Evaluation of an Artificial Intelligence-Assisted, Image-Based Dietary Assessment Tool in the Framingham Heart Study

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Background: Assessment of dietary intake in large, free-living populations is inherently challenging due to the complex nature of human diet. Advancements in traditional methods of dietary assessment (i.e., web-based dietary recalls or records) have aimed at improving data accuracy while reducing participant burden. Further utilizing food recognition technologies to capture real-time food intake may aid in overcoming limitations of existing methods. Keenoa□, an artificial intelligence-enhanced, image-assisted tool, is a newly designed mobile application that may facilitate collection of dietary data.

Aims: Primarily, we will assess acceptability and usability of Keenoa compared with the traditional, web-based Automatic Self-Administered 24-Hour (ASA24) Dietary Assessment Tool in the Framingham Heart Study Third Generation-based cohorts at examination 4. We will also determine the proportion of participants who complete all three days of dietary assessment with energy intake >600 kcal, either through Keenoa or ASA24.

Methods: With a randomized block design, this study will take place as part of the Framingham Heart Study (FHS) glucose study (R01 DK129305). We currently ask participants from the Third Generation-based cohorts, at their fourth examination, to wear Dexcom G6 Pro continuous glucose monitor on either their arm or abdomen for a duration of at least 4 days. During this time, we request participants to complete 3 consecutive days of dietary record through ASA24. For the purpose of this trial, we will randomize the dietary assessment tool weekly between ASA24 and Keenoa, therefore, depending on the week of administration, participants are randomized to either a 3-day dietary record via ASA24 or a 3-day dietary record through Keenoa. This trial will last a total of 6 weeks.

Background and Rationale

Assessment of dietary intake in large, free-living populations is inherently challenging due to the complex nature of human diet.[1] In epidemiological studies, methods of self-reported dietary assessment include food frequency questionnaires, multiple 24-hour dietary recalls and food records.[1] Although each instrument has a unique set of limitations, common concerns primarily revolve around issues of measurement error, high respondent burden, and high administrative cost.[2] Utilizing technology-based dietary assessment methods present opportunities for improving data accuracy while reducing the financial burdens associated with having trained dietary interviewers.[3] With advances in technology, web-based dietary assessment tools, such as the Automated Self-Administered 24-Hour (ASA24) dietary recall or record, have been developed, extensively validated, and used in population-based studies.[4] In recent years, image-based or image-assisted food recognition smartphone applications (apps) have also entered the nutrition science research space, with evidence suggesting that incorporating these apps may reduce energy underreporting and enhance the validity of self-reported dietary intake.[5-8]

Keenoa™ is an artificial intelligence-enhanced, image-assisted dietary assessment tool that has been originally designed to facilitate dietary data collection for dietitians and researchers.[9] Serving as a visual food diary, individuals can upload a picture of their meal, choose the food items eaten using a preselected food list available by the app, and confirm the portion size with the presented visual aids. Two recent trials have aimed to evaluate the validity and usability of Keenoa™ against common methods of dietary assessment.[10,11] In a randomized controlled trial of 72 Canadian adults, Keenoa™ performed better on analyzing group-level micronutrient intake relative to individual-level intake, suggesting its potential appropriateness for assessing dietary intake of the general population.[9] In the same study, a greater proportion of participants preferred using Keenoa™ over a traditional pen-and-paper method (34.2% vs. 9.6%).[9] Another randomized crossover trial with 136 participants showed that Keenoa™ has moderate to strong agreement, when compared against ASA24 recalls, in analyzing energy, macronutrient, and the majority of micronutrient intakes in both healthy adults and those with type 2 diabetes mellitus (T2DM).[11] In addition to Keenoa™, several image-based or image-assisted dietary assessment apps have been developed for research purposes.[12] With distinct interfaces, some of these apps, such as the mobile food record (used in All of Us Precision Nutrition study), require uploading pictures from specific distance or angle of the food to ensure precise portion size estimation, which in turn may impose burden on participants. Therefore, selecting proper technology-based instrument relies upon different factors including available resources, study objectives, study population,

etc.,[12] and we chose to assess the acceptability and feasibility of Keenoa™ in order to evaluate dietary habits in the Framingham Heart Study (FHS).

Specific Aims

We will assess the following aims in the FHS Third Generation-based cohort exam 4.

Aim 1: Evaluate acceptability of the Diet Tracking Smartphone Application Keenoa™, and compare it to that of ASA24 diet records among older adults. We hypothesize that dietary assessment through Keenoa™ is more acceptable than ASA24, using quantitative satisfaction scale (0-5).

Aim 2: Determine the response rates; defined as the proportion of participants who complete all three days of diet assessments with energy intake >600 kcal, either through Keenoa™ or ASA24. We hypothesize that Keenoa will have higher response rate for those completing 3-day diet records.

Methods

We will conduct a randomized block trial, recruiting participants from the Third Generation-based cohorts, at their fourth examination. For the purpose of this trial, we will randomize the dietary assessment tool weekly between ASA24 and Keenoa™, therefore, depending on the week of administration, participants are randomized to either a 3-day dietary record via ASA24 or Keenoa™. Refer to **Figure 1** for complete description of enrollment process.

During the weeks when Keenoa™ is administered: we will ask the participants if they have a smartphone. If not, individuals will not be eligible to participate in the trial, but they can still complete ASA24 dietary records, allowing their dietary information be collected for the FHS Glucose Monitoring Study. Then we will ask participants if they have a Google Play ID (for Android users) or Apple ID (for IOS users). If yes, our research technician at FHS center will help participants in setting up Keenoa™. If not, we will provide participants with at home instruction protocol.

Statistical Analysis Plan

Power calculation: We estimate that we will require ~50 participants per group to complete aims 1 and 2.

Over the first 8 months of the current exam, we have had a response rate of 62.1% of participants completing 3 days of diet record using ASA24. We estimate that Keenoa™ would have an 80% response rate among our participants, therefore, considering alpha=.05, and 80% power, the sample size required is 50 participants per group.

Aim 1 analysis:

We will use chi-square to evaluate whether the average satisfaction rate (out of 5) of the two instruments (Keenoa vs. ASA24) is statistically significantly different.

Aim 2 analysis:

We will use chi-square to evaluate whether the response rates, defined as the percentage who completed 3 days of dietary assessment with energy intake >600 kcal, from the two instruments (Keenoa vs. ASA24) are statistically significantly different.

We will generate a summary of participant characteristics using descriptive statistics.

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