ORIGINAL ARTICLE

Validity and Acceptability of Image-based Food Record in Assessing Nutrient Intake among selected Malaysian Undergraduates

Kai Sze Chan[1], Yit Siew Chin[1,2]

[1] Department of Nutrition and Dietetics, Faculty of Medicine and Health Sciences, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia
[2] Research Center of Excellence, Nutrition and Non-Communicable Diseases, Universiti Putra Malaysia, 43400, Serdang, Selangor, Malaysia

ABSTRACT

Introduction: Recognising the limitations of present dietary assessments method, recent attention had been drawn to image-based food record (IBFR) to assess dietary intake of the population. Thus, the present study aimed to compare nutrient intake assessed using IBFR with 24-hour diet recall (24DR) among nutrition and dietetics student. **Method:** There were 46 nutrition and dietetic undergraduates participated in the study, and information on the socio-demographic background and acceptability toward IBFR were obtained. Respondents were trained to complete one-day IBFR, and they were interviewed by researchers on the following day for their 24DR. **Result:** The mean age of respondents was 21.4±1.7 years old. The present study revealed that there were significantly higher protein and beta-carotene, but lower vitamin C reported by IBFR compared to 24DR. Medium to strong correlations were found between IBFR and 24DR for energy and nutrients intakes. The Bland-Altman analysis demonstrated a good level of agreement between IBFR and 24DR for energy and macronutrients (carbohydrates, protein and fat), respectively. The mean differences between IBFR and 24DR were -36 kcal for total daily energy intake, while mean differences of -12.24g, 0.79g, and 1.52g were reported for carbohydrates protein, and fat, respectively. Moderate level of agreement toward acceptability was demonstrated, and most of them (67.4%) preferred IBFR method. **Conclusion:** The present study revealed that IBFR showed a good level of agreement with 24DR in assessing nutrient intake. However, more extensive works should be considered to improve IBFR in assessing the energy and nutrients intake for the general population.

Keywords: Validity, Acceptability, Image-based food record, Dietary assessment, Bland-Altman analysis

Corresponding Author:
Yit Siew Chin, PhD
Email: chinys@upm.edu.my
Tel: +603-97692680

INTRODUCTION

Dietary assessment assesses food and beverage consumption at the individual level (1), and various methods are used to measure food and beverage consumption, such as weighed food records (2), estimated food record (3), 24-hour dietary (24DR) (3), and food frequency questionnaire (FFQ) (1). The weighed food record, that provides an accurate quantity of food consumed (2), was often taken as the "gold standard" in assessing dietary intake (4). However, the weighed food record method may burden the respondents and researchers and expensive to conduct when compared to other dietary assessment methods. On the other hand, several self-reported methods, such as 24DR, food record and FFQ are commonly used in the community, clinical and research settings in estimating the food consumption at the individual level, with 24DR and food record being the most widely used (3). The 24DR method relies heavily on respondents' memory and may have a bias in estimating the portion size of food and beverage consumed, while food record relies on respondents in estimating the portion size in which may reduce the accuracy (3). Hence, studies are ongoing in looking for a better method to assess dietary intake.

With the exponential growth of the audio-visual media and digital interfaces, such as smartphones and tablets, over the last few decades, and most people tend to have access to all these digital screens (5). As technology is getting advanced, dietary assessment with the assistance of digital device has been suggested in assessing food consumption, namely image-based dietary assessment. The image-based dietary assessment uses image or video as the primary record of food and beverages consumed at the individual level (6). There are two methods used for the image-based dietary assessments, which are the active method and passive method (7). The active method of image-based dietary assessments requires the individual to capture or record the image of the meal with handheld devices, such as the mobile phone, digital camera, and video recorder (7). On the other hand, passive method of image-based dietary assessments requires individual to wear a wearable camera that would capture point-of-view images of daily events automatically, including all the eating episodes, without the user input (8). Image-based dietary assessment creates less burden for individual and digital photos and videos collected can be analysed easily by researchers, nutritionists or dietitians when assessing the dietary intake of the individuals (9). Several studies were conducted in developing and validating the dietary assessment instrument among different population groups, such as adults (2-3,10-12), type 2 diabetes adults (13) and students (9,14).

As suggested by Bland and Altman (15), a simple plot with a difference in the means reported by two methods (Bland-Altman plot) was useful in determining the agreement between methods. Several studies assessed the agreement between image-based dietary assessment with weighed food record (10) and doubly labelled water (11) demonstrated comparable means in energy and macronutrients between the methods. However, another study revealed that image-based dietary assessment underestimated energy intake compared to weighed food record by 4.7 to 6.6% (3). On the other hand, some studies assessed only the correlation between image-based dietary assessment with the reference method (2,9,12,14,16). Hence, when the image-based dietary assessment is clearly differentiated when compared to other existing dietary assessments and respective information, such as level of agreement and acceptability are determined, it would be possible for the use of IBFR in community, clinical and research settings in assessing dietary intake.

Despite the better understanding of image-based dietary assessment is important, acceptability of the instrument should not be neglected. The acceptability aspects consider the instrument is simple to be used and provide the users with an enjoyable session (17), yet able to capture dietary information provided by the users. As suggested by Livingstone and colleagues (18), the level of usefulness of an instrument was determined by the acceptability and compliance of users. It is important to determine the acceptability of the image-based dietary assessment as it improves the compliance toward dietary assessment. While limited study had reported the acceptability of the image-based dietary assessment, there is a need in assessing the acceptability of the instrument.

In recognizing the importance of determining the dietary intake and reduce the recall bias of an individual in reporting his or her food and beverage consumed, the present study aimed to compare nutrient intake assessed using IBFR and 24DR among nutrition and dietetics students.

MATERIALS AND METHODS

The study was a cross-sectional study, and 46 respondents, from the Department of Nutrition and Dietetics, Faculty of Medicine and Health Sciences of Universiti Putra Malaysia, were recruited in the current study. The research ethical approval was obtained from the Ethics Committee for Research Involving Human Subjects of Universiti Putra Malaysia (UPM/TNCP1/RMC/1.4.18.1 (JKEUPM)/F20), and permission was obtained from the Faculty of Medicine and Health Sciences prior to the study conducted. Informed consent was obtained from each respondent prior to the study. The inclusion criteria of respondents were undergraduates who were undertaking nutrition-related programmes, either Bachelor of Science (Dietetics) or Bachelor of Science (Nutrition & Community Health), and possed smartphones or digital cameras with a picture capturing ability. Those who were pregnant and lactating were excluded from the present study.

Respondents were trained on the method to capture all the food and beverages consumed, and they were then required to complete a one-day IBFR. Following the protocol of the IBFR, respondents were required to capture a picture of food and beverages at aerial (90° angled) position before and after their meal consumption. In addition, respondents were requested to put a tablespoon or fork either at the side or at bottom of the food and beverages, which served as a reference marker in assisting the volume estimation for the present study. Respondents were also required to input information about the food, such as type of food, brand name, portion size, cooking method and additional information when necessary when submitting the photos. Respondents were required to send all the photos to a researcher through either email or phone at the end of the day they captured the photos. All images of food and beverages captured were converted into number of serving based on household measurements and further converted into metric quantities (gram or litre) by the researcher.

On the next day after submitting the photos, without prior exposure to the food and beverages photo provided by the respondent, 24-hour dietary recall (24DR) was conducted by the same researcher. Respondents were required to recall all the food and beverage consumed for the past 24 hours, including portion size, preparation method, and brand of the products. Household measurements were used to assist in the estimation of portion size during 24DR. Questions related to different type food groups, beverages, sauces, snacks, confectionery were probed by the researcher to respondents in aiding the recall process. Amount of food and beverages taken by the respondents were then converted into metric quantities (gram or litre), and the energy and nutrients intake of the respondents were calculated in term of kcal and gram by using the NutritionistPro® software (Axxya System, 2008). Nutrient Composition of Malaysian Food (19) and USDA Standard Reference Database (20) was used for energy and nutrients analysis in the Nutritionist Pro Software. Energy and nutrients estimated in using IBFR were compared with the data collected from 24DR (as the reference method).

Information regarding socio-demographic background, which included age, sex, ethnicity, course of study and academic year, were self-reported by respondents. Respondents were required to complete a set of questionnaire in rating their acceptability toward IBFR based on Technology Acceptance Model 2 (21). They were required to rate their acceptance with six-point Likert-scale ranging from "1 - Strongly Disagree" to "6 - Strongly Agree" based on four main components, namely Behavioural Intention, Perceived Usefulness, Perceived Ease of Use and Social Influence toward IBFR. Sum of the score was obtained from each component, and an average score was obtained by dividing the total score by number of statements for each component. For each of the components, a higher score indicating a higher agreement on the component. In addition, respondents were asked to choose between 24DR and IBFR as their preferred dietary assessment method in the questionnaire.

Statistical analysis was conducted by using IBM SPSS Statistics 22.0 (SPSS Inc., Chicago, IL, USA). Paired-sample t-test was carried out to determine the differences in energy and nutrients reported, while Pearson product-moment correlation (Pearson correlation) coefficients were used to assess the strength of relationship for energy and nutrients intake between IBFR and 24DR. Bland-Altman plot was used to analyse the level of agreement of the IBFR with 24DR for energy and macronutrients intake. A statistical probability level $p < 0.05$ was considered as significant.

RESULTS

The mean age of respondents in the present study was approximately 21 years, with most of the respondents were females (Table I). More than half of the respondents were Chinese, followed by Malay, and 2.2% was Indian. Three-quarter of the respondents were students of Bachelor of Science (Nutrition and Community Health) and the remaining were students of Bachelor of Science (Dietetics). Approximately 40% of the respondents were in their final year of study in the present study, followed by approximately one-third was first-year students, while the remaining 23.9% and 8.7% of respondents were in their second year and third year of study, respectively.

As presented in Table II, no significant differences were found in the energy, carbohydrates and fat intakes between IBFR and 24DR methods. However, IBFR showed a higher protein intake as compared to 24DR ($t = -2.40$, $p<0.05$). The present study also showed that there were significant differences in beta-carotene ($t = -5.60$, $p<0.001$) and vitamin C ($t = -2.02$, $p<0.05$) intakes between IBFR and 24DR methods. Pearson correlation coefficients showed that strong correlations were found for the intakes of energy and macronutrients, while medium to strong correlations was reported for other nutrients, between IBFR and 24DR methods (Table II), according to the rule of thumb suggested (22).

Table I: Socio-demographic characteristics of the respondents (n=46)

Characteristics	n (%)
Sex	
Male	3 (6.5)
Female	43 (93.5)
Ethnicity	
Malay	20 (43.5)
Chinese	24 (52.2)
Indian	1 (2.2)
Others	1 (2.2)
Age (years)	
Mean ± SD	21.4 ± 1.7
Course of Study	
Bachelor of Science (Dietetics)	11 (23.9)
Bachelor of Science (Nutrition & Community Health)	35 (76.1)
Academic year	
1	14 (30.4)
2	11 (23.9)
3	4 (8.7)
4	17 (37.0)

The energy and macronutrients intake were then further analysed with Bland-Altman analysis to determine the level of agreement between the two methods. Fig. 1 showed the Bland-Altman plot between IBFR and 24DR for total energy intake. The present study found that the difference in mean energy intake between IBFR and 24DR was approximately 37 kcal/d, with the lower and upper limits (±1.96 SD) of -428 kcal (with 95% confidence interval (95% CI) of between -326kcal and -530kcal) to 355 kcal (with 95% CI of between 253kcal and 457kcal). The difference in total energy intake between the two methods was small, and there was no significant difference in total energy intake ($p = 0.221$), with an estimated intra-class correlation coefficient (ICC) of 0.923 by using "two-way mixed model" and "absolute agreement" as suggested by Koo and Li (23). As shown in Fig 2, carbohydrates intake was lower in IBFR as compared to 24DR method, with the lower and upper limits were -79.9g (with 95% CI of between -62.32g and -97.48g) and 55.4g (with 95% CI of between 37.84g and 73.00g), respectively. Despite IBFR reported lower carbohydrates intake than 24DR, there was no significant difference in carbohydrates intake between the two methods ($p = 0.662$). On the other hand, protein intake was reported to be significantly higher in IBFR as compared to 24DR method, with a mean difference in protein intake of 0.79g ($p <0.05$). The lower limit and upper limits for protein intake ranged from -23.0g (with

Table II: Daily intake of nutrient estimated by IBFR and 24DR (n=46)

	Mean ± SD		Paired-sample *t*-test, *t*	*p*-value	Pearson Correlation Coefficient, *r*	*p*-value
	Image-based food record	24 hour dietary recall				
Energy (kcal/d)	1300 ± 366	1337 ± 384	-1.24	0.221	**0.859**	**< 0.001****
Carbohydrates (g/d)	157 ± 51.8	169 ± 55.2	0.440	0.662	**0.756**	**< 0.001****
Protein (g/d)	50.6 ± 18.2	49.8 ± 16.1	**-2.40**	**0.020***	**0.793**	**< 0.001****
Fat (g/d)	52.8 ± 24.8	51.3 ± 23.9	0.786	0.436	**0.855**	**< 0.001****
Cholesterol (mg/d)	200 ± 131	190 ± 118	1.28	0.206	**0.902**	**< 0.001****
Saturated Fat (g/d)	8.24 ± 4.91	7.59 ± 4.31	1.45	0.155	**0.791**	**< 0.001****
Monounsaturated Fat (g/d)	8.29 ± 4.59	7.77 ± 3.71	1.11	0.275	**0.727**	**< 0.001****
[ab]Polyunsaturated Fat (g/d)	4.98 (7.03)	5.12 (6.02)	-0.108	0.914	**0.947**	**< 0.001****
[ab]Total Dietary Fiber (g/d)	3.02 (4.04)	3.76 (3.97)	-1.91	0.056	**0.882**	**< 0.001****
Sugar (g/d)	22.7 ± 20.4	24.5 ± 23.8	-0.809	0.423	**0.783**	**< 0.001****
Vitamin A (RE/d)	681 ± 588	644 ± 481	0.669	0.507	**0.761**	**< 0.001****
[ab]Beta-Carotene (μg/d)	363 (992)	627 (1260)	**-5.60**	**<0.001****	**0.662**	**< 0.001****
[ab]Vitamin C (mg/d)	28.5 (54.3)	28.0 (75.6)	**-2.02**	**0.043***	**0.616**	**< 0.001****
Vitamin E (mg/d)	3.41 ± 2.48	3.61 ± 2.55	-1.06	0.293	**0.872**	**< 0.001****
[ab]Thiamin, B1 (mg/d)	0.449 (0.266)	0.435 (0.415)	-1.45	0.147	**0.834**	**< 0.001****
[ab]Riboflavin, B2 (mg/d)	0.716 (0.523)	0.713 (0.548)	-0.519	0.604	**0.774**	**< 0.001****
[ab]Niacin, B3 (mg/d)	6.55 (6.31)	7.38 (5.95)	-0.356	0.722	**0.837**	**< 0.001****
[ab]Pyridoxine, B6 (mg/d)	0.632 (0.654)	0.577 (0.689)	-0.872	0.383	**0.685**	**< 0.001****
[ab]Folate (μg/d)	68.7 (70.7)	72.3 (94.9)	-1.68	0.094	**0.824**	**< 0.001****
[ab]Cobalamin, B12 (μg/d)	0.794 (0.797)	0.846 (1.19)	-0.264	0.792	**0.809**	**< 0.001****
[ab]Vitamin K (μg/d)	5.53 (8.19)	5.43 (7.37)	-0.588	0.556	**0.752**	**< 0.001****
Sodium (mg/d)	1667 ± 911	1634 ± 1007	0.442	0.660	**0.871**	**< 0.001****
[ab]Potassium (mg/d)	838 (514)	903 (531)	-1.04	0.299	**0.654**	**< 0.001****
Calcium (mg/d)	273 ± 134	285 ± 141	-0.672	0.505	**0.626**	**< 0.001****
[ab]Iron (mg/d)	8.46 (7.42)	8.74 (7.81)	-0.963	0.336	**0.870**	**< 0.001****
[ab]Phosphorus (mg/d)	517 (514)	567 (376)	0.797	0.425	**0.763**	**< 0.001****
Magnesium (mg/d)	81.1 ± 43.3	84.7 ± 51.7	-0.685	0.497	**0.721**	**< 0.001****
[ab]Zinc (mg/d)	3.37 (3.82)	3.33 (2.586)	-0.022	0.983	**0.842**	**< 0.001****
Copper (mg/d)	0.435 ± 0.317	0.454 ± 0.327	-0.690	0.493	**0.841**	**< 0.001****

[a] Reported as Median (IQR);
[b] non-parametric (Wilcoxon-signed rank) test, value reported *Z*; (spearman's rank-order) test, value reported in r_s.
*Correlation is significant at $p < 0.05$.
** Correlation is significant at $p < 0.01$

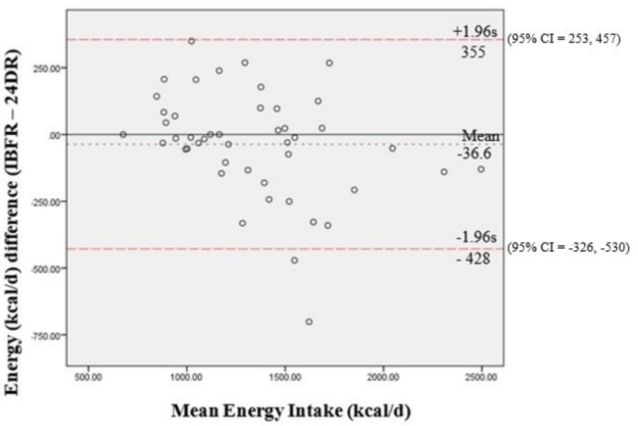

Figure 1: Bland-Atman plot of the difference between intakes recorded by Image-based food record (IBFR) method and that recorded by 24-hour Dietary Recall (24DR) against the mean intakes for the two reporting methods for energy

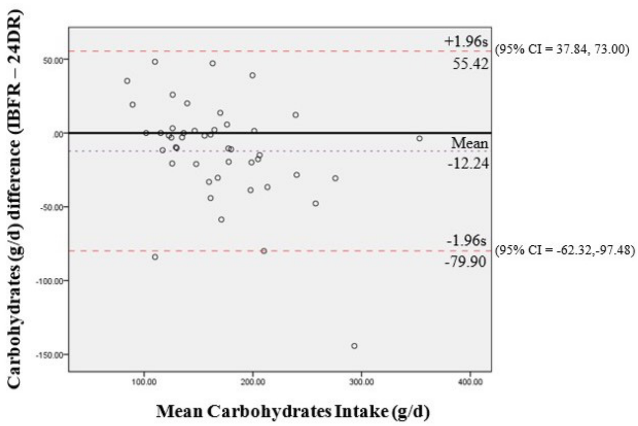

Figure 2: Bland-Atman plot of the difference between intakes recorded by Image-based food record (IBFR) method and that recorded by 24-hour Dietary Recall (24DR) against the mean intakes for the two reporting methods for carbohydrate

95% CI of between -16.81g and -29.15g) to 24.6g (with 95% CI of between 18.39g and 30.73g) as demonstrated in Fig 3. Further, IBFR method showed a higher intake of fat than fat intake using 24DR method, with a mean difference of 1.52g. The lower limit and upper limit for fat intake ranged from -24.2g (with 95% CI of between -17.54g and -30.92g) and 27.3g (with 95% CI of between 20.58g and 33.96g). Similar to energy and carbohydrates intake, there was no significant difference in fat intake between the two methods (p = 0.436). Interclass correlation coefficients (ICC) for carbohydrates, protein and fat were 0.860, 0.873 and 0.922 respectively. Bland-Altman plots for energy and macronutrients revealed little outliers, as most of the data fall within the lower and upper limits. Proportion bias was not observed in the Bland-Altman plots; and thus, suggesting that differences in values reported by both methods may occur randomly across all values of intakes.

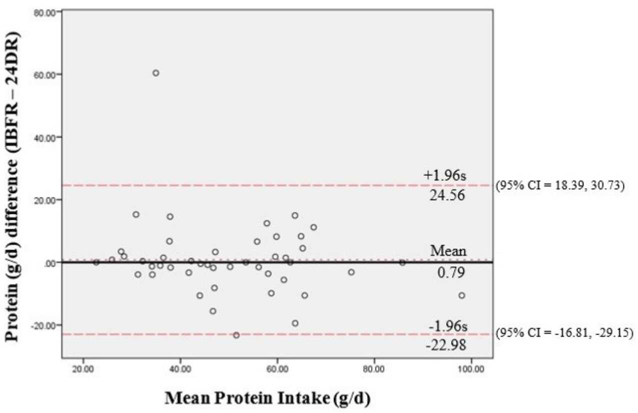

Figure 3: Bland-Atman plot of the difference between intakes recorded by Image-based food record (IBFR) method and that recorded by 24-hour Dietary Recall (24DR) against the mean intakes for the two reporting methods for protein

As depicts in Table III, respondents showed a moderate level of agreement for behavioural intention, perceived usefulness, perceived ease of use and social influence in using IBFR as a dietary assessment. Approximately two-thirds of the respondents preferred using IBFR as the dietary assessment method, while the remaining preferred using 24DR in assessing their dietary intake (Table IV).

Table III: Acceptability on using IBFR (n=46)

Construct of Acceptability	Mean ± SD
Behavioural Intention	3.79 ± 1.14 (max score = 6)
Perceived Usefulness	4.20 ± 0.84 (max score = 6)
Perceived Ease of Use	4.12 ± 0.67 (max score = 6)
Social Influence	3.58 ± 0.99 (max score = 6)

Table IV: Dietary assessment method preferred by the participants (n= 46)

Dietary assessment method	n (%)
Image-based food record	31 (67.4)
24 hour dietary recall	15 (32.6)

DISCUSSION

The present study found that the IBFR showed a lower total energy intake than 24DR method. Our findings supported by studies conducted among college students in USA (11) and Japan (14), but it was inconsistent with studies conducted among adults in Japan (2) and USA (24). The study that conducted among Japanese adults used a one-day weighed food record as the reference method, and they found that IBFR reported a higher total energy value compared to a one-day weighed food record (2). Another study that used doubly labelled water as the reference method demonstrated significantly lower total energy intake was reported in IBFR compared to doubly labelled water (24). The study conducted by Martin and colleagues (11) used two approaches, which were doubly labelled water and weighed food record. They demonstrated a significant difference in energy reported, but no significant difference in energy was found between IBFR and weighed food record. The inconsistent findings in the present study as compared to other studies may be due to different reference methods used. It should be noted that weighed food record was often referred as the "gold standard" in dietary assessment and as a reference method, thus it produced a more accurate result compared to 24DR (4). However, with the strengths and limitations of dietary assessment method, it is worth investigating the difference in total energy reported by IBFR and 24DR, as 24DR is one of the most common dietary assessments used in the community, clinical and research setting.

For macronutrients, carbohydrates and fat intake reported by IBFR and 24DR were found to be no significant difference, which was supported by several studies (11,14). However, the protein was found to demonstrate a higher intake in IBFR as compared to 24DR in the current study. The result of the present study was comparable to the study conducted in Japan (2), as the study revealed that a significant difference in protein intake reported by IBFR and a one-day weighed food record. However, the study conducted by Kikunaga and colleagues (2) demonstrated that IBFR showed lower protein intake as compared to a one-day weighed food record, which is inconsistent with the present study. It is not unexpected that IBFR reported a higher protein intake as compared to 24DR, as 24DR was known for the under-reporting issue as respondents may have under-reported their food and beverages consumption due to several reasons related to memory, knowledge and environment during the interview (1).

In term of micronutrients, the present study reported a significantly lower intake for Beta-Carotene, but significantly higher intake for Vitamin C when compared IBFR with 24DR method. The current findings were comparable with findings in Japan for Vitamin C when compared with one-day weighed food record (2). However, several studies revealed that no significant difference in reported intake in Vitamin C between IBFR with 24DR (11) and weighed food record (14), respectively. Previous studies proposed that the errors in estimating the intake using IBFR may be attributed to the comprehensive protocol in capturing the image of food and beverage were not comply by the respondents, poor quality food and beverage images captured or failed to capture food and beverage images prior meal (2, 11, 13).

The present study also showed significant correlations between IBFR and 24DR in assessing intakes of energy and nutrients, which was comparable to several studies (2, 14). While a previous study reported the correlates of IBFR with weighed food record for nutrients ranged from 0.304 to 0.776 (2), the present study demonstrated higher correlates when comparing IBFR and 24DR that ranged from 0.616 to 0.947. The use of different reference methods may yield different results. The use of weighed food record often provides a more accurate result in dietary assessments (4). On the other hand, the issue of under-estimating the portion size of dishes using 24DR was common (1), this may result in a higher correlation when correlating the nutrients intake estimated by IBFR with 24DR in the present study since both methods were prone to underestimate nutrient intake. In addition, a recent study showed that only approximately less than 30% of the nutrition professionals able to identify portion size within 10% actual weight based on food images (23), this may also result in an error in estimating the portion size from IBFR and thus affect the strength of the correlation.

Based on the Bland-Altman analysis, the present study demonstrated a good level of agreement between IBFR and 24DR for energy and macronutrients, which was comparable to several studies for energy intake (3,11,24). According to Giavarina (26), it was expected that 95% of the differences to lie between d+1.96s (upper limit of agreement) and d-1.96s (lower limit of agreement) to show the existence of agreement between methods; and thus, the tested method was able to report the values reported by the reference method. Despite a good level of agreement was reported in the present study, IBFR reported a significantly lower mean protein intake (-0.79g) as compared to 24DR method. While noting the under-reporting issues of 24DR method, the difference between the dietary assessment methods ranged from 0-16% (27). As a few respondents in the present study failed to capture snacks and drinks consumed in-between meal, hence, this may contribute to the differences in nutrient intake reported between IBFR and 24DR methods. In short, it is difficult to delineate the level of agreement between IBFR and other dietary assessment methods, as there were limited studies assessed the level of agreement based on Bland-Altman analysis. More research and extensive work should be warranted in investigating the level of agreement.

While for the 95% CI for the limit of agreement for energy, result demonstrated that the limit of agreement for the sample may be as wide apart as approximately 457kcal to – 530kcal, or as narrow as approximately 253kcal to -326kcal. The 95% CI demonstrated in the present study suggested that limit of agreement may lie further or closer from the mean of differences (28). For macronutrients, protein revealed the narrowest 95% CI (as narrow as 18.39g to -16.81g) when compared to carbohydrates and fat, which suggested that IBFR may be better in reporting protein intake as compared to carbohydrates and fat, as suggested by study (28). In contract, carbohydrates reported widest 95% CI, which might be less accurate in reporting carbohydrates intake when used IBFR as compared to the other two macronutrients. The ICC reported in the present study revealed a good to excellent level of reliability, as suggested that ICC between 0.75 and 0.90 indicate good reliability, and ICC higher than 0.90 demonstrated excellent reliability (23). However, with limited studies available, it is difficult to understand the 95% CI and ICC of IBFR, thus more extensive studies are needed to provide a better understanding on the acceptable range for 95% CI and ICC.

In term of acceptability, respondents showed moderate acceptability toward the use of IBFR as the dietary assessment method, and approximately 67% preferred to use IBFR compared to 24DR method. The finding was consistent with a study conducted among health campus students, which they demonstrated a high level of acceptability toward the use of image-based dietary assessment (9,17). Previous studies reported that young adults, including university students, were having higher intention in adopting new technology as compared to other age groups (29,30). Boushey and colleagues (31) suggested to incorporate the element of entertainment in the device would increase the acceptance and use of image-based dietary assessment method. Thus, features such as mini-games and rewards could be incorporated into the devices to improve the use of image-based dietary assessment. Besides, interaction with the device may play an important role in improving the acceptability of image-based dietary assessments (32), such as provide brief feedback to users when necessary. In short, incorporation of gaming features and interaction with users may help to improve the acceptability of the image-based dietary assessment, as well as the behaviour intention in using the IBFR.

To the best of our knowledge, this is the first Malaysian study that compare nutrient intake assessed using IBFR with 24DR. The main strength of the present study was the use of Bland-Altman analysis in determining the level of agreement of IBFR with 24DR in assessing nutrient intake. The acceptability test that was employed in the present study gives a better understanding of the acceptance and intention to use of IBFR method. Nevertheless, there were several limitations should be considered in the present study. Firstly, the present study used 24DR as the reference method, which might be subject to bias in related to memory and knowledge. Secondly, the population involved in the current study was mainly nutrition and dietetics students, with the majority of them were female final year students; and thus, it is difficult to generalize to other population. Thirdly, the respondents were asked to capture food and beverages images prior meal consumption, all image was capture at the aerial (90°) angle, and this may add another limitation in estimating the serving size of beverages. It is recommended that future studies may also capture the food and beverages image in angled (45°) view to reduce the limitation in estimating the serving size of food and beverages.

CONCLUSION

In conclusion, the present study showed a good level of agreement for energy and macronutrients between IBFR and 24DR methods. Respondents also revealed a moderate level of acceptability toward the use of IBFR, and more than half of them preferred the use of IBFR as the dietary assessment method as compared to 24DR. Considering the burden and limitations of traditional dietary assessments, and the technology advancement in digital devices, it is time to incorporate technology in improving current dietary assessments. However, there is a need to further enhance the use of IBFR in dietary assessment. More researches are needed to determine the validity and reliability of IBFR in different groups of the population.

ACKNOWLEDGEMENT

We would like to sincerely explicit our gratitude to the Faculty of Medicine and Health Sciences UPM, all officers, volunteers and respondents for their great cooperation and assistance during the period of data collection.

REFERENCES

1. Coulston AM, Boushey CJ & Ferruzzi MG. Nutrition in the Prevention and Treatment of Diseases (3rd Ed.). London, UK: Elsevier; 2013
2. Kikunaga S, Tin T, Ishibashi G, Wang DH, & Kira S. The Application of a Handheld Personal Digital Assistant with Camera and Mobile Phone Card (Wellnavi) to the General Population in a Dietary Survey. Journal of Nutritional Science and Vitaminology. 2007;53(2);109–116.
3. Martin CK, Han H, Coulon SM, Allen HR, Champagne CM, & Anton SD. (2009). A novel method to remotely measure food intake of free-living individuals in real time: The remote food photography method. British Journal of Nutrition. 2009;101(3);446–456.
4. Wrieden W, Peace H, Armstrong J, & Barton K. A short review of dietary assessment methods used in National and Scottish Research Studies. Group on Monitoring Scottish Dietary. 2013;1–17. Retrieved from: http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:A+short+review+of+dietary+assessment+methods+used+in+National+and+Scottish+Research+Studies#
5. Spence C, Okajima K, Cheok AD, Petit O, & Michel C. Eating with our eyes: From visual hunger to digital satiation. Brain and Cognition. 2016; 110;53–63.
6. Gemming L, Utter J, & Ni Mhurchu C. Image-assisted dietary assessment: A systematic review of the evidence. Journal of the Academy of Nutrition and Dietetics. 2015;115(1);64–77.
7. Sun M, Fernstrom JD, Jia W, Hackworth SA, Yao N, Li Y, et al. A Wearable Electronic System for Objective Dietary Assessment. Journal of the American Dietetic Association. 2010;110(1);45–47.
8. Gemming L, Doherty A, Kelly P, Utter J, & Ni Mhurchu C. Feasibility of a SenseCam-assisted 24-h recall to reduce under-reporting of energy intake. European Journal of Clinical Nutrition. 2013;67(10), 1095–1099.
9. Wang DH, Kogashiwa M, Ohta S, & Kira S. Validity and reliability of a dietary assessment method: The application of a digital camera with a mobile phone card attachment. Journal of Nutritional Science and Vitaminology. 2002;48(6);498–504.
10. Lassen, AD, Poulsen S, Ernst L, Andersen KK, Biltoft-Jensen A, & Tetens, I. (2010). Evaluation of a digital method to assess evening meal intake in a free-living adult population. Food and Nutrition Research. 2010;54.
11. Martin CK, Correa JB, Han H, Allen HR, Rood JC, Champagne CM, et al. Validity of the remote food photography method (RFPM) for estimating energy and nutrient intake in near real-time. Obesity. 2012;20(4);891–899.
12. Sharp DB, & Allman-Farinelli M. Feasibility and validity of mobile phones to assess dietary intake. Nutrition. 2014;30(11–12);1257–1266.
13. Rollo ME, Ash S, Lyons-Wall P & Russell AW. Evaluation of a mobile phone image-based dietary assessment method in adults with type 2 diabetes. Nutrients. 2015;7(6);4897–4910.
14. Wang DH, Kogashiwa M, & Kira S. (2006). Development of a New Instrument for Evaluating Individuals' Dietary Intakes. Journal of the American Dietetic Association. 2006;106(10);1588–1593.

15. Bland JM, & Altman DG. Statistical methods for assessing agreement between two methods of clinical measurement. The Lancet. 1986;1(8476), 307–310. Retrieved from https://www-users.york.ac.uk/~mb55/meas/ba.pdf
16. Rollo ME, Ash S, Lyons-Wall P, & Russell A. Trial of a mobile phone method for recording dietary intake in adults with type 2 diabetes: Evaluation and implications for future applications. Journal of Telemedicine and Telecare. 2011;17(6);318–323. https://doi.org/10.1258/jtt.2011.100906
17. Chen YS, Wong JE, Ayob AF, Othman NE, & Poh BK. Can Malaysian young adults report dietary intake using a food diary mobile application? A pilot study on acceptability and compliance. Nutrients. 2017;9(1);1–11.
18. Livingstone MBE, Robson PJ, & Wallace JMW. . Issues in dietary intake assessment of children and adolescents. British Journal of Nutrition. 2004;92(S2);S213–S222.
19. Tee ES, Mohd Ismail N, Mohd Nasir A, & Khatijah I. Nutrient Composition of Malaysian Food (4th Ed.). Kuala Lumpur, Malaysia: Malaysian Food Composition Database Programme; 1997
20. United States Department of Agriculture & Agricultural Research Service. Continuing Survey of Food Intakes by Individuals, 1994-1996, 1998. Washington, DC: USDA & ARS, 2000
21. Venkatesh V, & Davis FD. Theoretical extension of the Technology Acceptance Model: Four longitudinal field studies. Management Science. 2000;46(2);186–204.
22. Hinkle DE, Wiersma W, & Jurs SG. Applied Statistics for the Behavioral Sciences (5th ed). Boston: Houghton Mifflin; 2003.
23. Koo TK, & Li MY. A Guideline of Selecting and Reporting Intraclass Correlation Coefficients for Reliability Research. Journal of Chiropractic Medicine. 2016:15(2), 155–163.
24. Boushey CJ, Spoden M, Delp EJ, Zhu F, Bosch M, Ahmad Z et al. Reported energy intake accuracy compared to doubly labeled water and usability of the mobile food record among community dwelling adults. Nutrients. 2017;9(3);1–17.
25. Fatehah AA, Poh BK, Shanita SN, & Wong JE. Feasibility of reviewing digital food images for dietary assessment among nutrition professionals. Nutrients. 2018;10(8);1–12.
26. Giavarina D. Understanding Bland Altman analysis. Biochemia Medica. 2015;25(2);141–151.
27. Buzzard M. Nutritional Epidemiology. Oxford, U.K.: Oxford University Press, 1998
28. Carkeet A. Exact parametric confidence intervals for bland-altman limits of agreement. Optometry and Vision Science. 2015:92(3), e71–e80.
29. Casperson SL, Sieling J, Moon J, Johnson L, Roemmich JN, & Whigham L. A Mobile Phone Food Record App to Digitally Capture Dietary Intake for Adolescents in a Free-Living Environment: Usability Study. JMIR MHealth and UHealth. 2015;3(1);e30.
30. Hongu N, Pope BT, Bilgiз P, Orr BJ, Suzuki, A, Kim AS, et al. Usability of a smartphone food picture app for assisting 24-hour dietary recall: A pilot study. Nutrition Research and Practice. 2015;9(2);207–212.
31. Boushey CJ, Harray AJ, Kerr DA, Schap TE, Paterson S, Aflague T, et al. How Willing Are Adolescents to Record Their Dietary Intake? The Mobile Food Record. JMIR MHealth and UHealth. 2015;3(2);e47.
32. Aizawa K, Maeda K, Ogawa M, Sato Y, Kasamatsu M, Waki K, & Takimoto H. (2014). Comparative study of the routine daily usability of foodlog: A smartphone-based food recording tool assisted by image retrieval. Journal of Diabetes Science and Technology. 2014;8(2);203–208.