electronic medical device(s) such as pacemaker and implantable defibrillator?
☐ Yes **(INELIGIBLE)** ☐ No

If NO to Q9: I am sorry, but due to the fact that you are you wear electronic medical device(s) such as pacemaker and implantable defibrillator, you are not eligible for this study. Thank you for your time.

10) Please rate your liking of the foods included in the laboratory meals using a scale of 1-5. 1 means you do not like this food and 5 means you like this food very much.

Turkey & Provolone Cheese Sandwich	**Chicken and Wild Rice**	**Chocolate Chips Cookies**	**Potato Chips**
1 2 3 4 5	**1 2 3 4 5**	**1 2 3 4 5**	**1 2 3 4 5**
Ham & Cheddar Cheese Wrap	**Pasta with Broccoli and Alfredo Sauce**	**Chocolate Ice-cream**	**Red Seedless Grapes**
1 2 3 4 5	**1 2 3 4 5**	**1 2 3 4 5**	**1 2 3 4 5**

If any food is rated less than 3: I'm sorry, since you do not like _________ (food), you are ineligible for the study. Thank you for your interest.

IF ELIGIBLE: Congratulations! I am happy to tell you that you meet the eligibility criteria for this study. I'd like to schedule you for a screening session. We are scheduling appointments Monday-Friday, between 11am and 5pm.

Which days and times work best for you? (Review schedule for available appointments.)
We have ---- (day), ---- (date) at ---- (time). Does that work for you?

Screening Session: M T W R F (circle day), _____________ (date) at ______________(time)

HEAL is located in the Jessie Harris Building, room 102. Do you know where that is?
(If no, provide directions. JHB is located on Cumberland Ave and 12th Ave, next to the 11th Ave parking garage. The UTK website has a building locator if needed.)

We have you scheduled for ---- (day), ---- (date) at ---- (time). Your appointment will take approximately 30 minutes. Please arrive on time as we may have another appointment scheduled immediately after yours.

We will send you an email confirming the appointment. If for some reason you cannot keep your appointment please call our lab at 974-0752. Thanks for participating in our study!

First Name: ____________________________ Last Name: _________________________________

Mailing address:____

Email Address: ____

Day Phone:______________________________ mobile/home/other

Evening Phone:______________________________ mobile/home/other

Eligible: ☐ No ☐ Yes	Screened by:______________________________
If No, Reason:__________________________	Date:____________________________________
Appointment Date: ___/___/___ Time: _______	

Enter participant information on PTL

APPENDIX 5 – CONSENT FORM

INFORMED CONSENT STATEMENT

_________ ___________________

Committee # Name of Study Volunteer

Dietary Assessment via Digital Images

You are being asked to take part in a research study. All research studies carried out at the University of Tennessee are covered by the rules of the federal government as well as rules of the state of Tennessee and the university. Under these rules, the researcher will first explain the study, and then he or she will ask you to participate. You will be asked to sign this agreement, which states that the study has been explained, that your questions have been answered, and that you agree to participate.

The researcher will explain the purpose of the study. She/he will explain how the study will be carried out and what you will be expected to do. The researcher will also explain the possible risks and possible benefits of being in the study. You should ask the researcher any questions you have about any of these things before you decide whether you wish to take part in the study. This process is called informed consent.

This form also explains the research study. Please read the form and talk to the researcher about any questions you may have. Then, if you decide to be in the study, please sign and date this form in front of the person who explained the study to you. You will be given a copy of this form to keep.

INTRODUCTION

Nature and Purpose of the Study

Tsz-Kiu Chui and Dr. Hollie Raynor are conducting a study to investigate the accuracy of a new dietary assessment method using images taken by Sony Smarteyeglass. A total of 30 men and women will participate in this study.

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You have been asked to participate in the study because you are of a healthy weight according to medical standards, an adult between the ages of 18 and 65, and do not have any dietary restrictions to prevent you from taking part in this study. Also, you do not wear any electronic medical devices (such as cardiac pacemakers, implantable defibrillators, etc.) that would make you ineligible for the study.

Please inform researchers any food allergies before enrolling in the research.

INFORMATION ABOUT PARTICIPANTS' INVOLVEMENT IN THE STUDY

<u>Explanation of Procedures</u>

You will be asked to come to the Healthy Eating and Activity Laboratory (HEAL) for 1, 30-minute screening session, and then for 2, 40-minute meal sessions, with approximately one week occurring between each session. During the screening session, after consenting, you will be asked questions about your demographic information (age, race, education, etc.) and your height and weight will be measured. Then you will be scheduled for two meal sessions. You will be asked 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 wear and use Sony Smarteyeglass will be provided to you. The instructions will include how to wear and use the Sony Smarteyeglass. You will be asked to put on the Sony Smarteyeglass and to initiate the recording via the controller of the Sony Smarteyeglass. Next, you will look at each provided food at the table prior to starting to eat. Then, you will turn your head toward your left shoulder and look at each food from the left side, and you will turn your head toward your right shoulder and repeat the same steps. After you looked at each provided food, you will take one bite of each provided food. For the first bite of each food, you will hold the food, either in your 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, you will eat normally until satisfied and be given 30 minutes to eat. At the end of 30 minutes, you will be instructed to again look at each provided food at the table following the exact same procedure at the beginning of the meal.

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For each meal session you will be provided with one of two meals. Meal 1 consists of a turkey and provolone cheese sandwich, chicken and wild rice, chocolate chips cookie, and potato chip. Meal 2 consists of a ham and cheddar cheese wrap, pasta with broccoli and Alfredo sauce, chocolate ice-cream, and red seedless grapes.

On the day following the meal session, you will be called to complete a dietary recall of all foods and beverages consumed within the past 24 hours. The phone call will take approximately 20 minutes to complete.

The second meal session will follow the same procedure as the first meal session, but you will be provided with the meal, either Meal 1 or 2, that you did not receive in the first meal session. At the end of second meal session, you will be asked to complete a questionnaire to provide feedback on your experience using Sony Smarteyeglass. You will need to complete all meal sessions within 4 weeks of the initial screening session. Please call Tsz-Kiu Chui at (865) 974-0752 if you have any questions about these procedures for the study.

All information collected during the study including telephone screening, screening session, and meal sessions will be used for research purpose.

RISKS

Risks of this investigation are considered minimal. Participants may be allergic to foods used in this investigation, but participants will be phone-screened on this criterion. However, you may be at risk for unknown food allergies. Videos/images taken by Sony Smarteyeglass may capture things other than served foods during the meal sessions; however, all meal sessions will be conducted in HEAL (JHB 102) with only one participant at each scheduled time period. In addition, no personal identification information will be digitally recorded during sessions. Other possible risks related to the research may include loss of confidentiality, discomfort (such as eye strain, fatigue, nausea, or motion sickness) while using the Sony Smarteyeglass, and the use of Sony Smarteyeglass may affect the performance of electronic medical device such as cardiac pacemakers and implantable defibrillators. Most studies involve some risk to confidentiality and it is possible that someone could find out you were in this study or see your study information,

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but the investigators believe this risk is unlikely because of the procedures we will use to protect your information.

BENEFITS

There are no direct benefits to participating in this study. However, the results of this study may provide important information to the development of new dietary assessment methodology.

CONFIDENTIALITY

All your records from this study will be kept confidential. Data will be stored securely and will be made available only to persons conducting the study unless participants specifically give permission in writing to do otherwise. No reference will be made in oral or written reports, which could link participants to the study. Participants will be given a unique identification number that will be used on all documents and electronic data files with no references to individual names, addresses, or phone numbers. Hard copies of data will be stored securely and accessible only to research personnel. No personal identification information including participants' names, addresses, or phone numbers will be digitally recorded by Sony Smarteyeglass during sessions. Videos/images will be downloaded directly to the university server weekly and saved as electronic data files with a unique identification number assigned to each documents and files. Only project staffs will have access to the electronic copies of videos/images. Videos/images will only be analyzed by the project staffs using the DietCam software.

COMPENSATION

Participants who complete all study sessions will receive a $20 gift card from Walmart. After the completion of the all 24-hour dietary recalls, the gift card will be mailed to participants. Participants will fill out (name and address) an incentive form and sign the form at the end of second meal session. All information collected to facilitate payment will only be used by the project staff.

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EMERGENCY MEDICAL TREATMENT

The University of Tennessee does not "automatically" reimburse subjects for medical claims or other compensation. If physical injury is suffered in the course of research, or for more information, please notify the investigator in charge, Dr. Hollie Raynor, at (865) 974-6259 or Tsz-Kiu Chui, at (865) 974-0752.

CONTACT INFORMATION

If you have questions at any time about the study or the procedures, or you experience adverse effects as a result of participating in this study, you may contact the researcher, Tsz-Kiu Chui 102 Jessie Harris Building, The University of Tennessee, Knoxville, TN 37996-1920, (865) 974-0752. If you have questions about your rights as a participant, contact the Office of Research Compliance Officer at (865) 974-7697.

PARTICIPATION

Your participation in this study is voluntary; you may decline to participate without penalty. If you decide to participate, you may withdraw from the study at any time without penalty and without loss of benefits to which you are otherwise entitled. However, under any circumstances, the researchers may end your participation in the research. It is possible participants could excluded after enrollment (due to the screening procedures performed at the lab, etc.). Participants may also be excluded after enrollment if they no longer meet eligibility criteria (such as discovery of unknown food allergy). If participants were excluded from the study before data collection is completed, your ineligibility data will be kept indefinitely for publication purposes.

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APPENDIX 6 – STUDY MEASURES

Date: ___________________ Reference #: _____________

Anthropometric Measures

Height: __________ inches

Weight: __________ pounds

BMI: __________ kg/m^2

Dietary Assessment Study

Office Use Only
Reference #:

DATE ☐☐ ☐☐ ☐☐
M M D D Y Y

Demographic Information

1. AGE ☐☐

2. SEX: ☐ MALE ☐ FEMALE
(1) (2)

3. EDUCATION: Check years of school completed. (CHECK ONLY ONE ANSWER)
☐ (1) Grade School (6 yrs or less)
☐ (2) Junior High School (7-9 yrs)
☐ (3) High School (10-12 yrs)
☐ (4) Vocational Training (beyond High School)
☐ (5) Some College (less than 4 yrs)
☐ (6) College/University degree
☐ (7) Graduate or Professional Education

4. MARITAL STATUS:
☐ (1) Married
☐ (2) Separated
☐ (3) Divorced
☐ (4) Widowed
☐ (5) Never Married
☐ (6) Not Married (living with significant other)
☐ (7) Other (specify): ______________________

5. Which of the following best describes your racial heritage? (you may choose more than one)
☐ (1) American Indian or Alaskan Native
☐ (2) Asian
☐ (3) Black or African American
☐ (4) Native Hawaiian or other Pacific islander
☐ (5) White
☐ (6) Other ____________________________

6. Which of the following best describes your ethnic heritage?
☐ (1) Hispanic or Latino
☐ (2) Not Hispanic or Latino

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Dietary Assessment Study

Office Use Only	
Reference #	

DATE of Reported Intake ☐☐/☐☐/☐☐
M M D D Y Y

Meal & Time	Description of Food and Drink	Amt. Consumed

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Dietary Assessment Study

Office Use Only
Reference #:

DATE ☐☐ ☐☐ ☐☐
M M D D Y Y

<u>Participant's Experience with Sony Smarteyeglass</u>

Thinking about your experience with Sony Smarteyeglass, please answer the following three questions.

1. How easy was Sony Smarteyeglass to use? (Please circle one response)

Extremely Hard (1)	Hard (2)	Neither Hard or Easy (3)	Easy (4)	Extremely Easy (5)

a. If you choose *extremely hard or hard*, please describe why.

2. How clear were the instructions for using Sony Smarteyeglass? (Please circle one response)

Extremely Unclear (1)	Unclear (2)	Neither Unclear or Clear (3)	Clear (4)	Extremely Clear (5)

a. If you choose *extremely unclear or unclear*, please describe why.

3. Were you satisfied with your experience using Sony Smarteyeglass? (Please circle one response)

Extremely Unsatisfied (1)	Unsatisfied (2)	Neither Unsatisfied or Satisfied (3)	Satisfied (4)	Extremely Satisfied (5)

a. If you choose *extremely unsatisfied or unsatisfied*, please describe why.

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Thinking about using Sony Smarteyeglass in your every day life, please answer the following three questions.

4. How likely would you wear Sony Smarteyeglass while you are eating in the following situations? (Please check one column for each situation)

	Extremely Unlikely (1)	Unlikely (2)	Neither Unlikely or Likely (3)	Likely (4)	Extremely Likely (5)
a. At home eating alone?					
b. At home eating with family/friends?					
c. At a restaurant eating alone?					
d. At a restaurant eating with family/friends?					
e. At work eating alone?					
f. At work eating with family/friends?					
g. At a party eating with family/friends?					

h. If you choose *extremely unlikely or unlikely* to any of the above situations, please describe why.

5. How likely would you remember to put on Sony Smarteyeglass and start the recording before eating? (Please circle one response)

Extremely Unlikely (1)	Unlikely (2)	Neither Unlikely or Likely (3)	Likely (4)	Extremely Likely (5)

a. If you choose *extremely unlikely or unlikely*, please describe why.

6. How comfortable would you feel using Sony Smarteyeglass if it captures images other than your eating (e.g. faces of people surrounding you, your surrounding area, etc.)? (Please circle one response)

Extremely Uncomfortable (1)	Uncomfortable (2)	Neither Uncomfortable or Comfortable (3)	Comfortable (4)	Extremely Comfortable (5)

a. If you choose *extremely uncomfortable or uncomfortable,* please describe why.

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APPENDIX 7 – STUDY PROTOCOL

Dietary Assessment Study Procedures

Materials needed for the screening session:

- Dietary Assessment Study Checklist
- Stamped consent forms (2)
- Anthropometrics form (1)
  - Calculator for BMI
  - Formula for BMI = [Pounds/ (Inches^2)] X 703
- Demographics form (1)
- Appointment Reminder form
- Pens

Before participant arrive:

1. Print out materials – under "Session1-SCREENING" folder of the Dietary Assessment Study (CEHHS Share → NTR-HEAL → Dietary Assessment Study → Session1-SCREENING)
2. Check the PTL (Dietary Assessment-PTL) to determine the participant's scheduled screening session.

During the session:

1. Once the participant arrives for the appointment, escort him or her into the group room and close the door. Say the following:

   Welcome to the Healthy Eating and Activity Laboratory. You are here today because you indicated that you are interested in participating in the Dietary Assessment Study. The purpose of this study is to investigate the accuracy of a new dietary assessment method using images taken by Sony Smarteyeglass. As you were told over the phone, this study will require three sessions; this first screening sessions will take approximately 30 minutes and the remaining two meal sessions will also take approximately 40 minutes. The meal sessions will need to be scheduled between the hours 11am and 5pm, Monday-Friday. These meal sessions will need to be completed within the next 4 weeks. During this first session, I will describe the study to you and collect informed consent. I will also take measurements of your height and weight. Lastly,

you will also be asked to complete questionnaires regarding your demographics.

2. **Say: We will first start with the informed consent.**
    a. Read through the consent form, making sure that he or she initials each page and then signs the last page. Sign and keep this copy. Hand the participant the other copy and have him or her initials each page and then signs the last page again. Then, give the participant a copy for his or her records.
3. **Say: Thank you for completing the informed consent. Now we will take your height and weight measurements.**
    a. Next, take the participant's height and weight measurements using the stadiometer and scale located in the group room.
    a. Formula for BMI = [Pounds/ (Inches^2)] X 703
4. →If height and weight do not meet eligibility criteria (BMI between 18.5 and 24.9), thank the participant for his or her interest in the study and escort him or her out of the lab.
    a. **Say: Unfortunately, you do not meet the eligibility criteria required for this study. We appreciate your interest in the Dietary Assessment Study. Let me escort you out of the lab. Have a nice day.**
5. **IF ELIGIBILE:** After confirming that the participant is eligible for the study based on height and weight measurements, have the participant fill out the demographic form.
6. Then, scheduled the participant for his or her next in-lab session.
    a. **Say: I would like to schedule you for your next appointments. The appointments can be scheduled between 11am and 5pm, Monday-Friday.**

Will this same appointment day and time work over the next 2 sessions? If not, what day and time are you available to meet next week?

(TRY TO SCHEDULE ALL TWO REMAINING SESSIONS)

7. After the appointment is scheduled, tell the participant that if anything changes to please call the HEAL lab. Thank the participant for coming in for the first lab session and escort the participant out of the lab.

    a. **Say: Your next appointment has been scheduled for _______. If you are unable to keep this appointment for any reason, please call us at 974-0752. We will reschedule your appointment at your earliest convenience. For the next session, we ask that you please stop eating and only drink water 2 hours before your appointment. For example, since your appointment is scheduled at ____, we ask that you stop eating at ______. We look forward to seeing you again on _____ (Hand the participant the appointment sheet). Let me escort you out of the lab. Have a nice day.**

After Session

- Update the PTL and Kiu will randomize participant to Meal Order 1 or 2.
- Meal Order 1 = Screening, Meal A, Meal B
- Meal Order 2 = Screening, Mean B, Meal A

Responsibilities prior to all meal sessions

- Clean cutting board, knives, containers, and serving plates
  *****Make sure everything is dry before using it*****

- Prepare each meal according to the preparation instructions for Meal A or B
- Properly store each food ingredient:

Meal A:

Room Temperature:	**Keep Refrigerated:**	**Keep Frozen:**
Minute® Ready-to-serve Brown & Wild Rice	Nature's Own® 100% whole wheat bread	Tyson® Fully Cooked Chicken Breast Fillets:
	Oscar Mayer Delifresh Smoked Turkey Breast	
	Food Club® Not Smoked Provolone Cheese	
	Tomato	
	Lettuce	
	Nabisco Chips Ahoy! Original	
	Food Club® Classic Potato Chips	

Meal B:

Room Temperature:	**Keep Refrigerated:**	**Keep Frozen:**
Barilla Ready Pasta Fully Cooked Penne	OLE Mexican Foods High Fiber Low Carbs Tortilla	Food Club® Broccoli Spears
	Oscar Mayer Delifresh Smoked Ham	Blue Bell® Dutch Chocolate
	Food Club® Mild Cheddar Cheese (Thin Sliced)	
	Spring Mix	
	Food Club® Fat Free Ranch Dressing	
	Ragu® Classic Alfredo	
	Red seedless grapes	

- Wear non-latex gloves
- **Remember: Always go by the number of grams**

Materials for Sessions 2 and 3:

1. Checklist
2. Sony Smarteyeglass instructions
3. Dietary Recall instructions (Portion estimation)
4. Dietary Assessment Food Information and Weight Sheet
5. Pre-measured Meal A or Meal B
6. Google Calendar
7. Appointment Sheet
8. **Participant's Experience Questionnaires (ONLY FOR SESSION 2)**
9. **Compensation form (ONLY FOR SESSION 2)**

Before participant arrives:

1. Determine the meal order and preparation methods required for the meal that participant is to receive by referring to the "Order", "Status", and "Gender" columns in the Dietary Assessment-PTL. You can access the PTL by opening the CEHHS Share → Dietary Assessment Study → DietaryAssessment-PTL.
2. Weigh out the amount of food within +/-3 grams of each food. Based on the order number and participant's gender, prepare Meal A or Meal B according to the preparation listed below. ***It is important to pay attention to the order number and participant's gender, and prepare the correct meal with correct amount.*** Meal preparation instructions and presentations of each food are listed belo

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Meal A

Foods:

For Female Participant:	**For Male Participant:**
Turkey & Provolone Cheese Sandwich 52g Whole Wheat Bread (~2 slices) 70g Turkey 23g Provolone Cheese (~1 slice) 50g Tomato Slices (Washed & Dried) 45g Lettuce (Washed & Dried)	**Turkey & Provolone Cheese Sandwich** 52g Whole Wheat Bread (~2 slices) 133g Turkey 23g Provolone Cheese (~1 slice) 50g Tomato Slices (Washed & Dried) 45g Lettuce (Washed & Dried)
Chicken and Wild Rice 98g Chicken (~1.5-2 chicken breast) 71 g Wild Rice	**Chicken and Wild Rice** 98g Chicken (~1.5-2 chicken breast) 107 g Wild Rice
44 g Chocolate Cookie (~4 cookies)	**60.5g Chocolate Cookie (~5 ½ cookies)**
39g Potato Chips	**52g Potato Chips**
20 oz water	**20 oz water**

Other Materials:

- Weighing container (HEAL Plate with Yellow print on the edge)
- Microwave plates
- Paper towels
- Serving plates (White Rectangular Plate) x 4
- Pens
- Sandwich Sticks x 2
- 20 oz white plastic water cup

Instructions:

1. Set out measuring cups and measuring spoons, cutting board, chef knife, pen, oven mitts, weighing container, microwave plates, and Dietary Assessment Food Information and Weight Sheet.
2. Record the reference #.
3. Wash Tomato and Lettuce. **** Make sure they are dry before weighing! ****
4. Zero the scale and place the weighing container on the scale
5. Record the number of grams (at the container weight column on Dietary Assessment Food Information and Weight Sheet) for the weighting container and zero the scale.
6. Weigh the first ingredient within +/- 3 grams and record the number of grams for each ingredient in the Dietary Assessment Food Information and Weight Sheet.
7. Then, remove the weighing container with ingredient from the scale and zero the scale. Put the weighing container with ingredient back to the scale and record the weight in Food + Container Pre- Weight Column on Dietary Assessment Food Information and Weight Sheet.

8. Repeat the step for the next ingredient until all ingredient are weighed.
9. Next, assemble each food:
    a. **Turkey & Provolone Cheese Sandwich**

***You may have to cut one side of each slice of bread to make them weigh ~52g (+/- 3 grams) ***

i. Place 1 slice of Nature's Own® 100% whole wheat bread on the cutting board. Put pre-weighed Oscar Mayer Delifresh Smoked Turkey Breast, Food Club® Not Smoked Provolone Cheese, tomato slices, and lettuce on top of the bread. Place another slice of bread on the top. Cut finished sandwich in half diagonally. Stick one sandwich stick in the middle of each half of cut sandwich.
***** Ensure the stick firmly hold everything together *****

ii. **Presentation:** Place cut sandwich on the white rectangular serving plate with all the ingredients facing up to the participant. (Ensure all the ingredients are shown clearly)

b. **Chicken and Wild Rice**

i. Chicken
- Read the Tyson® Fully Cooked Chicken Breast Fillets package. Follow the directions for the microwave heating option. Follow package's directions and heat up 1 chicken breast **[You might have to prepare an additional chicken breast, if 1 chicken breast is shy 95g].**
***** For smaller chicken breast, heat up for 2 minutes *****

ii. Wild Rice
- Read the Minute® Ready-to-serve Brown & Wild Rice package. Follow the directions for the microwave heating options. Follow

package's directions and heat up 1 package of rice.

ii. Weighing heated chicken and wild rice:
- Place a weighing container on a scale and record the container weight. Zero the scale and then measure the cooked chicken breast. Write down the cooked weight of chicken breast in the Dietary Assessment Food Information and Weight Sheet. Then, remove the weighing container with chicken breast from scale, and zero scale. Put the weighing container with chicken breast on scale and record the weigh on Food + Container Pre-weight column.
- Follow the same procedure for weighing the heated wild rice. Weigh 71g cooked rice for female participant **<u>or</u>** 107g cooked rice for male participant **(within +/- 3 grams)**

iii. **<u>Presentation:</u>** Cut chicken breast into strips (~1-inch-wide), and plate on the left side of the white rectangular serving plate (different than the one for sandwich). Then, place wild rice on the right side of the plate.

**** You may have to re-heat the chicken & wild rice dish before serving to participants****

c. Chocolate Chip Cookie:

i. **<u>Presentation:</u>** Place pre-measured cookies in the middle of a white rectangular serving plate

d. Potato Chips:

i. **<u>Presentation</u>**: Place pre-measured potato chips in the middle of a white rectangular serving plate (different plate than the one for the cookie)

e. 20 oz water:

i. Provide a cup of 20 oz water to participant using a white 20 oz plastic cup

Presentation of each food in Meal A:

1. Turkey & Provolone Cheese Sandwich
    a. Place cut sandwich on a white rectangular serving plate with all the ingredients facing up to the participant. (Ensure all the ingredients are shown clearly)
2. Chicken and Wild Rice
    a. Plate cut chicken breast on the left side of the white rectangular serving plate (different than the one for sandwich). Then, place wild rice on the right side of the plate.
3. Chocolate Chip Cookie
    a. Place the cookie in the middle of a white rectangular serving plate.
4. Potato Chips
    a. Place potato chips in the middle of a white rectangular serving plate (different plate than the one for the cookie).
5. Provide a cup of 20 oz water to participant

Meal B

Materials

Foods:

For Female Participant:	**For Male Participant:**
Ham and Cheddar Cheese Wrap 45g Tortilla (~1 tortilla) 76g Ham Deli 21g Cheddar Cheese (~2 slices) 36g Spring Mix 29g FF Ranch Dressing	**Ham and Cheddar Cheese Wrap** 45g Tortilla (~1 tortilla) 103g Ham Deli 32g Cheddar Cheese (~3 slices) 36g Spring Mix 29g FF Ranch Dressing
Pasta with Broccoli and Alfredo Sauce 91g Pasta 66g Broccoli 38g Alfredo Sauce	**Pasta with Broccoli and Alfredo Sauce** 121g Pasta 66g Broccoli 50g Alfredo Sauce
107 g Chocolate Ice-cream	**138g Chocolate Ice-Cream**
365g Red Seedless Grapes (remove from stem, washed & dried)	**471g Red Seedless Grapes (remove from stem, washed & dried)**
20 oz water	**20 oz water**

Other Materials:

- Weighing container (HEAL Plate with Yellow print on the edge)
- Microwave plates
- Paper towels
- Serving plates (White Rectangular Plate) x 4
- Pens
- Sandwich Sticks x 2
- 20 oz white plastic water cup

Instructions:

1. Set out measuring cups and measuring spoons, cutting board, chef knife, pen, oven mitts, weighing container, microwave plates, and Dietary Assessment Food Information and Weight Sheet.
2. Record the reference #.
3. Wash Grapes. **** Make sure they are dry before weighing! ****
4. Place a serving plate in the freezer (For later use to plate ice-cream)
5. Zero the scale and place the weighing container on the scale.
6. Record the number of grams (at the container weight column on Dietary Assessment Food Information and Weight Sheet) for the weighting container and zero the scale.

7. Weigh the first ingredient within +/- 3 grams and record the number of grams for each ingredient in the Dietary Assessment Food Information and Weight Sheet.
8. Then, remove the weighing container with ingredient from the scale and zero the scale. Put the weighing container with ingredient back to the scale, and record the weight in Food + Container Pre- Weight Column on Dietary Assessment Food Information and Weight Sheet.
9. Repeat the step for the next ingredient until all ingredient are weighed.
10. Next, assemble each food:
    a. **Ham and Cheddar Cheese Wrap**
        i. Place 1 OLE Mexican Foods High Fiber Low Carbs Tortilla on cutting board. Spread pre-measured Food Club® Fat Free Ranch Dressing on the tortilla. Nicely layer the following ingredient on the torilla: Oscar Mayer Delifresh Smoked Ham, Food Club® Mild Cheddar Cheese (Thin Sliced), and Fresh Spring Mix. ***[It is important to make sure you carefully layout all the ingredients, so that when you cut the wrap, all the ingredients will show clearly.]*** Carefully roll the tortilla wrap with all the ingredients into a wrap. Place 2x sandwich sticks in the wrap (one on the center of each side). Cut the wrap diagonally.
        **** Ensure all ingredients are tightly hold by the sandwich sticks****

        ii. **Presentation:** Place the sliced on a white rectangular serving plate with all the ingredients facing up to the participant (Ensure all the ingredients are shown clearly)

    b. **Pasta with Broccoli and Alfredo Sauce**
        i. Read the Barilla Ready Pasta Fully Cooked Penne package. Follow the directions for the microwave heating option. Follow package's directions and heat up pasta.
        ii. While the pasta is in microwave, remove the Food Club® Broccoli Spears from freezer. Follow the directions for the microwave heating option. Follow package's directions and heat up pre-measured broccoli.
        iii. Remove the HOT pasta and broccoli from the microwaves and carefully place both containers on the counter (use oven mitts if necessary!)
        iv. Place a weighing container on a scale and record the container weight. Zero the scale and then measure the cooked pasta. Write down the cooked weight of pasta in the Dietary Assessment Food Information and Weight

Sheet. Then, remove the weighing container with pasta from scale, and zero scale. Put the weighing container with pasta on scale and record the weigh on Food + Container Pre-weight column.

iii. Follow the same procedure for weighing the heated broccoli.

v. Once you record the weight, pour cooked pasta and broccoli together to a same plate, and add pre-measured Alfredo sauce. Mix up sauce, broccoli and pasta.

vi. <u>**Presentation:**</u> Place the mixed pasta dish (Paste + broccoli + Alfredo sauce) on a white rectangular serving plate (different than the one for wrap).

**** You may have to re-heat the pasta dish before serving to participants****

c. Red Seedless Grapes

i. Pre-measure Red Seedless Grapes: 365g for female participant and 471g for male participant

ii. <u>**Presentation:**</u> Plate grapes in the serving plate.

d. Chocolate Ice-cream

***** DO ALL THIS RIGHT BEFORE SERVING TO PARTICIPANTS*****

i. Measure Blue Bell® Dutch Chocolate ice-cream: 107g for female participant and 138g for male participant

i. <u>**Presentation:**</u> Take out the serving plate from freezer. Plate the scooped ice-cream in the center of white rectangular serving plate (different plate then the one for grapes). Immediately serve to participant!

e. 20 oz water:

i. Provide a cup of 20 oz water to participant using a white 20 oz plastic cup

Presentation of each food in Meal B:

11. Ham and Cheddar Cheese Wrap
    a. Place the sliced (diagonal) on a white rectangular serving plate with all the ingredients facing up to the participant (Ensure all the ingredients are shown clearly)
12. Pasta with Broccoli in Alfredo Sauce
    a. Place the mixed pasta dish (Paste + broccoli + Alfredo sauce), with the broccoli mixed into the pasta, on a white rectangular serving plate (different than the one for wrap) with all the ingredients clearly shown
13. Red Seedless Grapes
    a. Plate the red seedless grapes on a white rectangular serving plate
14. Chocolate Ice-cream
    a. Plate the scooped ice-cream on a white rectangular serving plate (different plate then the one for grapes)
15. Provide a cup of 20 oz water to participant

***** Plate arrangement – same as Meal A (Refer to Meal A presentation picture on Page 9) *****

During the session:

1. Once the participant arrives for the appointment, escort the participant into the group room and close the door.
2. **Say: Thank you for coming in today!**
3. Ask the participant if he or she is feeling ill today and check about if participant has eaten within past 2 hours.
4. If the participant is feeling ill or ate within the past 2 hours, inform the participant that we will need to reschedule the appointment for a later time. **ENTER into PTL!**
5. If the participant is not feeling ill or has eaten the past 2 hours continue with the appointment.
   a. **Say: You are here today for your _______ (first or second) meal session appointment in the Dietary Assessment via Digital Images study. This session should take approximately 40 minutes. During this session, I will first go through the instructions on how to use Sony Smarteyeglass when you are eating. You will follow these instructions to consume each food while you are eating**
   b. Go through the Instructions to use Sony Smarteyeglass during meal session and provide the instruction paper to participant.
   c. **Say: Please follow the provided instructions (Point to the instruction paper) to consume the meal. You will have 30 minutes to consume the foods as it is presented to you. Eat as much or as little of the meal as you want, but please at least taste each food provided. You will also be given 20 fluid ounces of water; we ask that you do not consume any other foods or beverage other**

than provided during this session. I will check to see how you are doing every 10 minutes.

d. **Say: I will now bring your meal. Please put on Sony Smarteyeglass now and follow the instruction to start the digital recording.**

e. Ask participant if he/she see the frame number on the screen is increasing.

f. **If no,** ask participant to follow the instruction to start the digital recording.

g. **If yes, continue:**

- Put the first plate on the table in front of participant, ask participant to follow the instruction to look at the food. When participant is done looking at the first plate, move to the next plate until participant finished looking at all four foods.
- After participant finished looking all four plates, arrange the plates into the plate arrangement (Refer to Page 9). Ask participant to hold first food with hand or fork and look at the food for 5 seconds about 12 inches in front of Sony Smarteyeglass. When participant is done with the first food, ask the participant to follow the same procedure (provided in the instruction) for the rest of the foods.

6. Leave the room for participant to eat the meal and check with participant every 10 minutes. Set a timer for 10 minutes.
7. After 10 minutes, knock on the door and check on participant.
   a. **Say: Hello. How is everything going? You have about 20 minutes left.**
8. After 20 minutes, knock on the door and check on participant.
   a. **Say: Hello. How is everything going? You have about 10 minutes left.**

9. After 30 minutes, knock on the door. Remind the participant to look at each plate again.
    a. Put the first plate on the table in front of participant, ask participant to follow the instruction to look at the food. When participant is done looking at the first plate, move to the next plate until participant finished looking at all four foods. After the participant did the final look at the foods, remove meal from the room. Set aside the finished meal (DO NOT DISPOSE), then return to the conference room.
10. Once the participant finished eating, give the participant, explain the 24-hour dietary recall will need to be completed tomorrow regarding all the foods and beverages that they consumed in the last 24 hours including the meal they consumed during the meal session today. Explain that he/she will be asked to report detail dietary intake information such as food brands, food preparation methods, portion consumed etc. Provide the participant the portion estimation tool kit and tell them it will be very helpful if they have the tool next to them when we call.
    a. Ask participant when to call for 24-hour dietary recall tomorrow:
        - Morning: 8am-12pm
        - Afternoon: 12pm-5pm
        - Evening: 5pm-8pm
    b. *Enter the call time in the* ***DietaryAssessment-PTL*** *under the "****1st meal session note****" or* ***"2nd meal session note"***
11. If 2nd session need to be completed and has not been scheduled, schedule the second meal session appointment using Google calendar. **[Note: 2nd meal session need to be scheduled within 4 weeks from the screening session date]**

a. **Say: Now, I would like to confirm (schedule) you for your next appointment. The appointment can be scheduled between 11am and 5pm, Monday-Friday. What day and time are you available to meet next week?**

b. **Your appointment has been scheduled for _________ (hand participant appointment sheet). If you are unable to keep this appointment for any reason, please call us at 974-0752. We will reschedule your appointment at your earliest convenience. Thank you for participating in the first session of the Dietary Assessment via Digital Images. Additionally, we ask that you stop eating 2 hours before your scheduled appointment time. For example, since your appointment is scheduled at _____, we ask that you stop eating at ______. We look forward to seeing you again on _____. Let me escort you out of the lab. Have a nice day.**

c. if scheduled, **update PTL**

12. [AT THE END OF 2ND MEAL SESSION]

a. Ask participant to complete the Participant's Experience Questionnaire ***(you can find it under CEHHS Shares Drive → NTR HEAL → Dietary Assessment Study → Session3-Meal SESSION2 → Participants Experience Questionnaire)***

b. After participant completed questionnaire:

- **Say: You have now completed the last session. Thank you for participating in the Dietary Assessment via Digital Images Study. You will receive a $20 gift card via mail after you completed the 24-hour dietary recall. Please sign this form indicating you will receive the $20 gift card after you completed the second 24-hour dietary recall. We**

appreciate your time in taking part in this study. Let me escort you out of the lab.

After the Session:

1. Record the weight of weighing container (HEAL plate with yellow print on the edge) in the 2nd "***Container weight (g)***" column.
2. Then zero scale, weight each food and ingredient again. For mixed foods, separate all the ingredients and scrape off each ingredient as much as possible. Record the weight of each ingredient on ***"Food Weight Post (g)"***.
3. Then, zero scale again, weight each ingredient with container and then record the weight in the ***"Food + Container Weight Post (g)"*** column.
4. Then, calculate the change in weight by subtracting the post-weight measurement from the pre-weight measurement. (i.e. ***Weight Change*** = ***"Food Weight Post (g)" - "Food Weight Pre (g)")*** Put the difference between these two values in the last column labeled "Weight Change."
5. Update the PTL indicating the participant completed the session and make any notes about the session in the ***"Notes"*** column.
6. Place all session materials in the appropriate place.

APPENDIX 8 – SONY SMARTEYEGLASS INSTRUCTION

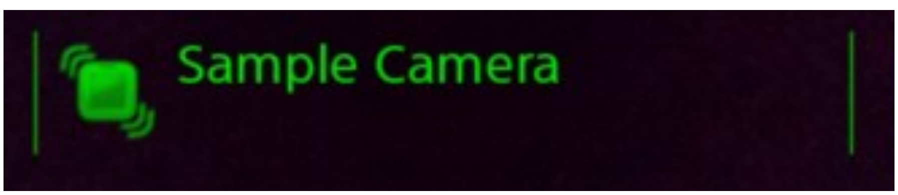
Instructions to Use Sony Smarteyeglass during Meal Sessions

1. When you see the home screen of the Sony Smarteyeglass (in green words with date and time, battery percentage), using your finger to swipe to the right on the controller (on the arch) to go to “Sample Camera.

Home Screen of Sony Smarteyeglass:

Use your finger to swipe to right on the arch of controller (show in red arrow).

2. Once you see “Sample Camera”, tap the controller (on the arch) to choose the app.



3. When the researcher instructs you to start the JPEG Stream, tap the controller (on the arch) to initiate the recording. When it is recording, the display will show "JPEG Streaming" and the frame number will be increasing.

<u>Follow the following instructions to eat:</u>

4. **Before eating, please look at each provided food.**
    a. Please look at **<u>first</u>** provided plate at ~12 inches away from the plate for approximately **<u>5 seconds</u>**. (Look at one food and slowly and silently count to 5.)

Make sure you locate the green words in the center of the foods that you are recording

    b. Turn your head toward your left shoulder, look at the first food from the left side at ~12 inches away from the plate for another 5 seconds.
    c. Turn your head toward your right shoulder, look at the first food from the right side at ~12 inches away from the plate for another 5 seconds.
    d. Then, move to the next plate and do the same, and continue to **<u>each</u>** food until you have looked at all four foods.

5. After you looked at each provided food, take one bite of each provided food.

6. **For the first bite of each food**, hold the food approximately 12 inches in front of the Sony Smarteyeglass and to look at the food, either in your hand or on a fork or spoon (depending on the food).

7. **Following taking the first bite of each provided food**, eat normally until you are satisfied. You will be given **<u>30 minutes</u>** to complete the meal. Researcher will leave the

room while you are eating, and he/she will check in with you every 10 minutes to see if you are completed with the meal or if you need anything.

8. **When you are done eating**, look at **each** provided plate for **5 seconds** in the exact same way you did at the start of the meal for all four foods

9. Once you completed looking at all four foods, tap the controller (on the arch) to stop recording.

VITA

Tsz-Kiu Chui (Kiu) was born and raised in Hong Kong. In 2008, she came to the United States to pursue a bachelor's degree, and she graduated from the University of Illinois at Urbana-Champaign with a Bachelor of Science in Dietetics in 2013. Upon completion, she started her Dietetic Internship at Meredith College. After she became a registered dietitian in 2014, Kiu worked as a Clinical Dietitian at Aiken Regional Medical Center for a year and then moved back to Hong Kong to work as a Registered Dietitian at a primary care clinic. In August 2016, Kiu moved to Knoxville to pursue graduate degree of Master of Science in Public Health Nutrition at the University of Tennessee, Knoxville.

As a graduate student, Kiu worked in the Healthy Eating and Activity Laboratory, where she developed passion for nutrition research and expanded her skills in research under the direction of Dr. Hollie Raynor. Additionally, she developed skills in pediatric and adult weight management while involved in different projects in the lab. After graduation, Kiu hopes to find a job in research area to continue her passion for nutrition research.