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Narrative Review

Reliability and validity of an adherence score sheet to monitor adherence of patients with diabetes to personalised nutrition education

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SUMMARY

Background: Dietary management of diabetes relies on the patient's ability to adhere to the nutrition guidelines presented to them by a health care professional. Traditional analysis of dietary intake to monitor adherence can be tedious, and there is a need for a short, easy-to-use tool to measure dietary adherence from food records. This study aimed to determine the reliability and validity of an Adherence Score Sheet (ASS) developed to quantify dietary adherence to personalised nutrition education.

Methodology: 67 three-day food records of patients with diabetes who received nutrition education were scored using the ASS Adherence scores were given for adhering to glycemic index (GI), glycemic load (GL), protein and fat guidelines, and a total adherence score. Intraclass correlation (ICC) and Bland–Altman plots were used to demonstrate the amount of agreement between ASS from two independent raters (inter-rater reliability) and ASS score from Rater 1 [test method] vs ASS obtained from dietary analysis (DA) program [reference method] for the assessment of concurrent validity.

Results: ICC values for the total adherence score showed good agreement (ICC = 0.74) between raters, with subcategories agreement being fair to excellent (ICC ranging from 0.56 to 0.81). The Bland–Altman plots for all 5 categories (GI, GL, protein, fat, and total score) indicated acceptable agreement between Rater 1 and Rater 2. ICC values for all categories indicated excellent validity between Rater 1 and the DA scores. The Bland–Altman plots for validity indicated overall acceptable agreement between Rater 1 and DA for all 5 categories.

Conclusion: Our findings reveal that the ASS is a reliable and valid tool to determine and quantify adherence to personalised nutrition education among patients with diabetes.

1. Introduction

Type 2 diabetes is classified as a worldwide pandemic [1,2]. In 2021, the International Diabetes Federation (IDF) estimated that there were 537 million people with diabetes worldwide. These numbers are expected to rise to 783 million people with diabetes by 2045 [3]. These alarming figures emphasise the importance of evidence-based nutrition intervention in the management of insulin resistance and type 2 diabetes. But more importantly, assessing adherence to these nutritional recommendations is critical to achieving the desired outcomes.

As far as dietary management of diabetes is concerned, evidence-based recommendations suggest diets containing carbohydrates with a low GI and low GL [4]. A meta-analysis of 29 trials indicated that low GI, low GL diets resulted in improved glycaemic control and lowered blood lipids, adiposity, blood pressure, and inflammation among patients with moderately controlled diabetes [5]. A systematic review and meta-analysis of randomized controlled trials indicated that low GI diets are more effective in controlling glycated haemoglobin and fasting blood glucose compared with diets with higher GI-values in patients with [6] type 2 diabetes. The GL takes the GI and the carbohydrate content of a specific serving of carbohydrate into account [7–15], and directly affects the amount of postprandial insulin secreted [14–18]. Studies have shown that ingesting high-protein food

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items can induce insulin responses similar to a high-carbohydrate meal, and high-fat meals can cause sustained late hyperglycemia and insulinemia [19]. The food insulin index (FII) is a valuable tool to identify types and amounts of food (including foods that are high in carbohydrates, proteins, and fats) that can increase/decrease postprandial insulin response and can be linked to the development and dietary treatment of insulin resistance [20–22]. Although GI, GL and FII principles are shown to be effective in the dietary management of diabetes [4–6,8,16,18,23–25] adherence to these principles needs to be monitored.

Successful dietary adherence has several positive consequences, including improved quality of life, and improved clinical outcomes such as glycated hemoglobin, body mass index, lipid profile and blood pressure [26]. Assessing patients with diabetes's adherence to nutrition education is critical as it can provide the healthcare professional with insight into the patient's understanding of the diabetic diet to direct further discussions and improve long-term adherence to nutrition guidelines [27]. Methods to assess patients' dietary intake, like 24-h recalls or food frequency questionnaires, can provide detailed information about nutrient and food group intake [28], but these methods can be very time-consuming for healthcare providers to analyse [27,28]. In clinical settings where large numbers of patients are seen, there is a need to assess dietary adherence quickly and easily to guide further patient education. Limited questionnaires have been developed to test adherence to diabetic guidelines, and are mainly based on Canadian, Finnish, and Polish guidelines [28–30]. No questionnaires or scoring sheets have been developed to assess adherence to GI, GL and FII principles. The researchers developed an Adherence Score Sheet (ASS) to assess adherence to personalised nutrition education based on GI, GL and FII principles, by monitoring GI, GL, fat, and protein intake from food records. This study aimed to determine the reliability and validity of this ASS among diabetic patients who received personalised nutrition education.

2. Material and methods

2.1. Study type and population

A retrospective patient file sample was obtained from type 2 diabetic adults aged between 18 and 85 years who attended a dietetic private practice in Pretoria, South Africa, between January 2015 and December 2022.

2.2. Sample size

Simple random sampling was used to select 67 patient files. The sample size calculation was done using G*Power 3.1.9.7. The conventional power levels of significance of 0.8 and 0.05 levels of significance were specified for a medium effect of 0.3, based on Cohen's guidelines [31] for effect sizes for correlation coefficients. This sample size was confirmed as also appropriate for analysis using the ICC, with similar parameters (alpha = 0.05, beta = 0.8 and effect size 0.3) using 2 raters [32].

2.3. Data collection

Patients received personalised nutrition education for diabetes management based on GI, GL and FII principles at their first visit as described elsewhere (Strydom et al. [33]). Patients were advised to consume low/intermediate GI carbohydrates. Suggested portions were calculated to keep the GL of main meals ≤25 and of snacks ≤10, protein of main meals ≤27g for females and 37g for males, protein of snacks ≤ 7g), and fat for main meals ≤14g for females and 16g for males, fat for snacks ≤ 3g). Patients were given a 3-day food record form and were asked to complete the record 30 days (±two weeks) after the first consultation. All food and drinks consumed for three consecutive days were recorded by patients. Patients were asked to specify the types of food (for example, 'basmati rice' or 'white low GI bread') and amounts taken as standard amounts ('one slice of bread' or 1 medium egg') or in cups ('3/4 cup of rice'). Patients were encouraged to fill in details about the amounts and types consumed as close to consumption as possible (so that they do not rely on memory). For this study, completed 3-day food records (collected from patients during the follow-up visits) were taken from the 67 selected patient files and were used in this study for reliability and validity testing. Fig. 1 illustrates the assessment of the reliability and validity of the ASS.

The ASS was developed to quantify ('score') how well patients adhered to the personalised nutrition education presented to them. Adherence to four categories, namely GI, GL, protein, and fat was assessed at the three main meals (breakfast, lunch, and supper) and the three in-between meal snacks. Scores were allocated based on set criteria/recommendations by comparing the food choices and amounts recorded on the 3-day food record with the nutrition education given to patients. For example, if it was advised that no more than *two slices of low GI bread* should be eaten at main meals, but four slices of low GI bread or two slices of high GI bread were eaten, this would indicate poor adherence because the choice or amount was incorrect, and subsequently 0 was scored for that meal in the GI category. A score of '1' indicates adherence to the specific recommendation given for that category, while a '0' indicates non-adherence. A maximum score of 4 points per meal or snack, 24 per day and a total adherence score of 72 for all three days could be achieved. At each category (i.e. GI, GL, protein and fat), a maximum score of 6 per day and 18 per 3-day record could be achieved. Please see Table 1 for an example of the ASS and how the scoring was done.

2.4. Reliability assessment (test method)

The inter-rater reliability of the ASS was tested by assigning the selected 67 patients' 3-day food records to two raters, Rater 1, and Rater 2 (dietitians with more than 10 years of experience), who independently completed an ASS for each 3-day food record (Fig. 1).

2.5. Validity assessment (reference method)

Data from the same 3-day food records were used to test validity. The food items and the amounts consumed listed on 3-day food records were entered into an electronic dietary analysis program (FoodFinder3.0) [34] to obtain the nutritional analysis of protein, fat and carbohydrates for each of the 3 days of meals and snacks. From the analysis, GI values were determined for each food item using South African GI values [35]. The GI, together with the grams of carbohydrates, were used to calculate GL values per serving and adherence scored on the ASS (GI: low/intermediate; GL: meals ≤25; snacks ≤10). The analyses (in grams) for protein and fat for each meal or snack were compared with cut-off points for adherence to protein (meals ≤27g female/37g male; snacks ≤ 7g), and fat (meals ≤14g female/16g male; snacks ≤ 3g).and scored on the ASS. The total and sub-scores for the 3 days adherence on the ASS obtained by DA [reference method] were calculated and compared with the total and sub-score obtained by Rater 1 on the ASS [test method] to measure the concurrent validity of the ASS.

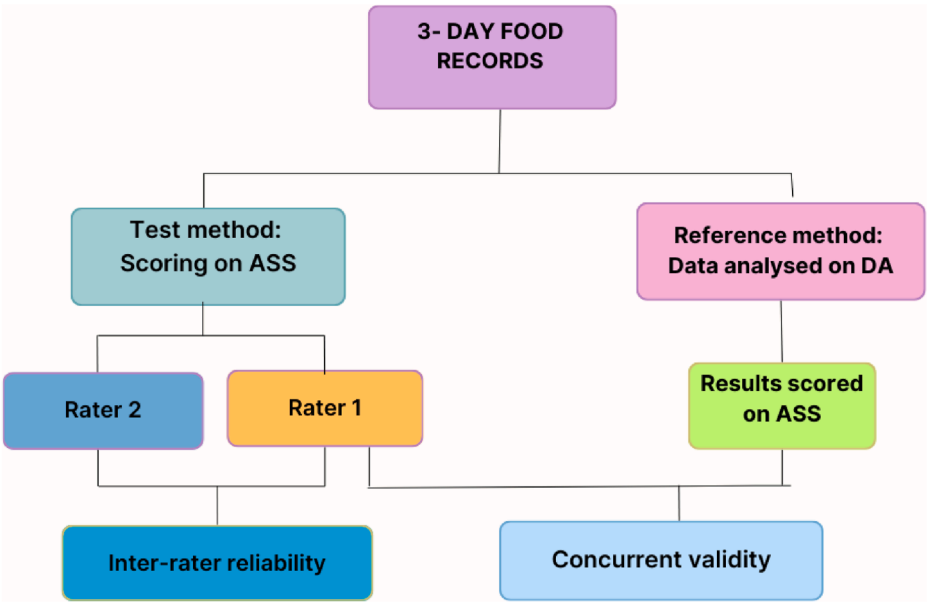

Fig. 1. Reliability and validity testing.

Table 1
The ASS and breakfast scoring example.

Day 1	GI	GL	PROTEIN	FAT	MEAL SCORE
Breakfast	1	1	0	1	3
Snack					
Lunch					
Snack					
Supper					
Snack					
TOTAL SCORE					

In this example, breakfast is scored where 1 slice of low GI bread, an apple and 4 boiled eggs were eaten. Therefore, the GI and GL were correct (score of 1 each); no fat was added (score of 1), but the protein content was too high (score of 0).

Table 2
Characteristics of the patient sample ($n = 67$).

Characteristic	*n* (%)
Age (years; mean ± SD)	53.8 ± 11.8
Gender	
Male	36 (54)
Female	31 (46)
Body mass index (BMI) (kg/m^2; mean ± SD)	34.5 ± 6.0
Body mass index (BMI) (kg/m^2) classification	
Underweight (<18.5)	0 (0)
Normal weight (18.5–24.9)	2 (3)
Pre-obesity (25.0–29.9)	14 (21)
Obesity class I (30.0–34.9)	22 (33)
Obesity class II (35.0–39.9)	15 (22)
Obesity class III (>40.0)	14 (21)

2.6. Statistical methods

Descriptive statistics were used to describe participants' characteristics. Intraclass correlation (ICC) [36] and Bland–Altman plots [37] were used to demonstrate the amount of agreement between the two different raters (reliability) and assessment methods (validity). The ICC estimates and their 95 % confidence intervals were calculated using R/RStudio Software for Statistical Analysis [38]. Implementing the ICC package, based on the 2-way mixed-effects model, single measurements (type), and absolute agreement (definition), the ICC for each variable, with its 95 % Confidence Interval (CI) and p-values, is presented. The ICCs are interpreted using the scales according to Fleiss et al. [36] where values greater than 0.75 represent excellent agreement beyond chance, values between 0.40 and 0.75 represent fair to good agreement beyond chance and values below 0.40 represent poor agreement beyond chance.

A mean difference between −0.5 and 0.5 was considered acceptable for reliability and validity testing (indicating minimal systematic bias) between subcategories (GI, GL, protein, and fat), where a maximum score of 6 could be obtained for each subcategory. A mean difference between −2 and 2 for the total score was considered acceptable (indicating minimal systematic bias), where a maximum total score of 24 could be obtained. Bland–Altman plots were visually checked for normality, whether clustering or patterns in points were present, and if most values fell within narrow limits of agreement (LOA) relative to the mean difference. A LOA between −1.5 and 1.5 was considered acceptable for subcategories and an LOA between −3 and 3 was considered acceptable for total scores.

3. Results

This study included a total of 67 patient files, which provided retrospective data for the reliability and validity testing of the ASS. The patient sample had almost equal proportions of males (54 %) and females (46 %). Patients had a mean age of 53.8 ± 11.8 years and were classified as obese (76 %). The characteristics of the patients are given in Table 2.

3.1. Reliability

The inter-rater reliability results of the ASS for the total score and four subcategories are presented in Table 3. An excellent level of reliability was shown between Rater 1 and Rater 2 regarding GI (ICC = 0.75, 95 % CI (0.63,0.84)) and protein (ICC = 0.81, 95 % CI (0.71; 0.88)), while a fair to good level of agreement was shown for GL (ICC = 0.70, 95 % CI (0.56, 0.81)), fat (ICC = 0.562, 95 % CI (0.372;0.71)) and total score (ICC = 0.74, 95 % CI (0.61,0.83)). ICC values for all subcategories and the total score were significant

Table 3
Intra-rater reliability of the ASS scores: comparison between Rater 1 and Rater 2 (n = 67).

Category	ASS Scores		Bland–Altman			
	Rater 1 Mean ± SD	Rater 2 Mean ± SD	Mean diffe-rence(bias)	Lower and upper LOA	ICC (95 % CI)	p-value
GI	5.47 ± 0.61	5.42 ± 0.56	0.05	−0.78;0.86	0.75 (0.63;0.84)	p < 0.0001
GL	5.06 ± 0.76	5.20 ± 0.73	−0.14	−1.27; 0.99	0.70 (0.56;0.81)	p < 0.0001
Protein	5.48 ± 0.63	5.53 ± 0.57	0.04	−1.41;1.49	0.81 (0.71;0.88)	p < 0.0001
Fat	5.12 ± 0.78	5.13 ± 0.70	0.18	−1.04; 1.39	0.56 (0.37;0.71)	p < 0.0001
Total	21.07 ± 2.05	21.27 ± 1.91	−0.2	−3.06;2.66	0.74 (0.61;0.83)	p < 0.0001

GI, glycemic index; GL, glycemic load.

(p < 0.0001). The Bland–Altman analysis showed that the mean difference (bias) fell within the acceptable range for all subcategories and the total score (Fig. 2). For all subcategories and the total score, the LOA's were narrow and within the acceptable range indicating that Rater 1 and Rater 2's ASS results were in agreement.

3.2. Validity

The ICC and Bland–Altman analysis were conducted to evaluate the agreement of category scores and total score of the ASS between Rater 1 and the DA to determine concurrent validity (Table 4).

For validity testing, an excellent agreement was seen between Rater 1 and DA regarding GI (ICC = 0.89, 95 % CI (0.81, 0.94)) and total score (ICC = 0.83, 95 % CI (0.74,0.84)). ICC indicated a fair to good level of agreement between Rater 1 and DA for GL, protein, and fat scoring. ICC values were significant for all subcategories and the total score (p < 0.0001). The Bland–Altman analysis (Fig. 3) showed that the mean difference fell within the acceptable range for all subcategories and the total score, indicating minimal systematic bias. The LOA's for all subcategories were narrow, and for GI, GL, protein, and total score, the LOA's were within the acceptable range, indicating acceptable agreement between methods. The upper LOA for fat (1.58) fell just outside the acceptable level (−1.5 to +1.5). Variability of all plots was consistent across the graphs with no trends or patterns, indicating that the difference between methods did not increase or decrease as the average increased.

4. Discussion

This study aimed to test the reliability and validity of the ASS among South African patients who suffer from diabetes. The ASS

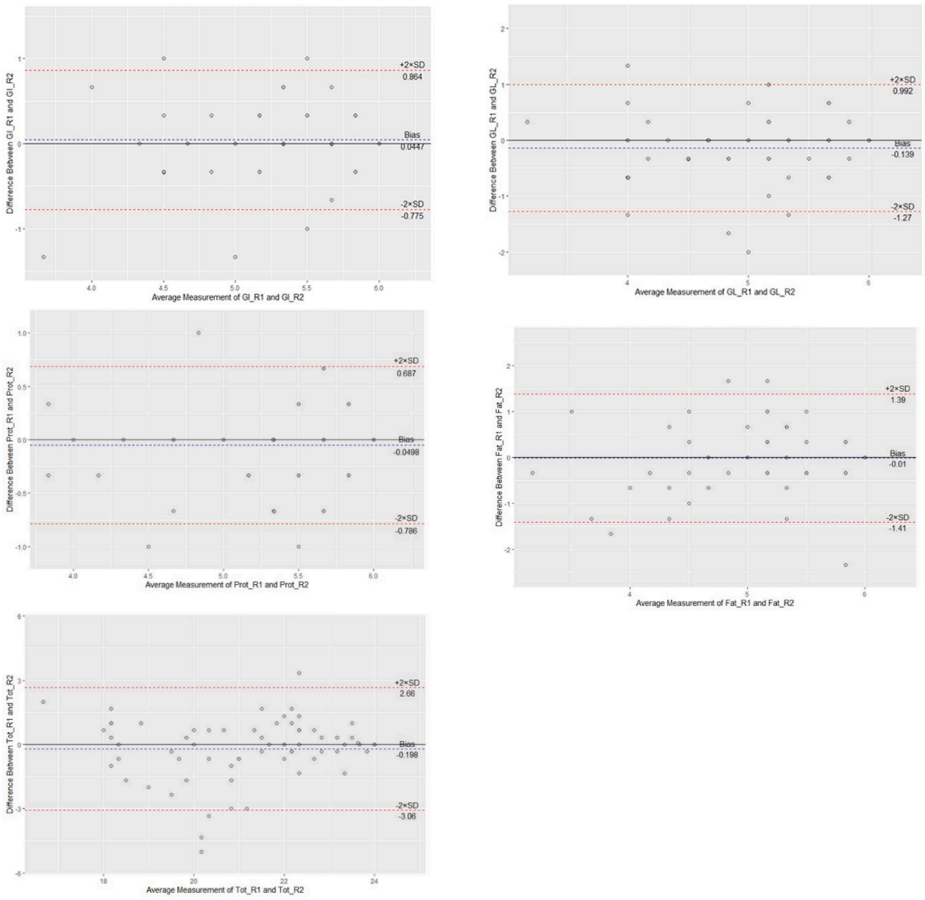

Fig. 2. Bland–Altman analysis for two raters (Tot_R1 and Tot_R2) measuring GI, GL, protein, fat and total score.

Table 4
Concurrent validity of the ASS: comparison of results obtained between Rater 1 and Dietary Analysis.

Category	ASS Scores		Bland–Altman			
	R1 Mean ± SD	DA Mean ± SD	Mean difference (bias)	Lower and upper LOA	ICC (95 % CI)	p-value
GI	5.47 ± 0.61	5.57 ± 0.57	−0.10	−0.62;0.42	0.89 (0.81;0.94)	p < 0.0001
GL	5.06 ± 0.76	5.33 ± 0.69	−0.26	−1.22; 0.69	0.71 (0.46;0.83)	p < 0.0001
Protein	5.48 ± 0.63	5.38 ± 0.56	0.04	−0.69; 0.78	0.41 (0.19;0.59)	p < 0.0001
Fat	5.12 ± 0.78	4.95 ± 0.79	0.18	−1.22; 1.58	0.68 (0.53;0.80)	p < 0.0001
Total	21.07 ± 2.05	21.20 ± 1.79	−0.12	−2.35; 2.1	0.83 (0.74;0.89)	p < 0.0001

R1, rater 1; DA, dietary analysis; GI, glycemic index, GL, glycemic load.

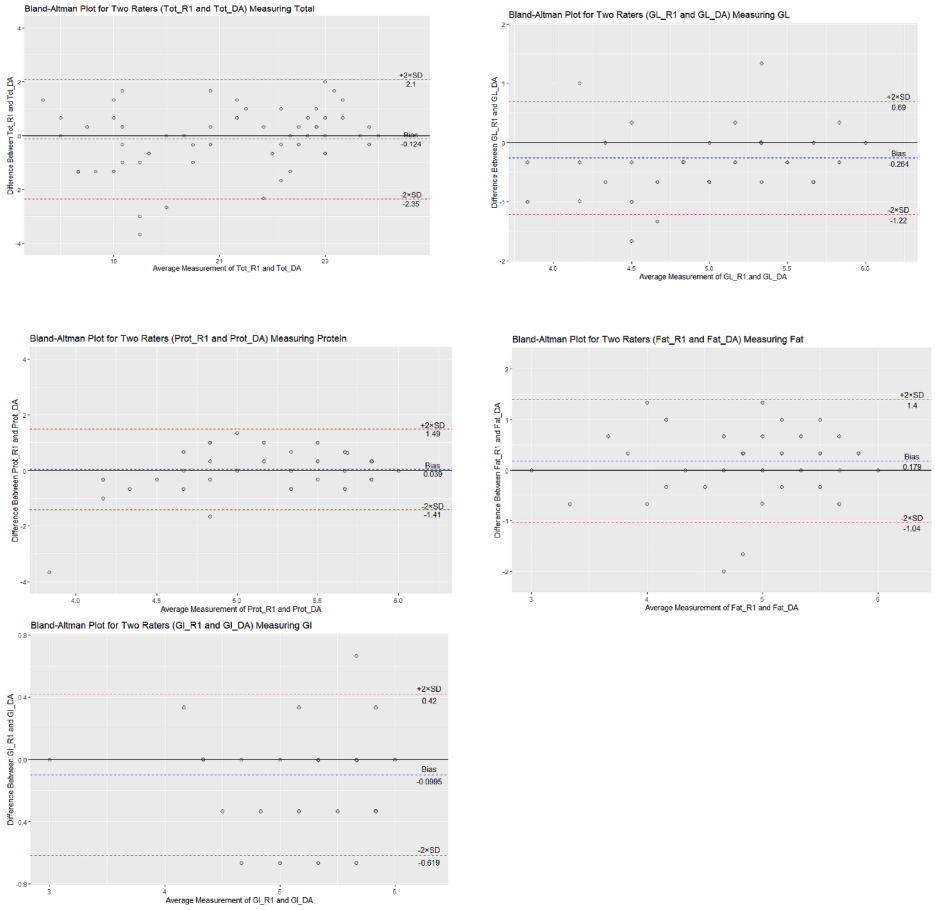

Fig. 3. Bland–Altman analysis for rater 1 and DA measuring GI, GL, protein, fat and total score.

was developed to serve as a short scoring sheet to provide the health care provider with information that determines adherence to personalised nutrition education. Previous studies have assessed the reliability and validity of short questionnaires to verify dietary adherence to a country's specific dietary guidelines, including Canada [28], the Netherlands [39], Australia [40], and India [41]. Similar questionnaires were developed in Poland and Finland, but the reliability and validity thereof have not been reported [29,30]. Only three questionnaires, however, have been developed to test dietary adherence to diabetes dietary recommendations among patients with diabetes [28,29,41]. The Perceived Dietary Adherence Questionnaire (PDAQ), the Patient Diet Adherence in Diabetes (PDAD) scale and the Diabetes Diet Adherence Scale (D-DAS) are short questionnaires that were developed to measure diabetic patients' adherence to Canadian, Polish and Indian diabetes dietary recommendations, respectively [28,30,41].

The ASS showed a fair to excellent level of reliability and validity for total scores. The PDAQ showed acceptable total internal reliability, whereas the D-DAS showed high total internal reliability [28,41]. As with the ASS, the PDAQ and D-DAS showed acceptable validity [28,41]. The validity and reliability of the PDAD have not been reported in the Polish study [30]. Although these three questionnaires are similar to the ASS as they also score adherence to diabetic dietary recommendations, they assess different aspects of dietary adherence to those assessed in the current study, limiting comparisons between studies. The PDAQ did, however, assess the frequency of omega-3, healthy oils and high-fat food intake over 7 days. The PDAQ showed good correlations with questions related to food high in omega-3 and healthy oils and showed moderate reliability for high-fat foods. The ASS showed fair to good reliability for fat scoring, but the inter-rater reliability was the lowest of all the categories (ICC = 0.56). In the PDAQ study, the researchers attributed the low test-retest

reliability of high-fat foods to the fact that fats can be hidden in some foods and therefore disregarded. This could be true for our study as well, and it would be beneficial if fat is better defined in similar studies. The PDAQ also assessed the adherence to the consumption of carbohydrates with low GI values [28], similar to our ASS. Where the ASS assessed the GI of every carbohydrate consumed over 3 days, the PDAQ assessed how many days in a week a low GI carbohydrate was included [28]. The PDAQ showed moderate validity and test-retest reliability for GI testing [28], while in this study, ICC values for GI scoring indicated excellent agreement for inter-rater reliability and validity testing. High reliability and validity for GI scoring in this study can be attributed to the fact that fixed GI values were used as determined by the GI Foundation of South Africa [35], and the raters used in this study were well-trained in GI principles and South African GI values. The use of a predetermined GI list during education and dietary adherence testing would therefore be advisable in similar studies.

For this study, raters were specifically selected based on their experience and knowledge of GI, GL and FII principles for them to be able to effectively score patients' adherence to these principles. The Two-Way Mixed-Effects Model was therefore used because the raters were the only raters of interest. This, however, limits the generalisability of the results to other healthcare professionals [42].

A strength of the study is that the study population were representative of both genders and most age groups across the adult population. Another strength is that we used 3-day food records as the reference method for validity testing. In comparison to 24-h recall and food frequency questionnaires, food records do not rely on memory and are the preferred reference method when testing the validity of other dietary assessment methods [43,44].

The monitoring of adherence to personalized nutrition education in diabetes management is essential for effective glycaemic control. The reliability and validity of dietary adherence tools are critical for ensuring their effectiveness in both clinical settings and research. To our knowledge, no other dietary adherence tools have been developed specifically for the South African diabetic population. The ASS is quick and simple to use to assess adherence to GI, GL protein, and fat recommendations. As no computers are needed to complete the ASS, it can be used in a variety of settings like private practice or other health-care facilities like hospitals, clinics, or low-resource rural areas.

5. Conclusion

This study found that the ASS has acceptable reliability and validity to determine and quantify the adherence of patients with diabetes to personalised nutrition education based on GI, GL and FII principles. The assessment is short and can be used in any setting.

Informed consent statement

Informed consent was waived as no patient participation was required and therefore no risk, harm or injustice could occur.

Author contributions

The authors' responsibilities were as follows—H.S. and Z.W.: study design and conceptualisation; H.S.: Rater 1; E.D.: Rater 2; H. S.: developed the ASS; H.S.: drafted the original manuscript; H.S, Z. W., J.M. and E.D.: edited and reviewed original draft; H.S. and Z.W.: had primary responsibility for final content. All authors have read and agreed to the published version of the manuscript.

Institutional review board statement

All procedures were approved by the Faculty of Health Sciences Research Ethics Committee of the University of Pretoria (South Africa) and conformed to the principles outlined in the Declaration of Helsinki (approval number 392/23). This study was guided by ethical standards and national and international laws.

Data availability statement

Data is contained within the article or Supplementary Material.

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Declaration of competing interest

Elizabeth Delport is a co-founder of the GI Foundation of South Africa. The GI Foundation was not promoted by, nor did it benefit in any way from this study. The authors declare no other conflict of interest.

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