Published in final edited form as:
J Food Compost Anal. 2011 December 1; 24(8): 1160–1167. doi:10.1016/j.jfca.2011.06.006.

Evaluation of the Food and Nutrient Database for Dietary Studies for use with a mobile telephone food record

Bethany L. Six[1], **TusaRebecca E. Schap**[1], **Deborah A. Kerr**[2], and **Carol J. Boushey**[1]

[1]Purdue University, Department of Foods and Nutrition, 700 West State Street, West Lafayette, IN 47907-2059 USA

[2]Health Innovation Research Institute, School of Public Health, Curtin University of Technology, GPO Box U1987, Bentley, WA 6845, Australia

Abstract

The development of a mobile telephone food record (mpFR) in which image analysis and volume estimation data can be indexed with the Food and Nutrient Database for Dietary Studies (FNDDS) has the potential to improve the accuracy of dietary assessment. To validate the mpFR for use with adolescents, a convenience sample of adolescents, aged 11–18 years, was recruited to eat all meals and snacks in a controlled feeding environment over a 24-hour period. Each food item matched a food code in the FNDDS 3.0. The objective of this analysis was to compare the measured energy and protein content of foods to the published values in the FNDDS. Duplicate plates of all meals and snacks were prepared, and samples of 20 foods were individually weighed, homogenized, freeze dried, and analyzed for energy with a bomb calorimeter and for protein with a Dumas nitrogen analyzer. Eleven of the twenty food items had energy values in the FNDDS within ±10% of the measured energy value. The measured energy and protein values from all foods correlated significantly with the energy (r=0.981, $P<0.01$) and protein (r= 0.911, $P<0.01$) values in the FNDDS. These results support the use of the FNDDS with the mpFR.

Keywords

Mobile telephone; FNDDS; Bomb calorimeter; Dumas nitrogen analyzer; Dietary assessment; Energy; Protein; Proximate analysis; Food composition database

1 Introduction

Advances in technologies such as personal digital assistants (PDAs), computers, mobile telephones, and digital imaging have provided the opportunity to advance the traditional methods of dietary assessment. The National Institutes of Health (NIH) developed the Genes, Environment, and Health Initiative (GEI) to fund the development of these novel dietary assessment methodologies (Thompson et al., 2010). A mobile telephone food record (mpFR) is one method being developed under the auspice of the GEI (Six et al., 2010).

Corresponding author: Tel.: +1 765-496-6569; fax: +1 765-494-0674, boushey@purdue.edu (C. Boushey).

When using the mpFR to record dietary intake, individuals capture images of their foods and beverages before and after eating. Methods of image analysis are used to automatically identify the foods and beverages in the images (Mariappan et al., 2009; Zhu et al., 2008). The volume of food consumption can be estimated by including an object of known dimensions, called a fiducial marker. The information from image analysis and volume estimation can be indexed with the Food and Nutrient Database for Dietary Studies (FNDDS) to estimate the energy and nutrients consumed. The accuracy of this novel method of dietary assessment depends on the accuracy of the food composition database selected to compute energy and nutrient consumption (Stumbo, 2008; Thompson and Subar, 2008).

The United States Department of Agriculture (USDA) Nutrient Database for Standard Reference (SR) is the source of nutrient values in the FNDDS (U.S. Department of Agriculture, 2009). The FNDDS was developed for use in the dietary component of the National Health and Nutrition Examination Survey (NHANES), What We Eat in America (Ahuja and Perloff, 2008), and is free and available for researchers to download from the Nutrient Data Laboratory (NDL) website (Bodner-Montville et al., 2006). The FNDDS 3.0 includes values for energy and 62 nutrients and 30,000 different weights of 7,000 foods (Bodner-Montville et al., 2006; United States Department of Agriculture, 2008). A new version is released every two years based on the most recent SR release and in concordance with the release of NHANES results. Prior to inclusion in SR, all analytical data undergo rigorous quality control checks (Holden et al., 2002; Pehrsson et al., 2000; Phillips et al., 2006; Sharpless et al., 2004). Further, a series of nutrient integrity checks are used to evaluate the nutrient data obtained from SR before publishing the FNDDS (Ahuja and Perloff, 2008).

To validate the mpFR for use with adolescents, a convenience sample of adolescents was recruited to participate in a controlled feeding study in which 24-hour urinary nitrogen was measured as a biomarker of dietary protein intake. The food items served were selected to match food codes in the FNDDS 3.0. To account for any discrepancies between the estimated intakes, as derived from the FNDDS food codes, and the measured biomarker, the protein content of the food items served was measured using a Dumas nitrogen analyzer. In addition, the energy content of the foods served was measured using a bomb calorimeter. The objective of this analysis was to determine if the measured energy and protein values would match the published energy and protein values in the FNDDS. A priori, our hypothesis was that the measured energy and protein values would correlate significantly with the FNDDS ($P<0.05$).

2 Materials and methods

2.1 Controlled feeding study

Adolescents, between 11–18 years of age, received all meals and snacks for a 24-hour period as previously described (Six et al., 2010). Foods identified as commonly consumed by adolescents (Jensen et al., 2004; Novotny et al., 2003) were matched to food codes in the FNDDS 3.0 (Figure 1) (United States Department of Agriculture, 2008). The food combinations were obtained from SR for foods in which the FNDDS food codes did not link directly to one code in SR. Of the foods sampled for analysis, 12 linked directly to one food code in SR, and 8 were combination foods. The cheeseburger sandwich served at the lunch meal did not directly match a food code in the FNDDS. Using the FNDDS food codes of the individual food items in the cheeseburger sandwich, a combination was constructed to match the cheeseburger sandwich served and estimate the nutrient values. The individual food items comprising the cheeseburger sandwich were cheese slice (14502010), hamburger patty (21500100), hamburger bun (51150000), tomato (74101000), ketchup (74401010), and lettuce (75113000). The energy and protein content of each food item published in the

FNDDS 3.0 was found using the *What's In The Foods You Eat* Search Tool, 3.0. The foods were prepared in a metabolic kitchen, and trained staff weighed each food item before and after eating to calculate the gram weight of consumption.

2.2 Sample preparation

Duplicate plates of each meal and snack were prepared, transferred to collection containers, and stored in a refrigerator for one day prior to preparation for analysis. Collection containers were pre-weighed empty, without the lids, and each food item was collected in a separate container and weighed. The total weight of the food was calculated by subtracting the empty container weight. After weighing, each food item was blended with water to achieve homogeneity (Hamilton Beach Commercial Blender Model 990, Washington, NC). All samples were then weighed and transferred into insulated containers, and freeze-dried for seven days (Dura-Dry Freeze-Dryer Model PAC-TC-44, FTS System, Inc., Stone Ridge, NY). To help shorten the time to freeze-dry food samples, beverages (orange juice, 2% milk, Coca-Cola®), margarine, ketchup, Catalina dressing, and gummy bears were excluded from the analysis. The dry weight of each food sample was recorded before storing for analysis.

2.3 Energy analysis

Four aliquots from each dried food item were analyzed with a bomb calorimeter (Parr® 1281 Oxygen Bomb Calorimeter, Parr Instrument Company, Moline, IL). The bomb calorimeter was calibrated with benzoic acid. The energy content of each food item was expressed as kilocalories per 100 grams of food sample before drying.

2.4 Nitrogen analysis

For nitrogen, three aliquots from each dried food item were analyzed with a Dumas nitrogen analyzer (PE 2410 Series II Nitrogen Analyzer, Perkin-Elmer, Waltham, MA), and the two closest measurements were used for analysis. The Dumas nitrogen analyzer was calibrated with ethylenediaminetetraacetic acid (EDTA). The nitrogen content was multiplied by a conversion factor to convert nitrogen to protein which was expressed as grams protein per 100 grams of food sample before drying. The conversion factors were 6.25 for egg or meat, 6.38 for dairy, 5.70 for wheat, and 6.25 for other grains (Chang, 2003).

NIH-PA Author Manuscript

2.5 Statistical analysis

The energy value for each food was the mean of the four aliquots. The protein value for each food was the mean of the two aliquots. The coefficient of variation was calculated as the ratio of the standard deviation to the mean multiplied by 100. Analysis was performed on the ratio of the FNDDS energy and protein values to the measured energy and protein values and the 95% confidence intervals. A value greater than one indicated the FNDDS value was higher than the measured value and a value less than one indicated the FNDDS value was lower than the measured value. Pearson correlation coefficients were used to compare the FNDDS and measured energy and protein values. Bland-Altman plots were constructed to visualize the agreement between the FNDDS and measured energy and protein. SPSS 17.0 was used for all statistical analysis.

3 Results and discussion

A total of 15 adolescents (12 boys, 3 girls) participated in this controlled feeding study. The meals and snacks served are presented in Figure 1. Twenty of the 28 food items were sampled for energy and nitrogen analysis. The FNDDS energy values and measured values per 100 grams of food are given in Table 1. The Pearson correlation coefficient for the energy values was 0.981 (P<0.01). The coefficient of variation (CV) for the measured

NIH-PA Author Manuscript

energy values ranged from 0.08–3.16%. The food item with the highest CV was the chewy chocolate chip granola bar, and this is likely due to the difficulty in achieving a homogenous mixture when preparing the sample for analysis. When looking at the ratios of the FNDDS energy values to the measured values, eleven of the twenty food items had energy values in the FNDDS ± 10% of the measured value. Of the remaining nine foods, seven had energy values in the FNDDS ± 15% of the measured value. The two food items outside these ranges were crinkle cut French fries and spaghetti with sauce and cheese (Table 1). One possible reason for the larger difference in energy values for French fries is the variation in nutrient composition of different brands of French fries. Ore-Ida Golden Crinkles® were prepared from frozen for the lunch meal, and the energy per 100 grams of French fries based on the nutrient label is 155 kilocalories. Crinkle cut French fries likely absorb more fat during cooking due to increased surface area, and this may explain the higher measured energy value. The food codes in the FNDDS include a variety of different brands or types of the food item, and the nutrient values are published as the average of the nutrient values in the different brands (Holden et al., 2002; Pehrsson et al., 2000). Further, the food code in the FNDDS selected to represent the French fries served may not include crinkle cut French fries. The spaghetti with sauce and cheese is a combination food and difficult to obtain a homogenous mixture when preparing the sample for analysis. The spaghetti sauce used in preparation was flavored with meat; however, the SR combination codes include ground beef (U.S. Department of Agriculture, 2009). Thus, the larger energy value in the FNDDS could be attributed to the inclusion of ground beef in the SR combination codes.

The FNDDS protein values and measured values per 100 grams of food are given in Table 2. The Pearson correlation coefficient for the protein values was 0.911 ($P<0.01$). The CV for the measured protein values ranged from 0.50–14.79%. When looking at the ratios of the FNDDS protein values to the measured protein values, ten of the twenty food items had protein values in the FNDDS ± 10% of the measured value. The remaining ten foods had protein values in the FNDDS greater than 20% above the measured value. The romaine lettuce had low nitrogen content, and the high comparison ratio could be due to the difficulty in detecting a low concentration of nitrogen (Jung et al., 2003). The inclusion of ground beef in the SR codes for spaghetti may also contribute to the higher protein value in the FNDDS when compared to the measured value. In addition, the food codes in the FNDDS selected to represent these food items are likely comprised of multiple, similar food items, with varying protein contents, which may explain the higher protein values in the FNDDS. For example, the toasted garlic bread served was New York Brand® Texas Garlic Toast which contains three grams of protein per 40 gram slice of toast (7.5 g protein/100g) according to the nutrient label. The food code in the FNDDS likely includes several types of Texas Toast (e.g. cheese toast, parmesan toast) that have higher protein content, consistent with the higher published protein value. Likewise, the food code in the FNDDS for the Quaker® Chewy Chocolate Chip Granola Bar includes multiple types of granola bars with varying protein content. The stated protein value in the FNDDS is 9.8 grams per 100 grams of food. According to the nutrient label, the Quaker® Chewy Chocolate Chip Granola Bar contained 4.2 grams of protein per 100 grams which is closer to the measured protein value.

Bland-Altman plots of the differences between the FNDDS and measured energy and protein values are displayed in Figure 2. The plots show no bias for energy or protein. Eight foods have energy values in the FNDDS above the measured value, and twelve foods have energy values in the FNDDS below the measured value. With the exception of one food item with an energy value in the FNDDS greater than 1.96 standard deviations (SD) below the mean difference, the difference between the measured and the FNDDS energy values of food items fell within 1.96 SD. Therefore, the measured values and the FNDDS values were ± 1 SD of the mean difference for 65% of food items and ± 1.96 SD of the mean difference for 95% of the food items (Bland-Altman criteria for agreement). Sixteen foods have protein values in the FNDDS above the measured value and four have protein values in the FNDDS below the measured value. The measured protein values and the FNDDS values were ± 1 SD for 80% of the food items and ± 1.96 SD of the mean difference for 90% of the food items. For energy, the single food item lying outside the acceptable range of variation was the sugar cookie. For protein, the two food items lying outside the acceptable range of variation were toasted garlic bread and granola bar. The variations in the food codes in the FNDDS selected to represent these foods may contribute to these observed variations.

The measured energy and protein values of the cheeseburger sandwich, a food item constructed using the FNDDS food codes of the individual food items comprising the cheeseburger, matched the energy (0.95) and protein (1.00) values in FNDDS. Users of the mpFR may occasionally need to construct food items in this way for food items not automatically identified with image analysis. These results indicate that constructing food combinations using food codes for the individual food items food will provide an accurate estimate of the energy and protein content of the combination food.

The adolescents' energy and protein intakes over the 24 hours, from the twenty foods sampled for analysis, were estimated from the FNDDS energy and protein values and the measured energy and protein values. These dietary data are shown in Table 3, and the differences visualized with a Bland-Altman plot in Figure 3. The Pearson correlation coefficients for the energy and protein intake values, from the foods analyzed, were 0.990 and 0.995, respectively ($P<0.01$). With the exception of one participant, the energy intakes estimated from the FNDDS values were greater than the energy intakes computed with the measured values. For all adolescents, the energy intakes estimated from the FNDDS were within ± 10% of the energy intakes computed from the measured values. As anticipated, the adolescents' protein intakes estimated from the FNDDS were 17–30% higher than the protein intakes computed from the measured values. The energy intakes estimated from the measured energy values and the FNDDS values were ± 1 SD for 80% of the participants and ± 1.96 of the mean difference for 93% of the participants. The energy intake estimated from the measured energy values was greater than the energy intake computed from the FNDDS values for the single participant outside the acceptable ranges of variation. Compared to other participants, this participant consumed more snacks such as brownies, Hostess Ding Dongs®, and Little Debbie Swiss Rolls®. These snack items had measured energy values greater than the FNDDS energy values which may have attributed this participant being outside the acceptable ranges of variation. The protein intakes estimated from the measured protein values and the FNDDS values were ± 1 SD for 80% of the participants and ± 1.96 of the mean difference for all of the participants.

4 Conclusions

These results support the use of nutrient values from the FNDDS for controlled feeding studies. Foods selected to represent food codes in the FNDDS will translate to accurate estimates of total energy intake. The variation in protein contents may be due to the variation in the food codes in the FNDDS. Constructing food combinations using separate food codes for the individual food items food can provide an accurate estimate of the energy and protein content of the food item. In addition, the FNDDS is an acceptable food composition database to index with information obtained from image analysis and volume estimation from images captured with the mpFR. Advancements in dietary assessment methods and continued improvements in nutrient analysis methods will aid in improving the accuracy of dietary intake data.

Acknowledgments

Support for this work comes from National Institute of Diabetes and Digestive and Kidney Diseases (1R01DK073711-01A1).

Abbreviations

mpFR	mobile telephone food record
FNDDS	Food and Nutrient Database for Dietary Studies
PDA	personal digital assistant
NIH	National Institutes of Health
GEI	Genes, Environment, and Health Initiative
USDA	United States Department of Agriculture
SR	Standard Reference
NHANES	National Health and Nutrition Examination Survey
NDL	Nutrient Data Laboratory
CV	coefficient of variation
EDTA	ethylenediaminetetraacetic acid
SD	standard deviation

References

Ahuja JKC, Perloff BP. Quality control procedures for the USDA food and nutrient database for dietary studies nutrient values. Journal of Food Composition and Analysis. 2008; 21:S119–S124.

Bodner-Montville J, Ahuja JKC, Ingwersen LA, Haggerty ES, Enns CW, Perloff BP. USDA food and nutrient database for dietary studies: released on the web. Journal of Food Composition and Analysis. 2006; 19:S100–S107.

Chang, SKC. Protein Analysis. In: Nielsen, SS., editor. Food Analysis. 3. New York: Kluwer Academic/Plenum Publishers; 2003. p. 131-142.

Holden JM, Bhagwat SA, Patterson KY. Development of a multi-nutrient data quality evaluation system. Journal of Food Composition and Analysis. 2002; 15:339–348.

Jensen JK, Gustafson D, Boushey CJ, Auld G, Bock MA, Bruhn CM, Gabel K, Misner S, Novotny R, Peck L, Read M. Development of a food frequency questionnaire to measure calcium intake of Asian, Hispanic, and White youth. Journal of the American Dietetic Association. 2004; 104:762–769. [PubMed: 15127061]

Jung S, Rickert DA, Deak NA, Aldin ED, Recknor J, Johnson LA, Murphy PA. Comparison of Kjeldahl and Dumas methods for determining protein contents of soybean products. Journal of the American Oil Chemists' Society. 2003; 80:1169–1173.

Mariappan A, Ruiz MB, Bosch M, Zhu F, Boushey CJ, Kerr DA, Ebert DS, Delp EJ. Personal dietary assessment using mobile devices. 2009:7246.

Novotny R, Boushey C, Bock MA, Peck L, Auld G, Bruhn C, Gustafson D, Jensen JK, Misner S, Read M. Calcium intake of Asian, Hispanic and White youth. Journal of the American College of Nutrition. 2003; 22:64–70. [PubMed: 12569116]

Pehrsson PR, Haytowitz DB, Holden JM, Perry CR, Beckler DG. USDA's National Food and Nutrient Analysis Program: food sampling. Journal of Food Composition and Analysis. 2000; 13:379–389.

Phillips KM, Patterson KY, Rasor AS, Exler J, Haytowitz DB, Holden JM, Pehrsson PR. Quality-control materials in the USDA National Food and Nutrient Analysis Program (NFNAP). Analytical & Bioanalytical Chemistry. 2006; 384:1341–1355. [PubMed: 16501956]

Sharpless KE, Greenberg RR, Schantz MM, Welch MJ, Wise SA, Ihnat M. Filling the AOAC triangle with food-matrix standard reference materials. Analytical & Bioanalytical Chemistry. 2004; 378:1161–1167. [PubMed: 14689156]

Six BL, Schap TE, Zhu FM, Mariappan A, Bosch M, Delp EJ, Ebert DS, Kerr DA, Boushey CJ. Evidence-based development of a mobile telephone food record. Journal of the American Dietetic Association. 2010; 110:74–79. [PubMed: 20102830]

Stumbo PJ. Considerations for selecting a dietary assessment system. Journal of Food Composition and Analysis. 2008; 21:S13–S19. [PubMed: 19337578]

Thompson, FE.; Subar, AF. Dietary assessment methodology. In: Coulston, AM.; Boushey, C., editors. Nutrition in the Prevention and Treatment of Disease. 2. San Diego: Academic Press; 2008. p. 5-41.

Thompson FE, Subar AF, Loria CM, Reedy JL, Baranowski T. Need for technological innovation in dietary assessment. Journal of the American Dietetic Association. 2010; 110:48–51. [PubMed: 20102826]

U.S. Department of Agriculture, Agricultural Research Service. USDA National Nutrient Database for Standard Reference, Release 22. Nutrient Data Laboratory; 2009. Home Pagehttp://www.ars.usda.gov/ba/bhnrc/ndl

USDA Food and Nutrient Database for Dietary Studies, 3.0. Beltsville, MD: Agricultural Research Service, Food Surveys Research Group; 2008.

Zhu F, Mariappan A, Boushey CJ, Kerr D, Lutes KD, Ebert DS, Delp EJ. Technology-assisted dietary assessment. Proceedings SPIE-The International Society for Optical Engineering. 2008; 6814:1–10.

Breakfast	Food descriptions and food codes	
	Scrambled eggs	32105000[a]
	Sausage links	25221660[a]
	White toast	51101010[a]
	Margarine	81103040
	Strawberry jam	91402000
	Orange juice	61210220
	2% milk	11112110
Lunch	**Food descriptions and food codes**	
	Cheeseburger sandwich	99999999[a,b]
	Ketchup	74401010
	Crinkle cut French fries	71401020[a]
	Canned peach slices	63135140[a]
	Sugar cookie	53241500[a]
	2% milk	11112110
	Coca-Cola®	92410310
Dinner	**Food descriptions and food codes**	
	Spaghetti with sauce, cheese	58132310[a]
	Toasted garlic bread	51121040[a]
	Romaine lettuce	75114000[a]
	Catalina dressing	83202020
	Canned pear halves	63137170[a]
	Iced chocolate cake	53106050[a]
	2% milk	11112110
	Coca-Cola®	92410310
Snack	**Food descriptions and food codes**	
	Chocolate chip cookie	53206020[a]
	Brownie	53204010[a]
	Ice cream sandwich	13120500[a]
	Gummy bears	91745010
	Berry Blue Go-gurt®	11432000[a]
	Strawberry Splash Go-gurt®	11432000[a]
	Chewy chocolate chip granola bar	53542100[a]
	Hostess Ding Dong®	53108200[a]
	Little Debbie Swiss Roll®	53108200[a]

[a]Food item sampled for energy and protein analysis.
[b]Project derived combination food constructed using the FNDDS food codes of the individual food items. Cheeseburger sandwich components and the FNDDS food codes were 21g cheese slice (14502010), 64.8g hamburger patty (21500100), 44g hamburger bun (51150000), 9g tomato (74101000), 9.5g ketchup (74401010), and 47.5g lettuce (75113000).

Figure 1.

Menu for a 24-hour controlled feeding study with adolescents and the corresponding food codes in the Food and Nutrient Database for Dietary Studies (FNDDS).

[a]Food item sampled for energy and protein analysis.

[b]Project derived combination food constructed using the FNDDS food codes of the individual food items. Cheeseburger sandwich components and the FNDDS food codes were 21g cheese slice (14502010), 64.8g hamburger patty (21500100), 44g hamburger bun (51150000), 9g tomato (74101000), 9.5g ketchup (74401010), and 47.5g lettuce (75113000).

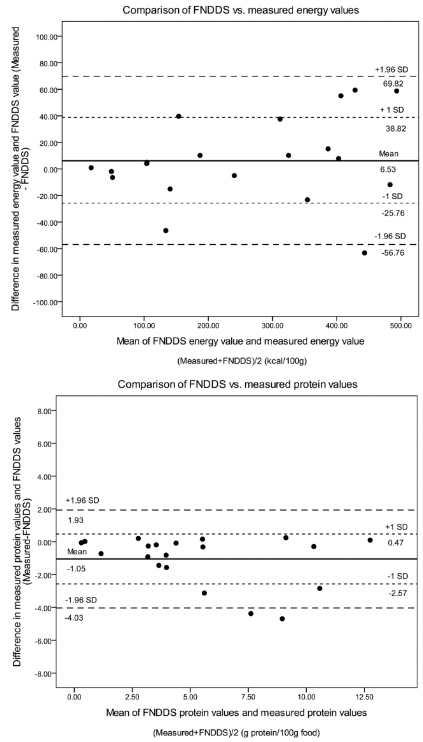
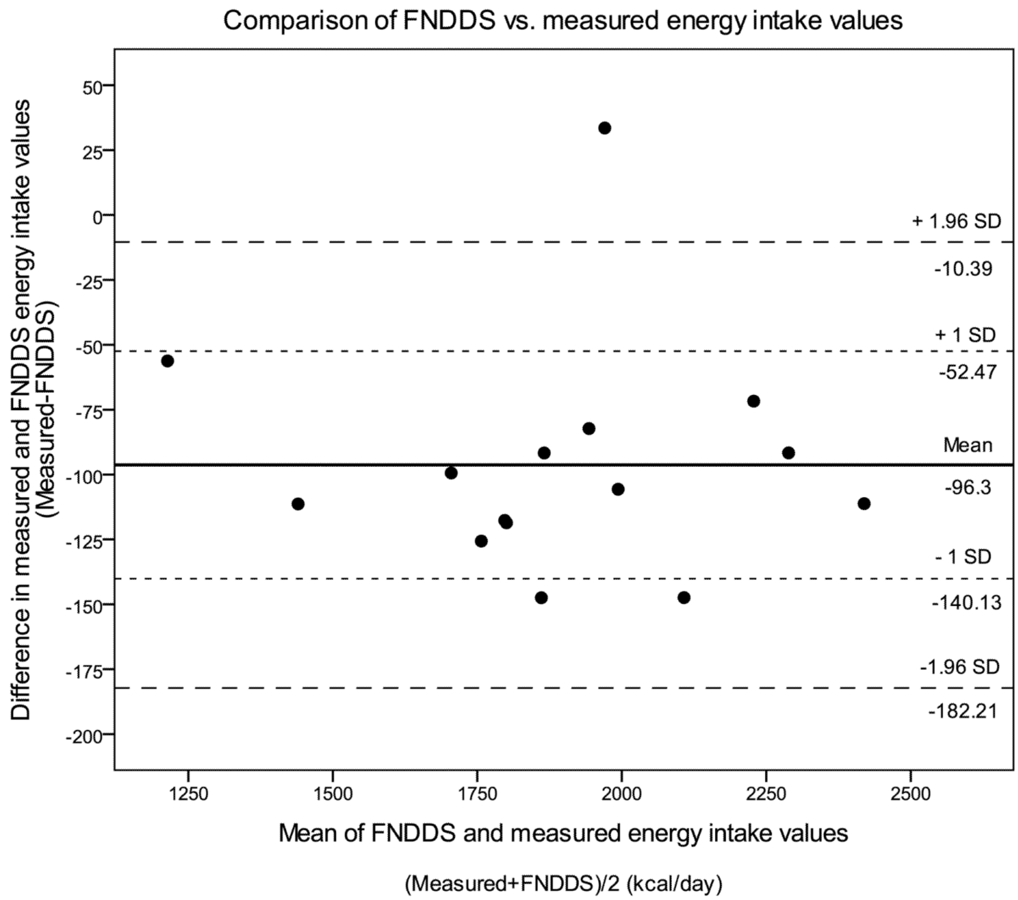


Figure 2.

Bland-Altman plots between the FNDDS energy and protein values and the energy and protein values of the foods measured with a bomb calorimeter and Dumas nitrogen analyzer, respectively. The solid lines represent the mean difference, and the dotted lines represent ± 1 and ± 1.96 standard deviations (SD) of the mean difference. Positive differences indicate the measured energy and protein values were greater than the FNDDS values, and negative differences indicate the measured energy and protein values were lower than the FNDDS values.


Comparison of FNDDS vs. measured energy intake values
Difference in measured and FNDDS energy intake values
(Measured-FNDDS)
50
25
0
-25
-50
-75
-100
-125
-150
-175
-200
+ 1.96 SD
-10.39
+ 1 SD
-52.47
Mean
-96.3
- 1 SD
-140.13
-1.96 SD
-182.21
1250
1500
1750
2000
2250
2500
Mean of FNDDS and measured energy intake values
(Measured+FNDDS)/2 (kcal/day)

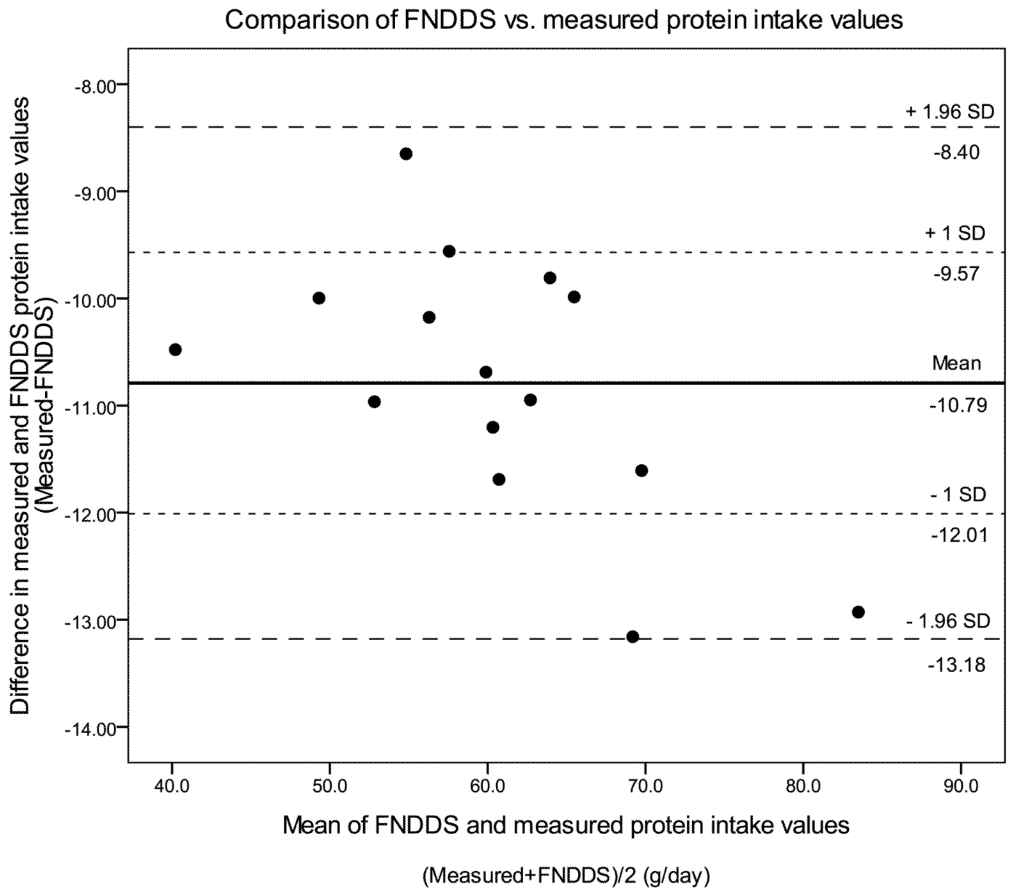


Figure 3.

Bland-Altman plots between the adolescents' energy and protein intakes estimated from the FNDDS values and the adolescents' energy and protein intakes computed using the measured values. The solid lines represent the mean difference, and the dotted lines represent ± 1 and ± 1.96 standard deviations (SD) of the mean difference. Positive differences indicate the energy and protein intakes computed using the measured values were greater than the intakes estimated from the FNDDS values, and negative differences indicate the intakes computed using the measured values were lower than the intakes estimated from the FNDDS values.

Table 1

Comparison of the FNDDS energy values and values measured with a bomb calorimeter of food items served to adolescents during a 24-hour controlled feeding study.

Food descriptions	FNDDS energy (kcal/100 g)	Measured energy (mean kcal/100 g±SD)	FNDDS energy: measured energy ratio	95 % Confidence interval
Breakfast				
Scrambled eggs	148	133±0.51	1.11	1.10, 1.12
Sausage links	320	330±1.78	0.97	0.96, 0.98
White toast	293	331±2.84	0.89	0.87, 0.91
Lunch				
Cheeseburger sandwich	182[a]	192±1.35	0.95	0.94, 0.96
Crinkle cut French fries	134	174±2.58	0.77	0.75, 0.79
Canned peach slices	54	48±0.15	1.14	1.13, 1.14[b]
Sugar cookie	475	412±0.77	1.15	1.15, 1.16[b]
Dinner				
Spaghetti with sauce, cheese	157	111±2.72	1.42	1.36, 1.48
Toasted garlic bread	379	394±2.40	0.96	0.95, 0.97
Romaine lettuce	17	18±0.01	0.95	0.95, 0.95[b]
Canned pear halves	50	48±0.11	1.04	1.04, 1.04[b]
Iced chocolate cake	366	343±0.63	1.07	1.06, 1.07[b]
Snacks				
Chocolate chip cookie	489	477±6.86	1.03	1.00, 1.05
Brownie	379	434±0.68	0.87	0.87, 0.88[b]
Ice cream sandwich	243	238±0.32	1.02	1.02, 1.02[b]
Berry Blue Go-gurt®	102	106±0.41	0.95	0.96, 0.97[b]
Strawberry Splash Go-gurt®	102	107±0.95	0.94	0.94, 0.97
Chewy chocolate chip granola bar	464	523±16.52		
Hostess Ding Dong®	399	407±1.61	0.98	0.97, 0.99
Little Debbie Swiss Roll®	399	458±3.12	0.87	0.86, 0.88

Table 2

Comparison of the FNDDS protein values and values measured with a Dumas nitrogen analyzer of food items served to adolescents during a 24-hour controlled feeding study.

Food descriptions	Protein conversion factor	FNDDS protein (g/100 g)	Measured protein (mean g/100 g ±SD)	FNDDS protein: measured protein ratio	95% Confidence interval
Breakfast					
Scrambled eggs	6.25	10.5	10.2±0.59	1.03	0.50, 1.57
Sausage links	6.25	12.0	9.2±0.67	1.31	0.47, 2.17
White toast	5.70	9.0	9.2±0.31	0.97	0.67, 1.27
Lunch					
Cheeseburger Sandwich	6.25	12.7[a]	12.8±1.75	1.00	−0.23, 2.24
Crinkle cut French fries	6.25	2.7	2.9±0.27	0.93	0.15, 1.72
Canned peach slices	6.25	0.5	0.5±0.02	0.96	0.62, 1.31
Sugar cookie	5.70	5.5	5.6±0.83	0.98	−0.32, 2.29
Dinner					
Spaghetti with sauce, cheese	5.70	7.2	4.0±0.21	1.77	0.95, 2.60
Toasted garlic bread	5.70	11.3	6.6±0.58	1.71	0.36, 3.07
Romaine lettuce	6.25	1.5	0.8±0.06	1.92	0.64, 3.20
Canned pear halves	6.25	0.3	0.3±0.01	1.24[b]	0.83, 1.65
Iced chocolate cake	5.70	3.3	3.1±0.04	1.08	0.95, 1.22
Snacks					
Chocolate chip cookie	5.70	5.7	5.4±0.71	1.06	−0.19, 2.33
Brownie	5.70	4.8	3.2±0.27	1.49	0.36, 2.64
Ice cream sandwich	6.38	4.4	4.3±0.02	1.02	0.97, 1.07
Berry Blue Go-gurt®	6.38	4.4	2.9±0.15	1.49	0.82, 2.17
Strawberry Splash Go-gurt®	6.38	4.4	3.6±0.43	1.24	−0.11, 2.59
Chewy chocolate chip granola bar	6.25	9.8	5.4±0.18	1.81	1.28, 2.33
Hostess Ding Dong®	5.70	3.6	3.4±0.17	1.06	0.59, 1.53
Little Debbie Swiss Roll®	5.70	3.6	2.7±0.13	1.34	0.78, 1.91

Table 3

Comparison of adolescents' total energy and protein intakes, from the food items analyzed, calculated from the FNDDS energy and protein values, and the energy and protein values, measured with a bomb calorimeter and a Dumas nitrogen analyzer, respectively.

	Energy				Protein			
Participant	**FNDDS energy consumed (kcal/day)**	**Measured energy consumed (kcal/day±SD)**	**FNDDS: measured energy intake ratio**	**95% Confidence interval**	**FNDDS protein consumed (g/day)**	**Measured protein consumed (g/day±SD)**	**FNDDS: measured protein intake ratio**	**95% Confidence interval**
1	2475	2364±167.12	1.05	0.92, 1.18	90.0	77.0±2.99	1.17	0.76, 1.58
2	2181	2034±99.94	1.07	0.99, 1.16	70.5	60.5±2.77	1.17	0.69, 1.65
3	1496	1384±84.43	1.08	0.97, 1.20	61.4	51.2±2.15	1.20	0.75, 1.65
4	2264	2192±87.47	1.03	0.97, 1.10	75.8	62.6±3.22	1.21	0.65, 1.77
5	1935	1787±51.05	1.08	1.03, 1.13	58.3	47.3±1.35	1.23	0.92, 1.55
6	2047	1941±88.78	1.06	0.98, 1.14	66.6	54.9±2.35	1.21	0.75, 1.68
7	2334	2243±85.41	1.04	0.98, 1.11	75.6	64.0±3.16	1.18	0.66, 1.71
8	1860	1741±79.05	1.07	0.99, 1.15	65.2	54.5±2.53	1.20	0.70, 1.70
9	1856	1739±87.80	1.07	0.98, 1.16	68.9	59.0±3.06	1.17	0.62, 1.71
10	1820	1694±80.78	1.08	0.99, 1.16	54.3	44.3±1.34	1.23	0.89, 1.56
11	1242	1186±11.43	1.05	1.03, 1.06	45.4	35.0±1.66	1.30	0.74, 1.86
12	1755	1655±90.61	1.06	0.96, 1.16	62.3	52.8±3.49	1.18	0.48, 1.89
13	1954	1987±75.07	0.98	0.92, 1.05	59.2	50.5±2.53	1.17	0.65, 1.70
14	1912	1820±52.17	1.05	1.00, 1.10	68.2	57.2±3.04	1.19	0.62, 1.76
15	1984	1902±47.37	1.04	1.00, 1.09	65.9	54.7±2.38	1.21	0.73, 1.68
Mean	1941±312.41	1845±310.32	1.05	1.04, 1.07	65.8±10.33	55.0±9.59	1.20	1.18, 1.22