

Original Article

Relative validity of a self-dietary assessment nutrition application compared with a 3-day food record in non-dialysis chronic kidney disease: A prospective study

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Abstract

Accurate and repeated dietary assessment is essential for nutritional management in chronic kidney disease (CKD); however, conventional methods, such as the 3-day food record, are burdensome for routine clinical use. Digital self-administered dietary assessment tools may offer a practical alternative; however, validation data in non-dialysis CKD, particularly among Asian populations, remain limited. This study aimed to evaluate the relative validity of a locally adapted digital self-dietary assessment application (Nutrirodcal) compared with a 3-day food record in patients with non-dialysis CKD. This prospective single-center study enrolled adults with non-dialysis CKD stages 3–5. Participants completed both a 3-day food record (reference method) and Nutrirodcal every 4 weeks for 12 weeks. Correlations between the two methods were assessed for energy, macronutrients, minerals, and fluid intake. Changes in nutritional status, biochemical parameters, and body composition were assessed as secondary outcomes. Twenty participants completed the study. At week 12, Nutrirodcal showed moderate-to-strong correlations with the 3-day food record for energy, protein, sodium, potassium, calcium, and phosphorus intake (Spearman $r=0.50-0.65$; all $p<0.05$). Correlations for fluid intake were weak at weeks 4 and 12 but reached a moderate and statistically significant level at week 8 ($r=0.55$, $p=0.012$). Over the study period, body mass index decreased significantly without deterioration in serum albumin or kidney function, while other biochemical and body composition parameters remained stable. Nutrirodcal demonstrated acceptable relative validity for assessing key nutrient intakes relevant to CKD management compared with a 3-day food record. This Thai-adapted digital tool may support repeated dietary monitoring and patient engagement in non-dialysis CKD care, although dietitian oversight remains essential, particularly for fluid intake assessment.

Keywords: Chronic kidney disease, dietary assessment, nutrition application, digital health, dietary validation

Introduction

Chronic kidney disease (CKD) is a major global public health problem associated with increased morbidity, mortality, and healthcare costs. Nutritional management plays a central role in slowing disease progression, preventing protein–energy wasting, and reducing metabolic complications in patients with non-dialysis CKD [1–4]. International guidelines emphasize individualized dietary prescriptions, particularly for protein, energy, sodium, potassium, and



phosphorus intake, as a cornerstone of CKD care [1-3]. However, the effectiveness of nutritional therapy relies heavily on accurate and repeated assessment of patients' habitual dietary intake.

The 3-day food record is widely regarded as a reference method for dietary assessment in CKD and is recommended by the 2020 KDOQI Clinical Practice Guideline for Nutrition in CKD [1]. Despite its strengths, routine use of food records in clinical practice is limited by high patient burden, recall bias, difficulties in portion-size estimation, and the need for trained dietitians to interpret dietary data [5]. These limitations restrict its feasibility for frequent monitoring, particularly in busy outpatient settings and among older patients or those with limited health literacy.

Digital self-dietary assessment applications have emerged as potential tools to facilitate dietary self-monitoring, enhance awareness, and support behavior change [6-9]. Such platforms can automate nutrient calculations and provide real-time feedback, potentially reducing workload for healthcare professionals. While several studies have demonstrated acceptable validity of dietary applications in the general population and selected chronic disease groups [7-10], evidence in non-dialysis CKD remains sparse. Moreover, few applications have been validated using locally relevant food composition databases, which is particularly important in Asian populations with distinct dietary patterns. Therefore, this study aimed to evaluate the relative validity of Nutrirodcal compared with a 3-day food record in adults with non-dialysis CKD stages 3–5 and to assess short-term changes in nutritional and clinical parameters during repeated digital dietary monitoring.

Methods

Study design and participants

This prospective, single-center study was conducted at the CKD clinic of Rajavithi Hospital, Bangkok, Thailand, between August 2022 and July 2023. Adult patients aged ≥ 18 years with non-dialysis CKD stages 3–5 were screened for eligibility. Inclusion criteria were stable kidney function, defined as no decline in estimated glomerular filtration rate (eGFR) greater than 25% within the preceding three months, and normal nutritional status (Subjective Global Assessment class A). Patients receiving renal replacement therapy, those with critical illness, active malignancy or infection, cognitive impairment, or inability to use the dietary application (with or without caregiver assistance) were excluded. Written informed consent was obtained from all participants.

Dietary assessment

Participants completed both dietary assessment methods concurrently at four time points: baseline (week 0), week 4, week 8, and week 12. At each time point, participants completed a 3-day food record (two weekdays and one weekend day) and entered their dietary intake into Nutrirodcal during the same assessment period. Accordingly, data from the 3-day food record and Nutrirodcal were collected simultaneously at each study visit. The 3-day food record served as the reference method and was analyzed using Inmucal-Nutrient software (version 4.0; Institute of Nutrition, Mahidol University, Thailand) by a trained dietitian blinded to application-derived data. Nutrirodcal is a web-based dietary assessment application developed using a validated Thai food composition database from the Bureau of Nutrition, Ministry of Public Health, Thailand. The application automatically calculates daily energy intake, macronutrients, sodium, potassium, calcium, phosphorus, and fluid intake based on user-entered food items. Standardized instruction on application use was provided prior to study initiation.

Although dietary intake was recorded at baseline (week 0), correlation analysis was not performed for this time point because participants were using Nutrirodcal for the first time. Baseline assessment was therefore treated as a familiarization phase to allow participants to become accustomed to food entry and portion size estimation. Accordingly, correlation analyses were conducted from week 4 onward.

Clinical and laboratory assessment

At each visit, body weight, height, blood pressure, and nutritional status were assessed. Body mass index (BMI) was calculated as weight divided by height squared (kg/m²). Blood samples were collected after an overnight fast to measure serum creatinine, blood urea nitrogen, albumin, electrolytes, lipid profile, fasting plasma glucose, and glycated hemoglobin (HbA1c). eGFR was calculated using the CKD-EPI equation.

Twenty-four-hour urine collections were obtained at weeks 4, 8, and 12 to assess urinary urea nitrogen and electrolyte excretion. Baseline collection was not performed to minimize participant burden and avoid pre-intervention behavioral modification. Urinary parameters were assessed to monitor longitudinal stability during the dietary assessment period. Body composition was evaluated using bioelectrical impedance analysis at weeks 4, 8, and 12 in participants without implanted electrical devices.

Outcomes

The primary outcome was the correlation between dietary intake estimated by Nutrirodcal and the 3-day food record for energy, protein, sodium, potassium, calcium, phosphorus, and fluid intake. Secondary outcomes included changes in nutritional status (BMI, serum albumin, normalized protein nitrogen appearance (nPNA)), biochemical parameters, and body composition over the 12-week study period.

Statistical analysis

Continuous variables are presented as mean ± standard deviation or median (interquartile range), as appropriate, and categorical variables as number (percentage). Comparisons across repeated time points were analyzed using repeated-measures analysis of variance (ANOVA). Correlations were assessed using Spearman’s rank correlation coefficient, reflecting relative validity rather than absolute agreement. A two-sided *p*-value <0.05 was considered statistically significant.

Results

Participant characteristics

Twenty-five eligible patients were enrolled, and 20 completed the 12-week follow-up. Baseline characteristics indicated a predominantly older population with advanced CKD and preserved nutritional status. Baseline demographic and clinical characteristics are summarized in **Table 1**. Participants had a mean age of 60 years, and most had CKD stage 4 or 5 with preserved nutritional status at baseline.

Table 1. Baseline demographic, clinical, and laboratory characteristics of chronic kidney disease patients included in this study (n=20)

Characteristics	Frequency (%); mean±SD; median (Q1, Q3)
Age (year)	60.15±10.10
Gender: male	10 (50.0)
Body mass index (kg/m ²)	25.21±3.51
Systolic blood pressure (mmHg)	135.20±20.24
Diastolic blood pressure (mmHg)	73.90±9.79
Mean arterial pressure (mmHg)	94.35±10.97
Heart rate (bpm)	86.50±19.44
Comorbidities	
Hypertension	18 (90.0)
Dyslipidemia	10 (50.0)
Diabetes mellitus	9 (45.0)
Other	6 (30.0)
Chronic kidney disease (CKD) stage	
CKD 3a	2 (10.0)
CKD 3b	5 (25.0)
CKD 4	9 (45.0)
CKD 5	4 (20.0)
Laboratory	

Characteristics	Frequency (%); mean±SD; median (Q1, Q3)
Fasting blood sugar (mg/dL)	115.63±35.38
HbA1C (%)	7.34±1.96
Blood urea nitrogen (mg/dL)	34.30±11.46
Creatinine (mg/dL)	2.67±1.08
eGFR (mL/min/1.73 m ²)	26.45±11.99
Sodium (mEq/L)	140.58±1.64
Potassium (mEq/L)	4.26±0.32
Calcium (mg/dL)	9.37±0.36
Phosphate (mg/dL)	3.73±0.51
Albumin (g/dL)	4.15±0.46
Cholesterol (mg/dL)	210.44±58.84
Triglyceride (mg/dL)	148.29±65.15
High-density lipoprotein (mg/dL)	44.14±7.01
Low-density lipoprotein (mg/dL)	122.64±44.28
Body composition analysis	
Age match of body (kg)	56.72±9.46
Basal metabolic rate (kcal/day)	1184.06±149.12
Total energy expenditure (kcal/day)	1823.33±229.77
Percentage body fat (%)	22.05 (11.70, 28.93)
Mass of body fat (kg)	4.7 (0.95, 8.43)
Soft lean mass (kg)	47.22±7.48
Body cell mass	18 (90.0)
Under	0 (0.0)
Optimal	11 (61.1)
Well	7 (38.9)
Lean body mass (kg)	50.98±7.81
Total body water (%)	36.71±5.62
Intracellular water (%)	21.79±3.28

eGFR: estimated glomerular filtration rate; kcal: kilocalories

Correlation between Nutrirodcal and 3-day food record

Baseline dietary data were collected; however, correlation analysis was restricted to weeks 4, 8, and 12 to minimize the influence of early familiarization bias with the digital application. At week 4, Nutrirodcal showed moderate correlations with the 3-day food record for energy, protein, sodium, potassium, and calcium intake, while correlations for phosphorus were weaker and fluid intake was poorly correlated (**Table 2**). At week 8, correlations were attenuated for several nutrients; however, energy intake remained strongly correlated, and calcium and fluid intake demonstrated moderate and statistically significant correlations. By week 12, correlations improved, demonstrating moderate to strong correlations for energy, protein, sodium, potassium, calcium, and phosphorus intake, whereas fluid intake showed a weak correlation. Correlation plots are presented in **Figure 1**.

Changes in nutritional status and biochemical parameters

Over the 12-week follow-up, BMI decreased significantly, while serum albumin levels and estimated glomerular filtration rate remained stable (**Table 3**). No significant changes were observed in body composition parameters. No significant variation was observed in 24-hour urinary parameters across weeks 4, 8, and 12 (**Table 4**).

Discussion

In this prospective validation study, we evaluated the performance of a self-dietary assessment nutrition application (Nutrirodcal) compared with the 3-day food record, a reference method recommended by current clinical guidelines, in patients with non-dialysis CKD stages 3–5. The principal finding was that Nutrirodcal demonstrated moderate to strong correlations with the 3-day food record for energy, protein, sodium, potassium, calcium, and phosphorus intake over a 12-week period, while fluid intake was weak at weeks 4 and 12 but reached a moderate and statistically significant level at week 8. These findings support the use of Nutrirodcal as a practical dietary assessment tool for key nutrients relevant to CKD management.

Table 2. Correlation of dietary intake assessed between the 3-day food record and Nutrirodcal at weeks 4, 8, and 12 among patients with chronic kidney disease

Time	Components	3-day food record	Nutrirodcal	Spearman correlation coefficient (r)	p-value ^a
		Median (Q1, Q3)	Median (Q1, Q3)		
Week 4	Energy (kcal/day)	791.12 (605.44, 974.45)	773.21 (644.05, 1080.07)	0.63	0.003*
	Protein (g/day)	38.73 (28.40, 43.80)	31.16 (27.39, 41.55)	0.49	0.027*
	Sodium (mg/day)	1429.50 (1133.78, 1943.52)	1272.91 (848.75, 1749.97)	0.45	0.048*
	Potassium (mg/day)	785.09 (609.65, 1331.04)	640.03 (578.73, 1030.33)	0.50	0.026*
	Calcium (mg/day)	171.01 (113.27, 287.43)	138.61 (85.56, 205.68)	0.48	0.032*
	Phosphorus (mg/day)	389.25 (264.97, 447.49)	295.63 (219.44, 392.30)	0.42	0.067
	Water (mL/day)	549.78 (408.46, 679.29)	391.69 (294.62, 541.31)	0.22	0.357
Week 8	Energy (kcal/day)	963.34 (774.53, 1249.34)	790.14 (556.64, 925.79)	0.72	<0.001**
	Protein (g/day)	49.27 (36.20, 60.31)	32.83 (25.57, 39.14)	0.37	0.107
	Sodium (mg/day)	1816.06 (1416.81, 2565.73)	1270.18 (658.05, 1424.01)	0.17	0.478
	Potassium (mg/day)	1094.54 (899.52, 1237.68)	494.41 (424.90, 658.41)	0.27	0.249
	Calcium (mg/day)	325.12 (130.78, 456.86)	104.70 (70.08, 165.16)	0.50	0.027*
	Phosphorus (mg/day)	507.29 (366.90, 541.26)	233.93 (196.68, 318.69)	0.34	0.147
	Water (mL/day)	745.19 (587.60, 877.70)	380.10 (253.94, 593.12)	0.55	0.012*
Week 12	Energy (kcal/day)	853.45 (708.58, 1177.54)	778.51 (536.36, 1060.22)	0.65	0.002**
	Protein (g/day)	50.27 (42.94, 57.83)	35.15 (26.05, 45.33)	0.62	0.003**
	Sodium (mg/day)	1924.60 (1413.05, 2951.90)	1195.29 (771.17, 1454.71)	0.59	0.003**
	Potassium (mg/day)	939.71 (838.39, 1255.77)	551.5 (386.15, 869.74)	0.64	0.002**
	Calcium (mg/day)	284.93 (138.66, 431.55)	124.00 (69.02, 240.91)	0.54	0.015*
	Phosphorus (mg/day)	442.60 (277.53, 545.58)	296.45 (187.10, 369.66)	0.50	0.026*
	Water (mL/day)	731.81 (497.27, 926.55)	388.16 (256.21, 474.39)	0.20	0.408

kcal: kilocalories

^a Analyzed using Spearman's rank correlation

* Statistically significant at $p < 0.05$

** Statistically significant at $p < 0.01$

Table 3. Laboratory data and body composition analysis at baseline and week 4, 8, and 12 during repeated dietary monitoring among patients with chronic kidney disease

Characteristics	Week 0	Week 4	Week 8	Week 12	p-value ^a
	Frequency (%); mean±SD; median (Q1, Q3)				
Body mass index (kg/m ²)	25.21±3.51	24.79±3.54	24.70±3.60	24.49±3.51	0.024*
Systolic blood pressure (mmHg)	135.20±20.24	138.70±19.60	138.90±16.49	139.15±15.24	0.369
Diastolic blood pressure (mmHg)	73.90±9.79	74.90±13.23	75.20±12.12	75.70±12.65	0.445
Mean arterial pressure (mmHg)	94.35±10.97	96.15±13.14	96.40±11.45	96.20±9.84	0.444
Laboratory data					
Fasting blood sugar (mg/dL)	115.63±35.38	113.25±47.76	109.10±34.76	111.90±38.52	0.345
HbA1C (%)	7.34±1.96	6.69±2.24	6.36±1.57	6.24±1.37	0.149
Blood urea nitrogen (mg/dL)	34.30±11.46	36.30±12.23	35.75±14.18	36.70±15.05	0.262
Creatinine (mg/dL)	2.67±1.08	2.78±1.21	2.87±1.10	3.01±1.30	0.059
eGFR (mL/min/1.73 m ²)	26.45±11.99	26.55±12.29	27.10±13.40	26.45±13.77	1.000

Characteristics	Week 0	Week 4	Week 8	Week 12	p-value ^a
	Frequency (%); mean±SD; median (Q1, Q3)				
Sodium (mEq/L)	140.58±1.64	139.60±4.47	140.70±2.45	140.80±1.58	0.567
Potassium (mEq/L)	4.26±0.32	4.40±0.34	4.46±0.45	4.47±0.47	0.083
Calcium (mg/dL)	9.37±0.36	9.42±0.44	9.44±0.47	9.44±0.38	0.395
Phosphate (mg/dL)	3.73±0.51	3.88±0.62	3.89±0.80	3.81±0.61	0.492
Albumin (g/dL)	4.15±0.46	4.21±0.46	4.18±0.52	4.05±0.44	0.058
Cholesterol (mg/dL)	210.44±58.84	189.77±54.33	193.83±55.93	181.20±61.24	0.245
Triglyceride (mg/dL)	148.29±65.15	140.00±50.65	131.86±63.80	85.50±21.86	0.074
High-density lipoprotein (mg/dL)	44.14±7.01	50.00±12.82	50.67±16.94	49.80±10.62	0.481
Low-density lipoprotein (mg/dL)	122.64±44.28	109.92±48.06	116.67±45.47	115.40±47.80	0.553
Body composition analysis					
Age match of body (kg)	56.72±9.46	56.89±8.85	56.83±9.29	55.00±7.80	0.080
Basal metabolic rate (kcal/day)	1184.06±149.12	1179.67±157.96	1174.39±153.64	1191.00±135.99	0.148
Total energy expenditure (kcal/day)	1823.33±229.77	1815.67±241.37	1808.67±236.64	1834.19±209.41	0.147
Percentage body fat (%)	22.05 (11.70, 28.93)	18.65 (15.22, 29.65)	19.90 (13.00, 29.48)	18.25 (12.58, 28.50)	0.078
Mass of body fat (kg)	4.7 (0.95, 8.43)	1.35 (-0.65, 5.38)	2.45 (-0.68, 5.88)	0.75 (-4.10, 6.03)	0.087
Soft lean mass (kg)	47.22±7.48	46.86±8.39	46.41±7.43	47.65±7.87	0.170
Body cell mass					
Under	0 (0.0)	1 (5.5)	0 (0.0)	0 (0.0)	
Optimal	11 (61.1)	10 (55.6)	13 (72.2)	10 (55.6)	0.735
Well	7 (38.9)	7 (38.9)	5 (27.8)	8 (44.4)	
Lean body mass (kg)	50.98±7.81	50.59±8.78	50.18±7.83	51.46±8.28	0.152
Total body water (%)	36.71±5.62	36.44±6.33	36.17±5.65	37.04±5.96	0.158
Intracellular water (%)	21.79±3.28	21.88±3.73	21.66±3.35	22.11±3.51	0.107

eGFR: estimated glomerular filtration rate, kcal: kilocalories

^a Analyzed using ANOVA

* Statistically significant at $p < 0.05$

Table 4. Twenty-four-hour urine parameters at week 4, 8, and 12 during repeated dietary monitoring among patients with chronic kidney disease

Parameter	Week 4	Week 8	Week 12	p-value ^a
	Mean±SD, median (Q1, Q3)	Mean±SD, median (Q1, Q3)	Mean±SD, median (Q1, Q3)	
Urine Protein (mg/day)	475.60 (99.0, 3592.8)	426.95 (142.8, 3622.5)	620.45 (135.8, 3217.2)	0.794
Urine sodium (mEq/day)	104.4 (63.7, 165.2)	117.35 (72.9, 151.5)	109.82 (79.5, 148.0)	0.888
Urine potassium (mEq/day)	27.42 (22.1, 31.7)	25.64 (22.1, 34.8)	28.96 (22.1, 37.3)	0.567
Urine calcium (mg/day)	24.90 (18.3, 40.4)	23.25 (16.4, 38.0)	27.00 (12.0, 35.9)	0.333
Urine phosphorus (mg/day)	405.05 (230.0, 480.5)	375.5 (297.6, 478.0)	360.5 (280, 517.65)	0.918
Urine urea nitrogen (g N/day)	2.06±0.36	2.05±0.37	2.05±0.37	0.556
Urine ammonia nitrogen (g N/day)	8.66±2.65	8.47±4.15	7.93±2.54	0.211
Protein nitrogen appearance (g protein/day)	52.61±19.02	52.94±25.93	49.03±16.26	0.349
Normalized protein nitrogen appearance (g protein/kg/day)	0.80±0.16	0.80±0.40	0.74±0.24	0.226

^a Analyzed using analysis of variance (ANOVA)

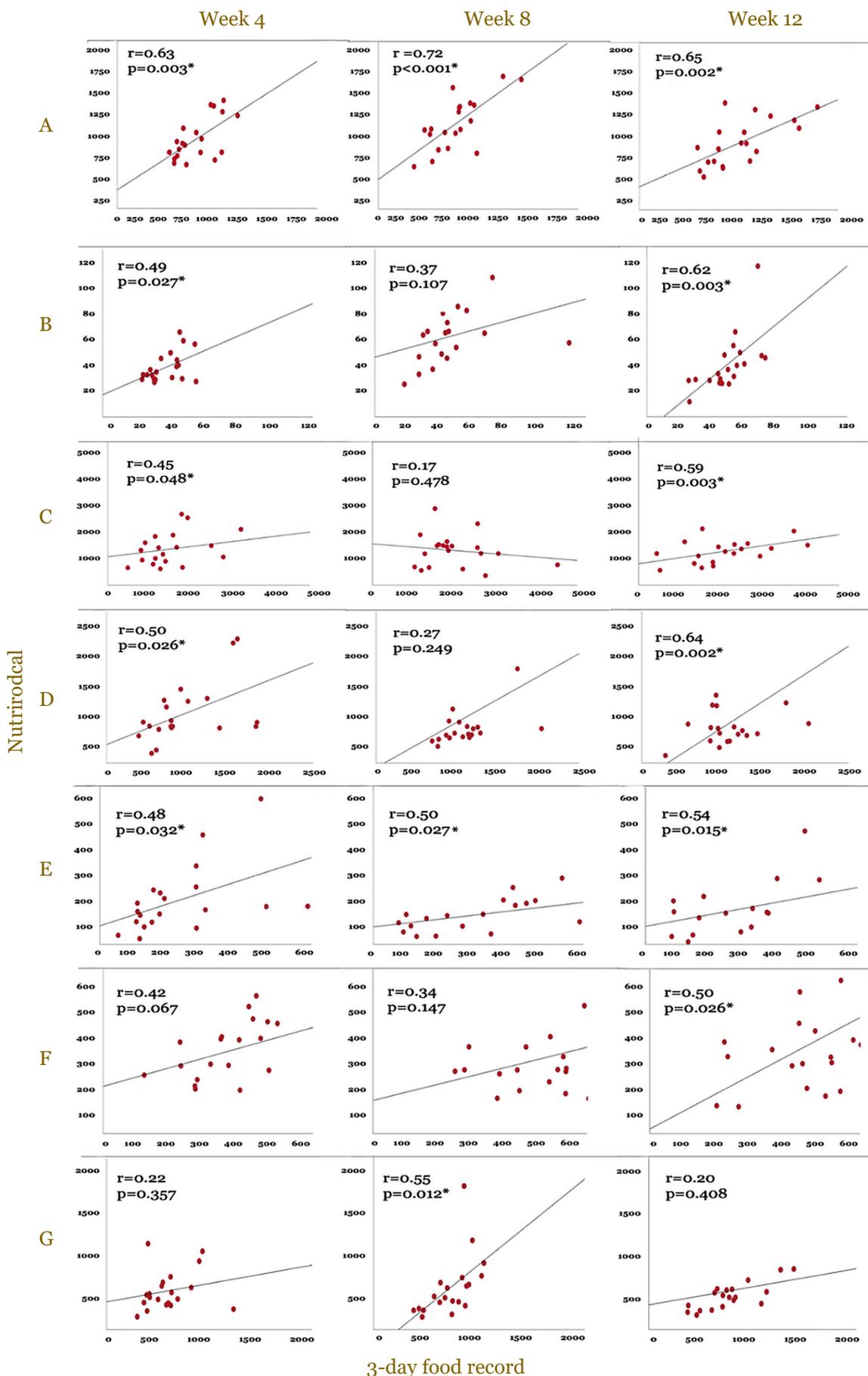


Figure 1. Correlation between dietary intake estimated by Nutrirodcal and the 3-day food records at weeks 4, 8, and 12 among CKD patients: (A) energy intake; (B) protein intake; (C) sodium intake; (D) potassium intake; (E) calcium intake; (F) phosphorus intake; (G) water intake. *Statistically significant at $p<0.05$.

Accurate assessment of dietary intake remains a cornerstone of nutritional management in CKD, as emphasized by the 2020 KDOQI guideline and the International Society of Renal Nutrition and Metabolism [1-3]. The 3-day food record, although widely accepted, is associated with substantial patient burden and requires trained dietitians for interpretation, limiting its feasibility for frequent reassessment in routine clinical practice [5]. Digital dietary assessment tools have therefore gained increasing attention as potential adjuncts to standard nutritional care. Our findings add to the growing body of evidence suggesting that mobile or web-based dietary applications can provide reasonably valid estimates of energy and nutrient intake when compared with traditional dietary assessment methods [6-13].

The magnitude of correlation observed in the present study ($r=0.50-0.65$ for most nutrients at week 12) is comparable to that reported in previous validation studies of dietary applications in both general and clinical populations [7-11]. Importantly, correlation coefficients of this range are generally considered acceptable for nutritional epidemiology and clinical monitoring, particularly when the objective is to track dietary patterns and support behavior change rather than to obtain exact quantitative intake values [14,15]. In this context, Nutrirodcal may be best positioned as a complementary tool to dietitian-led assessment rather than a replacement for comprehensive dietary evaluation.

An interesting temporal pattern was observed, with attenuated correlations at week 8 followed by improvement at week 12. This finding likely reflects a learning or familiarization effect, as patients may initially struggle with accurate food entry and portion estimation before becoming more proficient with repeated use of the application. Similar learning effects have been reported in studies of digital dietary self-monitoring tools [16-21]. These observations underscore the importance of periodic reinforcement and reassessment, which aligns with International Society of Renal Nutrition and Metabolism recommendations for nutritional evaluation every 1–3 months in patients with CKD [1-3].

Fluid intake showed weak correlations at weeks 4 and 12, but a moderate and statistically significant correlation at week 8, indicating variability across time points. This finding is consistent with previous studies reporting difficulty in accurately estimating fluid intake using self-reported methods [5]. In the present study, discrepancies may have been amplified by standardized volume assumptions within the application and challenges in accounting for fluid content embedded in foods. Consequently, fluid intake data derived from Nutrirodcal should be interpreted with caution, and direct clinical assessment remains essential for fluid management in CKD.

Beyond validation, secondary outcomes suggested favorable trends in nutritional status. BMI decreased significantly from the overweight to the normal range without a decline in serum albumin or eGFR, and normalized protein nitrogen appearance showed a non-significant downward trend. These findings may reflect improved dietary awareness and self-regulation rather than intentional caloric restriction, consistent with evidence that dietary self-monitoring can promote healthier eating behaviors [22-26]. Although changes in biochemical parameters and body composition did not reach statistical significance, the stability of serum albumin and lean mass indicators is reassuring and suggests no short-term adverse nutritional effects.

This study has limitations, including its single-center design, small sample size, and reliance on self-reported dietary data for both assessment methods. Correlation analysis evaluates relative validity but not absolute agreement. Larger, multicenter studies incorporating objective biomarkers and clinical outcomes are warranted.

Conclusion

Nutrirodcal is a locally adapted digital dietary assessment tool with acceptable relative validity for monitoring nutrient intake in non-dialysis CKD. Its integration into routine care may facilitate repeated dietary monitoring and patient engagement, while dietitian-led assessment remains essential.

Ethics approval

The study was approved by the Institutional Review Board of Rajavithi Hospital (approval number: 046/2022). Written informed consent was obtained from all participants.

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Competing interests

There were no identified potential conflicts of interest related to this article.

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Underlying data

Derived data supporting the findings of this study are available from the corresponding author on request.

Declaration of artificial intelligence use

This study used an artificial intelligence (AI) tool, ChatGPT, in language refinement to improve grammar, sentence structure, and readability of the manuscript. We confirm that all AI-assisted processes were critically reviewed by the authors to ensure the integrity and reliability of the results.

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