



Computer vision-assisted dietary assessment in youth in urban Ghana

Validity against weighed records and comparison with 24-hour recalls

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Background

Recent estimates suggest that diet-related risk factors cause 11 million deaths every year, more than any other factor included in the Global Burden of Disease analyses (Afshin et al., 2019). These risks have been exacerbated by trends associated with the “nutrition transition,” including increased consumption of unhealthy, processed foods and reductions in physical activity, leading to increases in rates of overweight and obesity (Popkin et al., 2020). Up-to-date dietary intake data are essential for the development of evidence-based nutrition actions (Hargreaves et al., 2022). However, dietary data collection and analysis is complex and expensive (Bell et al., 2017). Dietary assessment surveys commonly use the multi pass 24-hour recall (24HR) method that has been validated for use in adults self-reporting their intake and/or that of their young children (Gibson and Ferguson, 2008), and in adolescents (Arsenault et al., 2020; Nguyen et al., 2022). The costs of undertaking a 24HR are of the order of \$500 per recall (Adams et al., 2022).



Dietary assessment tools leveraging mobile technologies have potential to lower assessment costs but few tools have been validated and assessed for feasibility of use in low- and middle-income countries (LMICs) (Bell et al., 2017). In response to these challenges, the Nudging for Good project developed, validated, and assessed the feasibility of adopting innovative AI mobile technology to provide real-time diagnostics on dietary intake in adolescents living in urban settings in Ghana and Viet Nam. The PlantVillage Food Recognition Assistance and Nudging Insights (FRANI) app can estimate food and

nutrient intakes at least as accurately as a dietician undertaking a 24HR in Ghana and Viet Nam (Folson et al., 2023; Nguyen et al., 2022).

This study is aimed at validating the use of PlantVillage FRANI to measure food intake in female youth aged 18-24 years in urban Ghana against weighed records (WR) of full-day observations, the gold standard for dietary assessment, and comparing FRANI performance with that of a multi-pass 24HR.

Methods

Sixty-four female participants aged 18-24 were recruited from the University of Ghana (UG) student population resident in the Legon campus. Dietary intake was assessed on two nonconsecutive days, while ensuring that the reference day was the same for each method. For example, on the first visit, enumerators visited the participant early in the morning to handover the FRANI mobile phone application and then began the WR including all foods and beverages consumed. On the following day, a different enumerator undertook a multi-pass 24HR with the same participant. Data collection for WR and FRANI application thus took place simultaneously on each reference day, whereas the 24HR was completed the subsequent day using the previous day as a reference. For the WR, trained enumerators monitored participants from early morning until after their last evening meal, recording the weights of foods and liquids they consumed. Dietary data for the 24HR survey was collected using an adaptation of the interactive, multi-pass quantitative 24HR recall method. The method involves interviewing participants and listing all foods and liquids consumed individually and estimating portion sizes.

For FRANI, 64 standard android mobile phones (Samsung Galaxy A21s) were provided to participants with the preconfigured FRANI app one day prior to the WR. Participants were trained to record images of the foods and beverages consumed at every meal using FRANI. Users would take a picture of the meal they were about to consume, confirm the classification of food returned by FRANI and input the amount of actual food consumed as a proportion of the total portion served. When food classification returned by FRANI was not accurate or complete, users could record the particular food item consumed by selecting the appropriate item from a comprehensive list of foods consumed in Accra compiled from previous studies. To facilitate portion-size estimation, a “pop-socket” was used as a standardized visual prop, for automatic portion size estimation. A pop-socket is a small disc of standard size (diameter=3.96cm) that participants placed alongside foods when recording images. FRANI food recognition incorporates an algorithm designed to adjust each pixel in the respective images using the pop-socket reference to estimate the 2-dimensional area covered by each food in the image and then estimate the weight in grams using a weight per pixel parameter, equivalent to a 2-dimensional density, derived from prior images used in training the food recognition algorithm.

For the three different methods, quantities in grams of different food items that participants had consumed over the past 24 hour were converted into nutrients using several food-composition tables adapted to local Ghanaian foods. Nutrient composition data were obtained from the West African food-composition table and the RING nutrient composition table, which is a compilation of food-composition databases relevant to Ghana. The computation of nutrients was done using a program written in Stata. Equivalence of nutrient intake was tested by comparing ratios of intakes by method (FRANI/WR and 24HR/WR) with equivalence margins set at 10%, 15%, and 20% error bounds, using mixed effect regression models adjusting for repeated measures. Agreement between methods was also assessed using the concordance correlation coefficient (CCC).

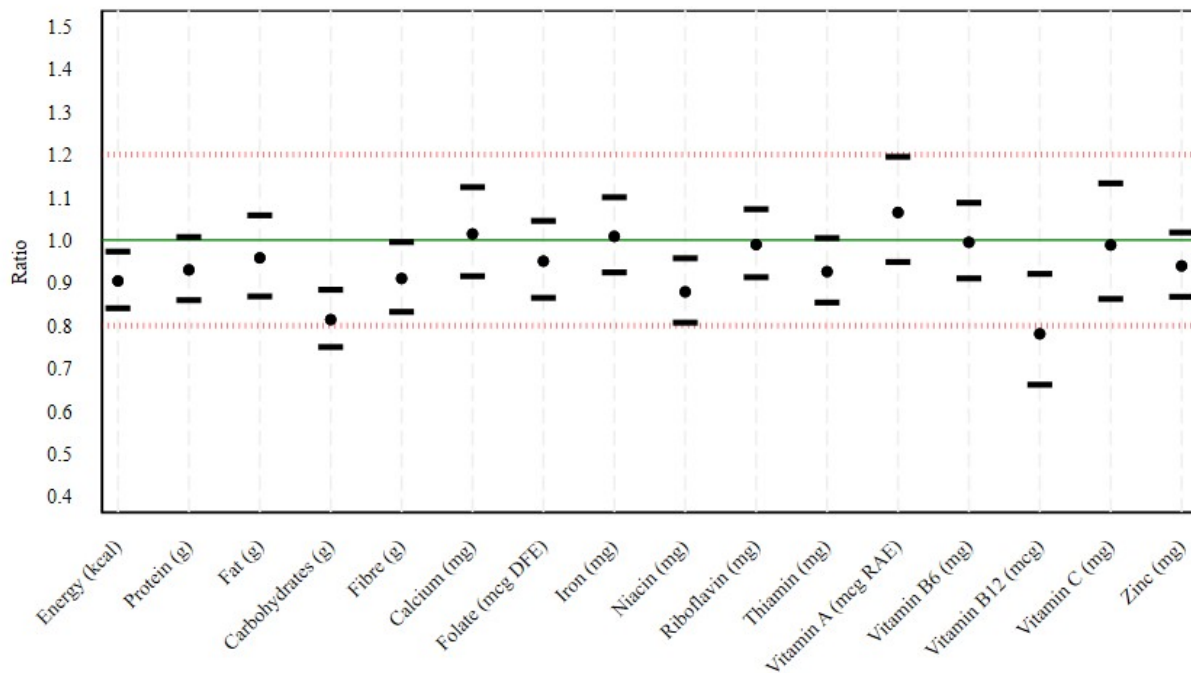
Results

Equivalence for FRANI and WR was determined at the 10% bound for fiber and folate intake (Figure 1); and at the 15% bound for energy, protein, fat, iron, riboflavin, thiamine, vitamin B6, and zinc. Calcium intake was equivalent at the 20% bound. Comparisons between 24HR and WR found protein and riboflavin intake estimates falling within a 10% bound (Figure 2). Iron, niacin, thiamine, and zinc intakes were equivalent at the 15% bound; and energy, folate, and vitamin B6 were equivalent at the 20% bound. The CCCs by nutrient between FRANI and WR ranged between 0.47 and 0.72 (mean=0.59), and between 0.28 and 0.76 (mean=0.5) for 24HR and WR. For FRANI, omission and intrusion errors were 15% and 22%, respectively. For 24HR, omission errors were higher (22%), while intrusion errors were lower (18%) than those reported for FRANI.

Conclusions

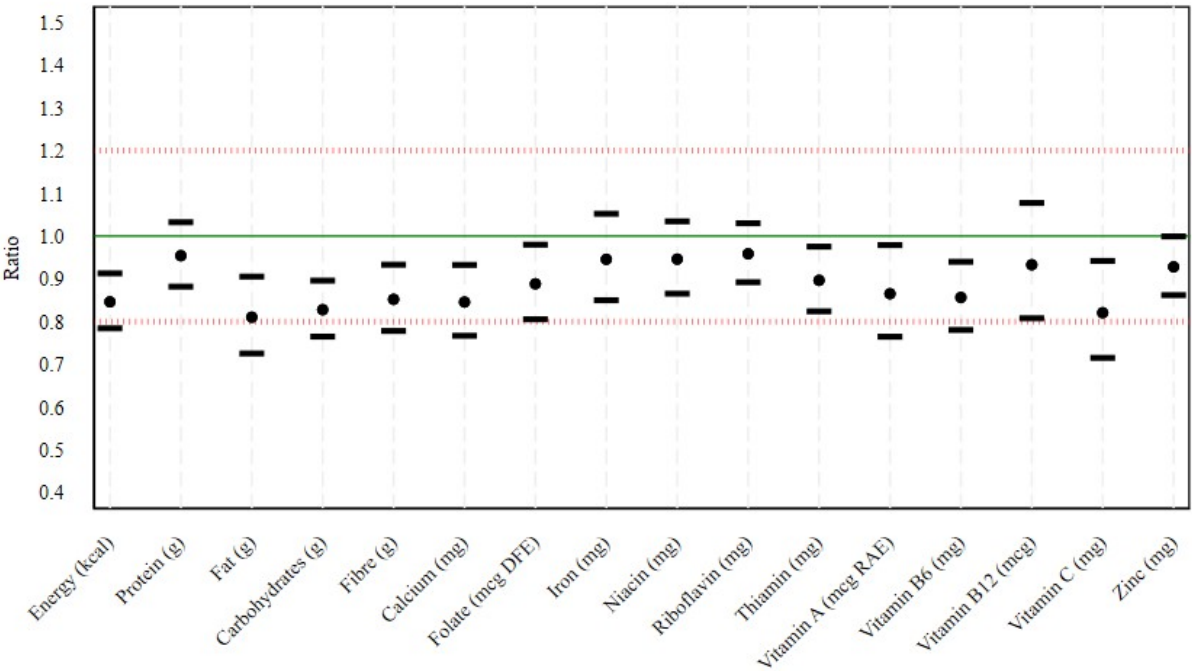
PlantVillage FRANI-assisted dietary assessment and 24HRs were found to accurately estimate nutrient intake in female youth in urban Ghana. Though improvements in the computer vision-assisted classification and portion estimation are possible, evidence in this emerging research area suggests that this technology is ready for scale-up.

Figure 1: Equivalence testing of ratios of nutrient intake on 3 days by weighed records, FRANI app, and 24-hour recall (FRANI app/weighed records)



Source: Authors.

Figure 2: Equivalence testing of ratios of nutrient intake on 3 days by weighed records, FRANI app, and 24-hour recall (24HR/weighed records)



Source: Authors.

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