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Association of DASH and Mediterranean Diet Adherence with Phase Angle in Patients with Crohn's Disease: An Exploratory Cross-Sectional Study

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Abstract

Background/Objectives: Patients with Crohn's disease (CD) are at increased risk of malnutrition, which may be reflected by reduced phase angle (PhA), a bioelectrical impedance marker of cellular integrity. This exploratory study investigated associations between Mediterranean and DASH diet adherence and PhA in adults with CD. Methods: This cross-sectional study included 39 adults with CD, mostly in clinical remission, from a Greek public hospital. PhA was measured by bioelectrical impedance analysis, and dietary quality was assessed with the MedDietScore and an adapted DASH score; the primary exposure was a food-based DASH index (seven food-group components), and the full 10-component score was exploratory. Associations were examined with multiple linear regression models adjusted for sex and physical activity. Results: After adjustment for sex and physical activity, each one-point higher food-based DASH index was associated with a 0.29° higher PhA, with a 95% CI from −0.003 to 0.588 ($n = 35$). In exploratory analyses, the full score, which includes qualitatively scored nutrient components, was also positively associated with PhA (B = 0.230, 95% CI 0.042–0.418). No clear association was observed for the total MedDietScore or full-fat dairy consumption. Conclusions: In adults with CD, the adjusted estimate for DASH-type food choices and PhA was positive but imprecise. These hypothesis-generating findings require confirmation in longitudinal and interventional studies.

Keywords: Crohn's disease; phase angle; bioelectrical impedance analysis; DASH diet; Mediterranean diet; dietary quality

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1. Introduction

Bioelectrical impedance analysis (BIA) measures whole-body impedance, which consists of resistance (R) and reactance (Xc) [1]. Phase angle (PhA), a key impedance-derived parameter, is considered a non-invasive indicator of cellular integrity, membrane function, and body cell mass [2]. Higher PhA values have been associated with better cellular health and overall physiological status [2]. Lower values, in contrast, have been linked to impaired

nutritional status [1,3], low-grade inflammation [4,5], and reduced muscle mass and muscle function [6,7]. These findings have increased interest in PhA as a marker of nutritional and functional status across diverse clinical populations.

As PhA is associated with nutritional and inflammatory status, dietary patterns may represent modifiable factors influencing this parameter. Dietary patterns rich in whole, minimally processed foods and bioactive compounds, such as the Mediterranean and Dietary Approaches to Stop Hypertension (DASH) diets, have been associated with favorable metabolic, inflammatory, and cardiovascular outcomes [8–10]. Consequently, these dietary patterns may be relevant in chronic inflammatory diseases.

Crohn's disease (CD) is a chronic inflammatory disease of the gastrointestinal tract. It is characterized by transmural inflammation and alternating periods of relapse and remission, and it has a considerable impact on nutritional status and body composition [11,12]. Individuals with CD frequently exhibit alterations in body composition [13] and are at risk of malnutrition [14,15] and sarcopenia [16], factors that may contribute to lower PhA values. PhA assessment has therefore attracted increasing interest in this population [17]. Identifying modifiable dietary factors associated with PhA may thus inform the long-term management of CD.

In patients with CD, lower PhA values have been associated with impaired nutritional status and higher disease activity [1] and with reduced muscle mass [6]. Disease-specific PhA cut-offs have also been proposed to identify malnutrition [17]. At the same time, diet quality is frequently suboptimal in patients with CD [18], partly because of dietary restrictions adopted to manage symptoms. In other populations, dietary factors such as the consumption of minimally processed foods and dietary antioxidant capacity have been associated with PhA [3,5]. However, evidence on the association between PhA and adherence to healthy dietary patterns in adults with CD remains limited. Therefore, the aim of the present exploratory study was to investigate the associations between PhA and adherence to the DASH and Mediterranean dietary patterns in adults with CD.

2. Materials and Methods

2.1. Participants

Participants were recruited between May and August 2022 from the outpatient clinic of the Gastroenterology Department of Theageneio Hospital, Thessaloniki, Greece. All were followed for CD by the collaborating gastroenterologist. All measurements and questionnaires were completed at the hospital. Data from this cohort on nutritional risk and sarcopenia features have been previously published [19]. Inclusion criteria were (a) confirmed diagnosis of CD in clinical remission or with mild or moderate disease activity, (b) age ≥18 years, (c) ability to perform daily activities independently, (d) self-reported engagement in physical activity (e.g., walking, running, swimming, football, volleyball, or tennis) at least twice per week, irrespective of duration or intensity, and (e) receiving pharmacological treatment for CD. Exclusion criteria were (a) disease exacerbation (active flare, as judged by the treating gastroenterologist), (b) age less than 18 years, (c) coexisting autoimmune diseases, and (d) difficulties in daily living. None of the participants had a history of malignancy. As part of their routine care, participants received dietary advice from the treating gastroenterologist; however, no specific diet was prescribed or required for participation. Data on disease duration, disease location (ileal, colonic, or ileocolonic), disease behaviour (non-stricturing non-penetrating, stricturing, and/or penetrating), perianal disease, previous intestinal resection, and biologic therapy were recorded. Clinical disease activity was assessed using the modified Harvey–Bradshaw Index [20] and classified as remission (<5), mild (5–7), or moderate (8–16) activity. Nutritional status was assessed with the Mini Nutritional Assessment–Short Form (MNA-SF), a six-item tool scored from 0

to 14. Scores of 12–14, 8–11, and 0–7 indicate normal nutritional status, risk of malnutrition, and malnutrition, respectively [21]. Additionally, high-sensitivity CRP and serum albumin were measured.

All patients were informed about the study process prior to participation, and written informed consent was obtained. The study was conducted in accordance with the Declaration of Helsinki. The protocol was approved by the Scientific Board of Theageneio Hospital (approval code: 3734/2-3-2022).

2.2. Body Composition

Body composition was assessed using bioelectrical impedance analysis (BIA; Bodystat® 1500MDD, Bodystat Ltd., Douglas, Isle of Man), as previously described [19]. Before the assessment, participants had refrained from exercise, caffeine, and alcohol on the previous day and had fasted for 2–3 h. Shoes, socks, and metal objects that could affect the measurement were removed. Female participants were assessed in the mid-phase of their menstrual cycle. Measurements were performed with participants lying supine and relaxed, with electrodes placed on the hand and foot according to the manufacturer's instructions. Phase angle (PhA) at 50 kHz was recorded as the primary outcome variable. Resistance (R) and reactance (Xc) at 50 kHz were also recorded. As a quality-control measure, BIA measurements yielding PhA values >10° were considered physiologically implausible. This criterion was defined post hoc, after the original BIA records were re-examined. It was based on reference data showing that mean PhA in healthy adults is approximately 6.4–7.3° [22], so that values >10° lie far above those expected in adults with CD. This threshold is a pragmatic plausibility criterion rather than a validated technical cut-off. Two measurements exceeded this threshold (17.4° and 11.0°). In both, the device-recorded values were internally consistent (resistance 568 and 543 Ω; reactance 178 and 105 Ω; PhA recalculated from resistance and reactance, 17.42° and 10.98°), but reactance was well outside the range of the other participants (33–90 Ω). Device alerts were not recorded and could not be retrieved. As the measurements could not be repeated, a measurement error could not be confirmed. Both values were therefore excluded on the grounds of implausibility rather than as confirmed errors, and the effect of retaining them was examined in sensitivity analyses. All remaining PhA values ranged from 3.8° to 7.6°. Appendicular lean mass (ALM) was estimated from the BIA-derived impedance index (height^2/resistance), weight and sex, using the equation of Scafoglieri et al. [23]. Because the sample was too small for a reliable ROC curve analysis, sex-specific PhA cut-off values were adopted from Peng et al. [17]. These authors derived optimal thresholds for identifying malnutrition according to the GLIM criteria in 169 patients with CD. Low PhA was defined as <6.11° in males and <5.55° in females, and values at or above these thresholds were classified as normal. Because these thresholds were derived in a different population, PhA was analysed as a continuous outcome in all regression models; the dichotomous classification was used only for secondary, exploratory group comparisons.

2.3. Physical Activity Assessment

Physical activity was assessed using the short version of the International Physical Activity Questionnaire (IPAQ) [24], which has been shown to have acceptable reliability in Greek adults [25]. The short IPAQ assesses the frequency and duration of walking, moderate-intensity and vigorous-intensity physical activity over the previous seven days. The total IPAQ score was calculated in MET-minutes per week, and participants were classified into low, moderate and high physical activity categories according to the IPAQ scoring protocol, which combines frequency, duration and MET-minutes. The moderate category requires ≥3 days of vigorous activity of ≥20 min/day, ≥5 days of moderate-

intensity activity and/or walking of ≥30 min/day, or ≥5 days of any combination of walking, moderate-intensity or vigorous activity achieving ≥600 MET-min/week. The high category requires vigorous activity on ≥3 days achieving ≥1500 MET-min/week, or ≥7 days of any combination achieving ≥3000 MET-min/week. Participants who met neither set of criteria were classified in the low category. Of note, the low category does not denote physical inactivity. Therefore, participants who were active twice weekly could still be classified in the low category. Because of the small number of participants in the high category ($n = 8$), the moderate and high categories were combined for the regression analyses (moderate/high vs. low).

2.4. Dietary Assessment

Dietary habits were assessed by a trained researcher using two dietary indices, the MedDietScore and an adapted DASH score. Adherence to the Mediterranean diet was assessed with the standard 11-item food-frequency questionnaire of the MedDietScore, which was developed and validated in Greek adults by Panagiotakos et al. [26]. The questionnaire records the usual consumption of 11 food groups in servings per month: non-refined cereals, fruits, vegetables, potatoes, legumes, fish, red meat and meat products, poultry, full-fat dairy products, olive oil, and alcoholic beverages. Each food group is scored from 0 to 5. For food groups characteristic of the Mediterranean pattern, higher consumption receives higher scores. For red meat and meat products, poultry, and full-fat dairy products, the scoring is reversed: rare or no consumption receives 5 points and the most frequent consumption receives 0 points. Alcohol is scored non-monotonically. The total score ranges from 0 to 55, with higher scores indicating greater adherence. For the analyses, the full-fat dairy item was reverse-coded (5 − item score), so that higher values indicate more frequent consumption.

Adherence to the DASH diet was assessed using an adapted, non-validated version of the scoring system described by Tangney et al. [27]. The score includes 10 components, each scored as 1, 0.5, or 0 points, with 1 point assigned to the intake level closest to the DASH recommendations (Table 1). As in the original scoring system, all components are expressed per day, except for sweets, which are expressed per week [27]. The seven food-group components were scored from the usual daily servings of each food group (weekly servings for sweets). Participants reported their usual intake, without a fixed reference period or standardised portion-size aids, and servings were estimated by the trained researcher. The corresponding category of each food-group component was recorded directly on a published DASH scoring form [28]; the number of servings was not recorded separately. As no quantitative dietary assessment was performed, the nutrient components (total fat, saturated fat, and sodium) could not be derived from quantitative intake data. Instead, the trained researcher scored them according to the thresholds of Tangney et al. [27] on the basis of a qualitative judgement of the reported habits rather than a predefined algorithm: sodium from the addition of salt to food and the consumption of salty and processed foods, and total and saturated fat from the type of added fats and the consumption of fried and high-fat foods. Because these three components cannot be reproduced, the primary DASH exposure was a food-based DASH index, defined as the sum of the seven food-group components (range 0–7). The full 10-component score (range 0–10) was examined as an exploratory exposure. Both are adapted indices and should not be equated with the original DASH score. As energy intake was not quantified, no energy adjustment was applied. For two participants in whom the sweets component was not recorded, the scores were prorated (sum of the available components × 7/6 for the food-based index and × 10/9 for the full score). This assigns the mean contribution of the observed components to the missing one and is a practical choice, not a reconstruction of actual consumption. Dietary questionnaires

and BIA measurements were administered by different researchers, and the dietary scores were assigned without knowledge of the participants' PhA values.

Table 1. Scoring of the adapted DASH score (adapted from Tangney et al. [27]).

Component	Unit	1 Point	0.5 Points	0 Points
Food-group components [a]				
Total grains	servings/day	≥7	≥5 to <7	<5
Vegetables	servings/day	≥4	≥2 to <4	<2
Fruits	servings/day	≥4	≥2 to <4	<2
Dairy products	servings/day	≥2	≥1 to <2	<1
Meat, poultry, and fish	servings/day	≤2	>2 to <4	≥4
Nuts, seeds, and legumes	servings/day	≥4	≥2 to <4	<2
Sweets	servings/week	≤5	>5 to <8	≥8
Nutrient components [b]				
Total fat	% of energy	≤27	>27 to <30	≥30
Saturated fat	% of energy	≤6	>6 to <9	≥9
Sodium	mg/day	≤2400	>2400 to ≤3000	>3000

Intake ranges are given as non-overlapping intervals so that fractional servings are also classified; the thresholds correspond to those of Tangney et al. [27], in which all components are expressed per day except for sweets. These non-overlapping intervals make the thresholds of the scoring form explicit; at data collection, the categories of the form, expressed in whole servings, were applied directly. [a] Food-based DASH index (primary exposure): sum of the seven food-group components (range 0–7). [b] Nutrient components could not be quantified and were scored by a qualitative judgement of the reported habits (see text); they are included only in the full 10-component score (range 0–10; exploratory exposure).

2.5. Statistical Analysis

The Kolmogorov–Smirnov test was used to assess normality of distribution. Continuous variables are presented as mean ± standard deviation (SD) or median and interquartile range (IQR) for non-normally distributed variables. Categorical variables are presented as frequencies and percentages within groups. The number of participants with available data is reported for each variable. Secondary, exploratory comparisons between patients with low and normal PhA were performed using the independent samples *t*-test or Mann–Whitney U test for continuous variables, and Fisher's exact test (2 × 2 tables) or the Fisher–Freeman–Halton exact test (larger tables) for categorical variables. Spearman correlation coefficients were calculated to examine associations between PhA and dietary, physical activity, body composition, and inflammatory variables. Unadjusted associations with PhA were examined using simple linear regression (Table S1). Multiple linear regression was used to examine the associations of dietary indices with PhA as a continuous dependent variable. The food-based DASH index and the total MedDietScore (Table S2) were considered the primary dietary exposures, and the full 10-component DASH score was examined as an exploratory exposure. The full-fat dairy item of the MedDietScore was examined as an exploratory exposure and was reverse-coded (5 − item score), so that higher values indicate more frequent consumption. Given the limited sample size, a parsimonious adjustment set was defined on the basis of prior knowledge rather than univariable *p*-values, so that approximately 10 observations per predictor were retained; this rule of thumb does not guarantee the stability of the estimates. Model 1 was adjusted for sex, and Model 2 was additionally adjusted for physical activity (IPAQ category; moderate/high vs. low), as both are established determinants of PhA that may also be related to dietary habits. Being a determinant of PhA does not by itself make a variable a confounder, and this limited adjustment set does not establish independence from other clinical factors. Models were fitted in all participants with complete data for the included

variables, and the number of participants in each model is reported. Model assumptions were checked as follows: normality of residuals with residual plots and the Shapiro–Wilk test; homoscedasticity with the Breusch–Pagan test; linearity by adding a quadratic term for the exposure; multicollinearity with variance inflation factors (VIF); and influential observations with Cook's distance (values $> 4/n$ were inspected) and by refitting the main model after removing each participant in turn and after sequentially removing the five most influential observations. Unstandardised (B) and standardised (β) coefficients with 95% confidence intervals (CI), R^2 and adjusted R^2 are reported. Several sensitivity analyses were performed (Tables S3 and S4). First, age, CRP, disease activity (Harvey–Bradshaw Index), or serum albumin was added separately to Model 2, and models with and without CRP or albumin were compared in the same complete-case samples, to distinguish the effect of adjustment from that of sample selection. Second, the continuous IPAQ score was used instead of the IPAQ category, and sex-standardised PhA (z-score) was used as the outcome. Third, the analyses were restricted to participants with all score components (seven for the food-based index and ten for the full score). Fourth, the participant with a PhA of 11.0° was retained, and then both excluded measurements (11.0° and 17.4°) were retained. Finally, nonparametric percentile bootstrap 95% CIs were calculated as a sensitivity analysis (2000 case resamples; all resamples could be estimated). A sensitivity power analysis indicated that, with $n = 35$ and three predictors, the study had 80% power ($\alpha = 0.05$) to detect an effect size of $f^2 \geq 0.24$ for a single regression coefficient. Statistical analysis was performed using IBM SPSS Statistics, Version 29.0 (IBM Corp., Armonk, NY, USA). Spearman correlation coefficients were visualized using a correlation heatmap generated in R (version 4.3.3; R Foundation for Statistical Computing, Vienna, Austria) with the ggplot2 package (version 3.4.4). The level of significance was set at $\alpha = 0.05$. Given the exploratory nature of the study, no correction for multiple comparisons was applied.

3. Results

Of the 53 patients in the cohort, 41 had BIA measurements. Two of them were excluded because of physiologically implausible PhA values (>10°), leaving 39 participants for the present analysis. Of these, 19 (48.7%) had normal and 20 (51.3%) had low PhA. Owing to missing dietary data, 35 participants were included in the main regression models. Participant characteristics are presented in Table 2. The mean age was 38.0 ± 10.8 years (range 18–58), and 53.8% of participants were female. Most participants with available data were in clinical remission (71.4%), with a median Harvey–Bradshaw Index of 1 (IQR 0–5). No significant differences were observed between the low and normal PhA groups in age, sex, BMI, lean mass, resistance, physical activity, MedDietScore, full-fat dairy consumption, CRP, albumin, or disease characteristics. In contrast, the Harvey–Bradshaw Index was higher in patients with normal PhA (median 4 vs. 1, $p = 0.025$). Full-fat dairy consumption was low, with 30 of 35 participants (85.7%) reporting rare or no consumption. Patients with normal PhA had higher reactance (62.5 ± 12.1 vs. 49.2 ± 9.4 Ω, $p < 0.001$), higher food-based DASH index scores (2.94 ± 0.98 vs. 2.29 ± 0.82, $p = 0.041$) and higher full DASH scores (4.69 ± 1.41 vs. 3.45 ± 1.25, $p = 0.010$) than those with low PhA. Disease characteristics were not available for 12 participants. PhA, DASH scores, age, and Harvey–Bradshaw Index were similar in participants with and without these data (all $p > 0.10$), although this does not exclude bias due to missing data.

Table 2. Participant characteristics by phase angle category.

	Total (n = 39)	Low PhA (n = 20)	Normal PhA (n = 19)	p-Value
Age (years) (n = 39)	38.0 ± 10.8	37.2 ± 11.3	38.8 ± 10.5	0.641 b
Sex, n (%) (n = 39)				0.341 a
Female	21 (53.8)	9 (45.0)	12 (63.2)	
Male	18 (46.2)	11 (55.0)	7 (36.8)	
BMI (kg/m^2) (n = 39)	25.2 (23.4–29.4)	24.6 (23.1–26.4)	26.9 (24.0–32.0)	0.232 c
Phase angle (°) (n = 39)	5.7 (5.2–6.5)	5.2 (4.6–5.5)	6.5 (6.0–7.0)	<0.001 c
Resistance, 50 kHz (Ω) (n = 39)	548.5 ± 96.1	544.3 ± 84.0	553.1 ± 109.6	0.779 b
Reactance, 50 kHz (Ω) (n = 39)	55.7 ± 12.6	49.2 ± 9.4	62.5 ± 12.1	<0.001 b
Lean mass (kg) (n = 39)	57.1 (46.8–69.8)	59.5 (46.9–70.2)	52.4 (47.8–68.4)	0.574 c
IPAQ (MET-min/week) (n = 39)	1440 (396–3460)	2002 (950–3414)	720 (148–2620)	0.284 c
IPAQ category, n (%) (n = 39)				0.227 d
Low	14 (35.9)	5 (25.0)	9 (47.4)	
Moderate	17 (43.6)	9 (45.0)	8 (42.1)	
High	8 (20.5)	6 (30.0)	2 (10.5)	
MedDietScore (0–55) (n = 35)	28.5 ± 3.4	28.2 ± 3.2	28.9 ± 3.7	0.570 b
Full-fat dairy intake (recoded item score), n (%) ‡ (n = 35)				0.194 d
0 (rare/no consumption)	30 (85.7)	18 (94.7)	12 (75.0)	
1	4 (11.4)	1 (5.3)	3 (18.8)	
2	1 (2.9)	0 (0.0)	1 (6.2)	
Food-based DASH index (0–7) § (n = 35)	2.59 ± 0.94	2.29 ± 0.82	2.94 ± 0.98	0.041 b
Full DASH score (0–10) § (n = 35)	4.02 ± 1.45	3.45 ± 1.25	4.69 ± 1.41	0.010 b
CRP (mg/dL) (n = 32)	0.14 (0.08–0.29)	0.12 (0.07–0.22)	0.16 (0.08–0.61)	0.543 c
Albumin (g/dL) (n = 31)	4.45 (4.29–4.63)	4.57 (4.29–4.70)	4.37 (4.29–4.49)	0.351 c
MNA-SF score (n = 33)	13 (12–14)	13 (12–14)	13 (12–14)	0.970 c
MNA-SF category, n (%) (n = 33)				1.000 a
Normal nutritional status	27 (81.8)	15 (83.3)	12 (80.0)	
At risk of malnutrition	6 (18.2)	3 (16.7)	3 (20.0)	
Harvey–Bradshaw Index (n = 35)	1.0 (0.0–5.0)	1.0 (0–2.0)	4.0 (2.0–5.0)	0.025 c
Clinical disease activity, n (%) (n = 35)				0.052 d
Remission (HBI <5)	25 (71.4)	16 (84.2)	9 (56.2)	
Mild (HBI 5–7)	7 (20.0)	1 (5.3)	6 (37.5)	
Moderate (HBI 8–16)	3 (8.6)	2 (10.5)	1 (6.2)	
Disease duration (years) (n = 27)	9 (4–11)	8 (4–10)	10 (9–11)	0.127 c
Disease location, n (%) (n = 27)				0.639 d
Ileal (L1)	12 (44.4)	8 (53.3)	4 (33.3)	
Colonic (L2)	3 (11.1)	1 (6.7)	2 (16.7)	
Ileocolonic (L3)	12 (44.4)	6 (40.0)	6 (50.0)	
Disease behaviour, n (%) (n = 27)				0.355 d
Non-stricturing, non-penetrating	7 (25.9)	4 (26.7)	3 (25.0)	
Stricturing	9 (33.3)	7 (46.7)	2 (16.7)	
Penetrating	3 (11.1)	1 (6.7)	2 (16.7)	
Stricturing and penetrating	8 (29.6)	3 (20.0)	5 (41.7)	
Perianal disease, n (%) (n = 27)				0.683 a
Yes	9 (33.3)	6 (40.0)	3 (25.0)	
Prior intestinal resection, n (%) (n = 27)				1.000 a
Yes	12 (44.4)	7 (46.7)	5 (41.7)	
Lines of biologic therapy (n = 27)	1 (1–2)	1 (1–2)	1 (1–2)	1.000 c
Intensified infliximab, n (%) (n = 27)				0.696 a
Yes	16 (59.3)	8 (53.3)	8 (66.7)	

Data are mean ± SD, median (IQR) or n (% within column); n indicates participants with available data, and percentages are calculated on these. a Fisher's exact test; b independent-samples t-test; c Mann–Whitney U test; d Fisher–Freeman–Halton exact test. ‡ MedDietScore full-fat dairy item reverse-coded (5 − item score): 0 = rare/no consumption; higher values indicate more frequent consumption. § Adapted DASH scores (Table 1). For two participants in whom the sweets component was not recorded, the scores were prorated (sum of the available components × 7/6 and × 10/9, respectively). Low PhA: <6.11° (males), <5.55° (females). BMI, body mass index; CRP, C-reactive protein; MNA-SF, Mini Nutritional Assessment–Short Form; HBI, Harvey–Bradshaw Index; IPAQ, International Physical Activity Questionnaire; PhA, phase angle. Comparisons between PhA categories are secondary and exploratory.

PhA was positively correlated with the full DASH score (ρ = 0.42, $p = 0.011$; $n = 35$), whereas its correlation with the food-based DASH index was weaker and not significant (ρ = 0.26, $p = 0.126$). PhA was not significantly correlated with the IPAQ score (ρ = −0.29, $p = 0.071$), full-fat dairy intake (ρ = 0.12, $p = 0.483$), the total MedDietScore (ρ = 0.28, $p = 0.099$), lean mass (ρ = 0.21, $p = 0.197$), age (ρ = −0.03, $p = 0.855$), or CRP (ρ = −0.04, $p = 0.820$). These findings are visually presented in Figure 1.

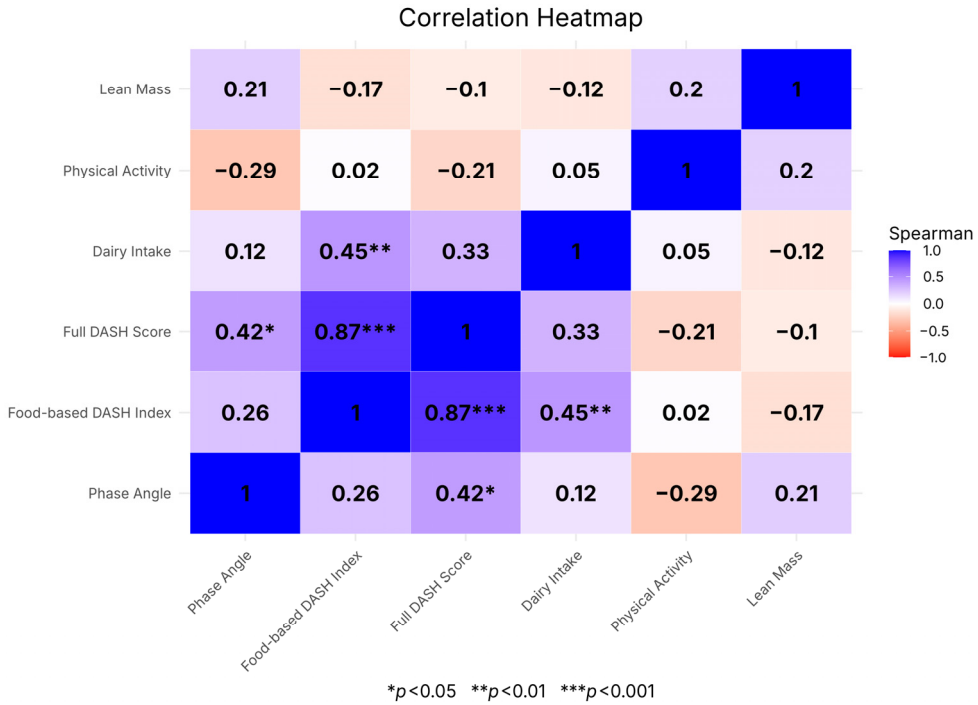


Figure 1. Spearman correlation heatmap of phase angle with dietary, physical activity, and body composition variables (pairwise complete observations: $n = 35$ for correlations involving dietary variables and $n = 39$ for the remaining variables). Colours indicate the direction and magnitude of the correlation coefficients (red, negative; blue, positive), and the values within the cells are Spearman's ρ. Dairy intake, MedDietScore full-fat dairy item reverse-coded so that higher values indicate more frequent consumption; physical activity, total IPAQ score (MET-min/week); food-based DASH index, sum of the seven food-group components of the adapted Dietary Approaches to Stop Hypertension (DASH) score (primary exposure); full DASH score, adapted 10-component score (exploratory exposure). * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

In unadjusted analyses (Table S1), PhA was associated with physical activity category (B = −0.690, 95% CI −1.299 to −0.082, $p = 0.027$), but not with the food-based DASH index (B = 0.230, 95% CI −0.109 to 0.570, $p = 0.177$) or the full DASH score (B = 0.206, 95% CI −0.009 to 0.422, $p = 0.060$). No clear association was observed between PhA and the total MedDietScore, full-fat dairy intake, age, sex, BMI, lean mass, CRP, Harvey–Bradshaw Index, or albumin. In multiple regression analysis (Table 3), a higher food-based DASH index was associated with higher PhA after adjustment for sex (Model 1: B = 0.317, 95% CI 0.007 to 0.626, β = 0.32, $p = 0.045$). After further adjustment for physical activity, the estimate was similar, but the confidence interval marginally included zero (Model 2: B = 0.293, 95% CI −0.003 to 0.588, β = 0.30, $p = 0.052$; $n = 35$; adjusted $R^2 = 0.297$). The estimate became larger after adjustment for sex, which is consistent with negative confounding: women had numerically higher food-based DASH index scores than men (2.76 ± 1.00 vs. 2.42 ± 0.88) but lower PhA (5.54 ± 0.94° vs. 6.04 ± 0.91°). In Model 2, male sex was positively associated with PhA (B = 0.829, $p = 0.004$), and moderate/high physical activity was inversely associated with PhA (B = −0.600, 95% CI −1.182 to −0.019, $p = 0.043$). No clear

association was observed for the total MedDietScore in either model (Model 2: B = 0.033, 95% CI −0.057 to 0.124, $p = 0.459$; Table S2).

Table 3. Multiple linear regression models for PhA (°) with the food-based DASH index as the primary dietary exposure.

	Model 1	**Model 2**
Male sex (ref: female)	0.861 (0.285 to 1.436); β = 0.47; $p = 0.005$	0.829 (0.280 to 1.377); β = 0.45; $p = 0.004$
Food-based DASH index (0–7)	0.317 (0.007 to 0.626); β = 0.32; $p = 0.045$	0.293 (−0.003 to 0.588); β = 0.30; $p = 0.052$
Moderate/high physical activity (ref: low)	—	−0.600 (−1.182 to −0.019); β = −0.30; $p = 0.043$
n	35	35
R^2/adjusted R^2	0.267/0.221	0.359/0.297
Max VIF	1.04	1.04

Values are unstandardised B (95% CI); β = standardised coefficient. Model 1: adjusted for sex; Model 2: additionally adjusted for physical activity (IPAQ category; moderate/high vs. low). The food-based DASH index is the sum of the seven food-group components (Table 1). The full 10-component DASH score (exploratory exposure) is presented in Table S4.

In exploratory models (Table 4), no clear association was observed for full-fat dairy intake (Model 2: B = 0.411, 95% CI −0.237 to 1.059, $p = 0.205$; $n = 35$).

Table 4. Exploratory multiple linear regression models for PhA (°) with full-fat dairy intake as the dietary exposure.

	Model 1	**Model 2**
Male sex (ref: female)	0.853 (0.243 to 1.463); β = 0.47; $p = 0.008$	0.823 (0.244 to 1.403); β = 0.45; $p = 0.007$
Full-fat dairy intake †	0.430 (−0.253 to 1.113); β = 0.21; $p = 0.209$	0.411 (−0.237 to 1.059); β = 0.20; $p = 0.205$
Moderate/high physical activity (ref: low)	—	−0.635 (−1.236 to −0.034); β = −0.32; $p = 0.039$
n	35	35
R^2/adjusted R^2	0.208/0.159	0.311/0.245
Max VIF	1.08	1.08

Values are unstandardised B (95% CI); β = standardised coefficient. Model 1: adjusted for sex; Model 2: additionally adjusted for physical activity (IPAQ category; moderate/high vs. low). † The MedDietScore full-fat dairy item was reverse-coded (5 − item score) so that higher values indicate more frequent consumption; 30/35 participants (85.7%) reported rare/no consumption.

Sensitivity analyses are presented in Table S3. The estimate for the food-based DASH index was similar or larger after additional adjustment for age (B = 0.291, $p = 0.058$), Harvey–Bradshaw Index (B = 0.396, $p = 0.004$), or albumin (B = 0.440, $p = 0.009$; $n = 31$; B = 0.364 without albumin in the same participants). It was also similar when physical activity was entered as a continuous variable (B = 0.328, $p = 0.037$), when sex-standardised PhA was used as the outcome (B = 0.280, $p = 0.081$), and when the analysis was restricted to participants with all seven food-group components (B = 0.319, $p = 0.046$; $n = 33$). In the bootstrap sensitivity analysis, the percentile 95% CI was 0.030 to 0.519. In the 32 participants with CRP data, additional adjustment for CRP attenuated the estimate from 0.334

($p = 0.023$) to 0.273 (95% CI −0.065 to 0.610, $p = 0.109$), and no clear association was observed for CRP itself ($p = 0.482$). When the participant with a PhA of 11.0° was retained, the estimate was larger (B = 0.417, $p = 0.035$; $n = 36$). When both excluded measurements were retained ($n = 37$), the estimate was 0.756 (95% CI 0.007 to 1.504); in this analysis, the 17.4° measurement had a Cook's distance of 0.99 and a studentised residual of 9.8, so that this single observation largely determined the estimate. Regression diagnostics for the main model showed no evidence of non-normality of residuals (Shapiro–Wilk $p = 0.394$), heteroscedasticity (Breusch–Pagan $p = 0.102$), non-linearity (quadratic term $p = 0.755$), or multicollinearity (all VIF < 1.1). All Cook's distances were below $4/n$ (maximum 0.11). When each participant was removed in turn, the coefficient ranged from 0.257 to 0.364, and it did not decrease when the five most influential observations were removed sequentially (range 0.319 to 0.462). No clear association was observed for full-fat dairy intake in the sensitivity analyses, except when the excluded measurements were retained (11.0°: B = 0.887, $p = 0.027$, $n = 36$; both: B = 2.472, $p < 0.001$, $n = 37$). In these analyses, no clear association was observed for the total MedDietScore ($p = 0.395$ and $p = 0.846$, respectively).

In exploratory analyses (Table S4), the full 10-component DASH score was associated with higher PhA after adjustment for sex (Model 1: B = 0.257, 95% CI 0.064 to 0.451, β = 0.40, $p = 0.011$) and physical activity (Model 2: B = 0.230, 95% CI 0.042 to 0.418, β = 0.36, $p = 0.018$; adjusted $R^2 = 0.338$). The estimate was similar after additional adjustment for age, Harvey–Bradshaw Index, or albumin, and after adjustment for CRP (B = 0.218, $p = 0.049$, vs. 0.246 without CRP in the same 32 participants). The confidence interval included zero when the participant with a PhA of 11.0° was retained (B = 0.254, $p = 0.055$; $n = 36$) and when the analysis was restricted to participants with all ten components and further adjusted for CRP (B = 0.221, $p = 0.074$; $n = 30$). When each participant was removed in turn, the coefficient ranged from 0.204 to 0.266 (all $p < 0.05$). When both excluded measurements were retained, the estimate was 0.514 (95% CI 0.021 to 1.006; $n = 37$).

4. Discussion

The present exploratory study investigated the association between dietary quality indices and PhA in adults with CD. The main finding was a positive but imprecise association between the food-based DASH index and PhA after adjustment for sex and physical activity (B = 0.293, 95% CI −0.003 to 0.588). The estimate was similar in direction and magnitude across most sensitivity analyses. In exploratory analyses, the full 10-component score was also positively associated with PhA (β = 0.36 vs. 0.30 for the food-based index); because the two indices differ in scale and components, these estimates are not directly comparable. No clear association was observed for the total MedDietScore or full-fat dairy consumption. Male sex was positively associated with PhA, and physical activity category was inversely associated with PhA in the main model.

To our knowledge, no previous study has examined the relationship between the DASH dietary pattern and PhA in patients with CD. In the present study, the adjusted estimate for the food-based DASH index was positive and of similar magnitude across most sensitivity analyses, and the full DASH score was correlated with PhA and associated with PhA after adjustment for sex and physical activity. Several mechanisms could potentially underlie the positive DASH-PhA relationship. First, the DASH pattern provides adequate amounts of high-quality protein from diverse sources (e.g., dairy, legumes, poultry) [29]. Dietary protein has been identified as a significant independent predictor of PhA even after adjustment for sex, age, and fat-free mass in athletes [30]. Second, the DASH diet is rich in potassium, magnesium, calcium and antioxidants, including polyphenols and vitamins C and E [29]. These nutrients have been associated with lower oxidative stress and systemic inflammation, and a meta-analysis of randomised trials showed a significant reduction

in hs-CRP with the DASH diet [31]. These effects may be relevant to cell membrane integrity and PhA. Consistent with this, dietary antioxidant capacity has previously been associated with higher PhA in healthy subjects [5]. Third, in patients with CD, chronic mucosal inflammation, malabsorption, and altered gut microbiota contribute to nutritional deterioration [32,33]. In this setting, adherence to a high-quality dietary pattern might help preserve cellular integrity by ensuring adequate micronutrient availability and attenuating the inflammatory burden. The mean scores in our sample (2.6 ± 0.9 out of 7 for the food-based index and 4.0 ± 1.4 out of 10 for the full score) were in the lower part of the possible range. As both indices are adapted and not validated, this should not be taken as a definitive measure of adherence, although it is consistent with the suboptimal diet quality previously reported in Greek patients with CD [18]. Additional adjustment for disease activity or albumin did not reduce the estimate (food-based index: B = 0.396 with vs. 0.293 without the Harvey–Bradshaw Index; 0.440 with vs. 0.364 without albumin in the same 31 participants), although the confidence intervals were wide. Adjustment for the measured CRP concentration only modestly attenuated the estimate, and no clear association was observed for CRP itself. However, residual confounding by inflammatory activity cannot be excluded, particularly because CRP may not fully capture the low-grade intestinal inflammation of CD in remission [34]. Patients with low PhA had lower reactance and similar resistance compared with those with normal PhA. However, because hydration status was not assessed, the relative contribution of cellular and fluid components cannot be determined. Importantly, reverse causality cannot be excluded given the cross-sectional design. Patients with better clinical and nutritional status, and thus higher PhA, may find it easier to follow a varied, high-quality diet, whereas those with more symptoms may adopt more restrictive dietary patterns [35].

In contrast to the DASH indices, no clear association was observed for the total MedDietScore. Previous studies have reported a positive association between overall Mediterranean diet adherence and PhA in healthy adults [36] and in patients with obesity and metabolic syndrome [37]. However, the lack of a clear association in our sample may partly reflect the limited variability of the MedDietScore and differences between the two indices. The full DASH score also includes nutrient-based components (total fat, saturated fat, and sodium) and rewards the consumption of dairy products, nuts, and legumes, whereas the MedDietScore is based solely on food-group consumption frequencies and penalises full-fat dairy consumption. No clear association was observed for full-fat dairy consumption, examined as an exploratory exposure. However, consumption was very low (85.7% of participants reported rare or no consumption), and this limited variability precluded a meaningful evaluation of this food group. Studies including a wider range of dairy intake are needed to examine whether dairy consumption is related to PhA in patients with CD.

Physical activity category was inversely associated with PhA in the unadjusted analysis. After adjustment, this association remained in the main model with the food-based DASH index ($p = 0.043$) and in the exploratory dairy model ($p = 0.039$), but not in the models with the full DASH score ($p = 0.063$) or the MedDietScore ($p = 0.077$). It was also not observed when the continuous IPAQ score was used. This finding contrasts with the established positive relationship between physical activity and PhA in the general population [38]. It may reflect chance and measurement error in self-reported physical activity in a small sample [39], although residual confounding by disease-related factors cannot be excluded. Notably, patients with low PhA in our sample had numerically higher lean mass and physical activity scores than those with normal PhA, although these differences were not statistically significant. This comparison, however, is likely confounded by the higher proportion of men in the low-PhA group. In addition, the health effects of physical activity may differ by domain. According to the so-called "physical activity health paradox", leisure-time physical

activity consistently improves health outcomes, whereas occupational physical activity may not confer similar benefits [40]. Moreover, the positive association between physical activity and PhA has been shown to be stronger when leisure-time activity exceeds occupational activity [41]. As the short IPAQ does not distinguish between leisure-time and occupational activity, this remains a hypothesis. Similarly, the higher Harvey–Bradshaw Index observed in patients with normal PhA was unexpected. However, disease activity was generally low, and after adjustment for the index, the estimates for the food-based and full DASH scores were 0.396 and 0.257, compared with 0.293 and 0.230 in the main models; the confidence intervals were wide. Reverse causality is also possible. In addition, these associations may have been confounded by unmeasured treatment exposures, such as corticosteroid use, which can adversely affect muscle protein balance and body composition [42].

The strengths of this study include the novel examination of DASH-type dietary patterns in relation to PhA in CD, the use of two dietary indices, the clinical characterisation of the sample, and the extensive sensitivity analyses. However, several limitations should be acknowledged. First, the cross-sectional design precludes causal inference, and reverse causality cannot be excluded. Second, the sample size was small ($n = 39$, with 35 participants in the main regression models owing to missing dietary data). As a result, the study was powered to detect only moderate-to-large effects ($f^2 \geq 0.24$), only parsimonious adjustment was possible, and the risk of unstable estimates was increased. The adjustment for sex and physical activity is limited and does not establish independence from key clinical factors, such as disease activity, treatment, and energy intake. The findings should therefore be considered exploratory and hypothesis-generating. Third, the study was conducted in a single centre in Greece and mostly included patients in clinical remission who were physically active and received dietary advice as part of their routine care. This may have influenced the dietary scores and limits the generalisability of the findings. Fourth, clinical data were missing for some participants, so bias due to missing data cannot be excluded. In addition, information on corticosteroid use, energy and protein intake, and nutritional support was not available. Residual confounding therefore cannot be excluded. In addition, the MNA-SF has been validated mainly in older adults, and its use in this younger sample should be interpreted with caution. Fifth, dietary intake and physical activity were self-reported. Usual intake was reported without a fixed reference period or standardised portion-size aids. Because only the categories of the food-group components were retained, and not the number of servings, the categorisation of individual responses cannot be re-checked retrospectively, although the scoring procedure is fully specified (Table 1). The nutrient components of the DASH score (sodium, total fat and saturated fat) were estimated from qualitative questions rather than quantitative intake data and were scored without a predefined algorithm. Such questions have limited ability to discriminate sodium intake [43]. This approach may have introduced misclassification and limits the reproducibility of these components; for this reason, the food-based DASH index was used as the primary exposure, and the full score was considered exploratory. Moreover, neither the food-based index nor the full adapted score has been formally validated, and the short IPAQ does not distinguish between leisure-time and occupational physical activity. Sixth, the recoded full-fat dairy item showed a marked floor effect, which precluded a meaningful evaluation of dairy consumption. In addition, several dietary exposures were examined without correction for multiple comparisons. Seventh, BIA was performed after a fasting period of only 2–3 h, which is shorter than commonly recommended [44]. Hydration status was not otherwise assessed, and both factors may have influenced PhA. Moreover, the PhA cut-offs were derived from a different CD population [17]. Finally, CRP may not fully capture the inflammatory burden in remission-phase CD, and more sensitive markers,

such as faecal calprotectin [34], should be considered in future studies. Longitudinal and interventional studies in larger, multicentre cohorts are needed to confirm these findings.

5. Conclusions

In conclusion, in adults with CD, the adjusted estimate for the association between DASH-type food choices, assessed with an adapted food-based index, and PhA was positive, but the confidence interval also included values close to zero. The full adapted DASH score, which also includes qualitatively scored nutrient components that cannot be reconstructed, was positively associated with PhA in exploratory analyses. No clear association was observed for the total Mediterranean diet score or full-fat dairy consumption. Given the cross-sectional design and the small sample, these findings should be regarded as hypothesis-generating. They do not show that dietary quality influences cellular integrity, nor that dietary assessment or any subsequent intervention confers clinical benefit. Longitudinal and interventional studies with larger samples are needed to establish whether improving dietary quality can improve PhA in patients with CD.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/diseases14110408/s1, Table S1: Unadjusted associations of participant characteristics with phase angle (°); Table S2: Multiple linear regression for phase angle (°): total MedDietScore; Table S3: Sensitivity analyses for the dietary exposures; Table S4: Full 10-component DASH score (exploratory exposure): regression models and sensitivity analyses.

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References

1. Cioffi, I.; Marra, M.; Imperatore, N.; Pagano, M.C.; Santarpia, L.; Alfonsi, L.; Testa, A.; Sammarco, R.; Contaldo, F.; Castiglione, F.; et al. Assessment of bioelectrical phase angle as a predictor of nutritional status in patients with Crohn's disease: A cross sectional study. *Clin. Nutr.* **2020**, *39*, 1564–1571. [CrossRef] [PubMed]
2. da Silva, B.R.; Orsso, C.E.; Gonzalez, M.C.; Sicchieri, J.M.F.; Mialich, M.S.; Jordao, A.A.; Prado, C.M. Phase angle and cellular health: Inflammation and oxidative damage. *Rev. Endocr. Metab. Disord.* **2023**, *24*, 543–562. [CrossRef] [PubMed] [PubMed Central]
3. Detopoulou, P.; Levidi, D.; Magni, O.; Dedes, V.; Tzoutzou, M.; Fappa, E.; Gioxari, A.; Panoutsopoulos, G. Phase angle is inversely related to the consumption of ultra-processed foods and positively related to the consumption of minimally processed foods by university students: A cross-sectional study. *Public Health Nutr.* **2024**, *27*, e161. [CrossRef] [PubMed] [PubMed Central]
4. Clinger, D.; Antush, M.T.; Aguiar Bonfim Cruz, A.J.; Vella, C.A. Whole-body phase angle as a non-invasive indicator of low-grade inflammation in generally healthy adults. *Nutr. Metab. Cardiovasc. Dis.* **2026**, *36*, 104630. [CrossRef] [PubMed]
5. Detopoulou, P.; Fragopoulou, E.; Nomikos, T.; Antonopoulou, S. Associations of phase angle with platelet-activating factor metabolism and related dietary factors in healthy volunteers. *Front. Nutr.* **2023**, *10*, 1237086. [CrossRef] [PubMed] [PubMed Central]

6. Bongiolo, A.M.; Machado, M.J.; Lazarotto, B.A.; Rupp, M.L.C.; Dal-Pizzol, F.; Pires, M.M.d.S. PHASE ANGLE AS A PREDICTOR OF MUSCLE MASS IN PATIENTS WITH INFLAMMATORY BOWEL DISEASE. *Arq. Gastroenterol.* **2024**, *61*, e23095. [CrossRef] [PubMed]
7. Lai, T.F.; Park, J.H.; Jang, M.; Chen, J.; Shin, M.J.; Moon, E.; Kang, J.M.; Lee, J.W.; Cho, Y.J.; Liao, Y.; et al. Elevated extracellular water to total body water ratio and low phase angle in relation to muscle function in middle-aged and older adults. *J. Int. Soc. Sports Nutr.* **2025**, *22*, 2536693. [CrossRef] [PubMed] [PubMed Central]
8. Leziak, A.; Lipina, J.; Reclik, M.; Kocelak, P. Dietary Modulation of Metabolic Health: From Bioactive Compounds to Personalized Nutrition. *Metabolites* **2025**, *15*, 624. [CrossRef] [PubMed] [PubMed Central]
9. Panbehkar-Jouybari, M.; Mollahosseini, M.; Salehi-Abargouei, A.; Fallahzadeh, H.; Mirzaei, M.; Hosseinzadeh, M. The Mediterranean diet and dietary approach to stop hypertension (DASH)-style diet are differently associated with lipid profile in a large sample of Iranian adults: A cross-sectional study of Shahedieh cohort. *BMC Endocr. Disord.* **2021**, *21*, 192. [CrossRef] [PubMed] [PubMed Central]
10. Wang, J.S.; Liu, W.J.; Lee, C.L. Associations of Adherence to the DASH Diet and the Mediterranean Diet With All-Cause Mortality in Subjects With Various Glucose Regulation States. *Front. Nutr.* **2022**, *9*, 828792. [CrossRef] [PubMed] [PubMed Central]
11. Christensen, C.; Knudsen, A.; Arnesen, E.K.; Hatlebakk, J.G.; Sletten, I.S.; Fadnes, L.T. Diet, Food, and Nutritional Exposures and Inflammatory Bowel Disease or Progression of Disease: An Umbrella Review. *Adv. Nutr.* **2024**, *15*, 100219. [CrossRef] [PubMed] [PubMed Central]
12. Petagna, L.; Antonelli, A.; Ganini, C.; Bellato, V.; Campanelli, M.; Divizia, A.; Efrati, C.; Franceschilli, M.; Guida, A.M.; Ingallinella, S.; et al. Pathophysiology of Crohn's disease inflammation and recurrence. *Biol. Direct* **2020**, *15*, 23. [CrossRef] [PubMed] [PubMed Central]
13. Velho, S.; Morão, B.; Gouveia, C.; Agostinho, L.; Torres, J.; Maio, R.; Baracos, V.E.; Cravo, M. Body composition and Crohn's disease behavior: Is adiposity the main game changer? *Nutrition* **2023**, *108*, 111959. [CrossRef] [PubMed]
14. Balestrieri, P.; Ribolsi, M.; Guarino, M.P.L.; Emerenziani, S.; Altomare, A.; Cicala, M. Nutritional Aspects in Inflammatory Bowel Diseases. *Nutrients* **2020**, *12*, 372. [CrossRef] [PubMed] [PubMed Central]
15. Wei, H.; Yuan, Z.; Ren, K.; Jin, Y.; Ren, L.; Cao, B.; Zhou, Y.; Chen, L. Body Composition in Inflammatory Bowel Disease. *Arch. Iran. Med.* **2023**, *26*, 172–175. [CrossRef] [PubMed] [PubMed Central]
16. Saleh, O.; Alshwayyat, S.; Hares, M.A.L.; Shalan, S.; Alasmar, D.; Alkurdi, O.; Hanifa, H.; Hajali, M. Evaluating the role of sarcopenia in adverse clinical outcomes for Crohn's disease patients: A systematic review and meta-analysis. *Int. J. Colorectal Dis.* **2025**, *40*, 35. [CrossRef] [PubMed] [PubMed Central]
17. Peng, Z.; Xu, D.; Li, Y.; Peng, Y.; Liu, X. Phase Angle as a Comprehensive Tool for Nutritional Monitoring and Management in Patients with Crohn's Disease. *Nutrients* **2022**, *14*, 2260. [CrossRef] [PubMed] [PubMed Central]
18. Karachaliou, A.; Yannakoulia, M.; Bletsa, M.; Mantzaris, G.J.; Archavlis, E.; Karampekos, G.; Tzouvala, M.; Bamias, G.; Kokkotis, G.; Kontogianni, M.D. Assessment of Dietary Adequacy and Quality in a Sample of Patients with Crohn's Disease. *Nutrients* **2022**, *14*, 5254. [CrossRef] [PubMed] [PubMed Central]
19. Papadimitriou, K.; Detopoulou, P.; Soufleris, K.; Voulgaridou, G.; Tsoumana, D.; Ntopromireskou, P.; Giaginis, C.; Chatziprodromidou, I.P.; Spanoudaki, M.; Papadopoulou, S.K. Nutritional Risk and Sarcopenia Features in Patients with Crohn's Disease: Relation to Body Composition, Physical Performance, Nutritional Questionnaires and Biomarkers. *Nutrients* **2023**, *15*, 3615. [CrossRef] [PubMed]
20. Best, W.R. Predicting the Crohn's disease activity index from the harvey-bradshaw index. *Inflamm. Bowel Dis.* **2006**, *12*, 304–310. [CrossRef] [PubMed]
21. Kaiser, M.J.; Bauer, J.M.; Ramsch, C.; Uter, W.; Guigoz, Y.; Cederholm, T.; Thomas, D.R.; Anthony, P.; Charlton, K.E.; Maggio, M.; et al. Validation of the Mini Nutritional Assessment short-form (MNA-SF): A practical tool for identification of nutritional status. *J. Nutr. Health Aging* **2009**, *13*, 782–788. [CrossRef] [PubMed] [PubMed Central]
22. Mattiello, R.; Amaral, M.A.; Mundstock, E.; Ziegelmann, P.K. Reference values for the phase angle of the electrical bioimpedance: Systematic review and meta-analysis involving more than 250,000 subjects. *Clin. Nutr.* **2020**, *39*, 1411–1417. [CrossRef] [PubMed]
23. Scafoglieri, A.; Clarys, J.P.; Bauer, J.M.; Verlaan, S.; Van Malderen, L.; Vantieghem, S.; Cederholm, T.; Sieber, C.C.; Mets, T.; Bautmans, I.; et al. Predicting appendicular lean and fat mass with bioelectrical impedance analysis in older adults with physical function decline—The PROVIDE study. *Clin. Nutr.* **2017**, *36*, 869–875. [CrossRef] [PubMed]
24. Craig, C.L.; Marshall, A.L.; Sjöström, M.; Bauman, A.E.; Booth, M.L.; Ainsworth, B.E.; Pratt, M.; Ekelund, U.; Yngve, A.; Sallis, J.F.; et al. International physical activity questionnaire: 12-country reliability and validity. *Med. Sci. Sports Exerc.* **2003**, *35*, 1381–1395. [CrossRef] [PubMed]
25. Papathanasiou, G.; Georgoudis, G.; Papandreou, M.; Spyropoulos, P.; Georgakopoulos, D.; Kalfakakou, V.; Evangelou, A. Reliability measures of the short International Physical Activity Questionnaire (IPAQ) in Greek young adults. *Hell. J. Cardiol.* **2009**, *50*, 283–294. [PubMed]

26. Panagiotakos, D.B.; Pitsavos, C.; Stefanadis, C. Dietary patterns: A Mediterranean diet score and its relation to clinical and biological markers of cardiovascular disease risk. *Nutr. Metab. Cardiovasc. Dis.* **2006**, *16*, 559–568. [CrossRef] [PubMed]
27. Tangney, C.C.; Li, H.; Wang, Y.; Barnes, L.; Schneider, J.A.; Bennett, D.A.; Morris, M.C. Relation of DASH- and Mediterranean-like dietary patterns to cognitive decline in older persons. *Neurology* **2014**, *83*, 1410–1416. [CrossRef] [PubMed] [PubMed Central]
28. Epstein, D.E.; Sherwood, A.; Smith, P.J.; Craighead, L.; Caccia, C.; Lin, P.H.; Babyak, M.A.; Johnson, J.J.; Hinderliter, A.; Blumenthal, J.A. Determinants and consequences of adherence to the dietary approaches to stop hypertension diet in African-American and white adults with high blood pressure: Results from the ENCORE trial. *J. Acad. Nutr. Diet.* **2012**, *112*, 1763–1773. [CrossRef] [PubMed] [PubMed Central]
29. Appel, L.J.; Moore, T.J.; Obarzanek, E.; Vollmer, W.M.; Svetkey, L.P.; Sacks, F.M.; Bray, G.A.; Vogt, T.M.; Cutler, J.A.; Windhauser, M.M.; et al. A clinical trial of the effects of dietary patterns on blood pressure. *N. Engl. J. Med.* **1997**, *336*, 1117–1124. [CrossRef] [PubMed]
30. Coelho-Ravagnani, C.d.F.; Lopes, L.C.C.; Godois, A.d.M.; Silva, A.M.; Cordeiro, V.; Dos Santos, A.H.C.; Mota, J.F. Association between phase angle from bioelectrical impedance and dietary intake in athletes: A cross-sectional study. *J. Nutr. Sci.* **2025**, *14*, e38. [CrossRef] [PubMed] [PubMed Central]
31. Soltani, S.; Chitsazi, M.J.; Salehi-Abargouei, A. The effect of dietary approaches to stop hypertension (DASH) on serum inflammatory markers: A systematic review and meta-analysis of randomized trials. *Clin. Nutr.* **2018**, *37*, 542–550. [CrossRef] [PubMed]
32. Papadimitriou, K.; Deligiannidou, G.E.; Voulgaridou, G.; Giaginis, C.; Papadopoulou, S.K. Nutritional Habits in Crohn's Disease Onset and Management. *Nutrients* **2025**, *17*, 559. [CrossRef] [PubMed]
33. Forbes, A.; Escher, J.; Hébuterne, X.; Kłęk, S.; Krznaric, Z.; Schneider, S.; Shamir, R.; Stardelova, K.; Wierdsma, N.; Wiskin, A.E.; et al. ESPEN guideline: Clinical nutrition in inflammatory bowel disease. *Clin. Nutr.* **2017**, *36*, 321–347. [CrossRef] [PubMed]
34. Mosli, M.H.; Zou, G.; Garg, S.K.; Feagan, S.G.; MacDonald, J.K.; Chande, N.; Sandborn, W.J.; Feagan, B.G. C-Reactive Protein, Fecal Calprotectin, and Stool Lactoferrin for Detection of Endoscopic Activity in Symptomatic Inflammatory Bowel Disease Patients: A Systematic Review and Meta-Analysis. *Am. J. Gastroenterol.* **2015**, *110*, 802–819. [CrossRef] [PubMed]
35. Limdi, J.K.; Aggarwal, D.; McLaughlin, J.T. Dietary Practices and Beliefs in Patients with Inflammatory Bowel Disease. *Inflamm. Bowel Dis.* **2016**, *22*, 164–170. [CrossRef] [PubMed]
36. Barrea, L.; Muscogiuri, G.; Macchia, P.E.; Somma, C.D.; Falco, A.; Savanelli, M.C.; Colao, A.; Savastano, S. Mediterranean Diet and Phase Angle in a Sample of Adult Population: Results of a Pilot Study. *Nutrients* **2017**, *9*, 151. [CrossRef] [PubMed]
37. de Luis, D.; Primo, D.; Izaola, O.; Lopez Gomez, J.J. Relationship between Mediterranean Diet and Phase Angle in a Sample of Patients with Obesity and Metabolic Syndrome. *Ann. Nutr. Metab.* **2023**, *79*, 493–501. [CrossRef] [PubMed]
38. Mundstock, E.; Amaral, M.A.; Baptista, R.R.; Sarria, E.E.; Dos Santos, R.R.G.; Filho, A.D.; Rodrigues, C.A.S.; Forte, G.C.; Castro, L.; Padoin, A.V.; et al. Association between phase angle from bioelectrical impedance analysis and level of physical activity: Systematic review and meta-analysis. *Clin. Nutr.* **2019**, *38*, 1504–1510. [CrossRef] [PubMed]
39. Lee, P.H.; Macfarlane, D.J.; Lam, T.H.; Stewart, S.M. Validity of the International Physical Activity Questionnaire Short Form (IPAQ-SF): A systematic review. *Int. J. Behav. Nutr. Phys. Act.* **2011**, *8*, 115. [CrossRef] [PubMed] [PubMed Central]
40. Holtermann, A.; Hansen, J.V.; Burr, H.; Søgaard, K.; Sjøgaard, G. The health paradox of occupational and leisure-time physical activity. *Br. J. Sports Med.* **2012**, *46*, 291–295. [CrossRef] [PubMed]
41. Yang, J.; Yu, J.; Kim, J.; Park, E. Association between Physical Activity and Phase Angle Obtained via Bioelectrical Impedance Analysis in South Korean Adults Stratified by Sex. *Nutrients* **2024**, *16*, 2136. [CrossRef] [PubMed] [PubMed Central]
42. Dhaliwal, A.; Quinlan, J.I.; Overthrow, K.; Greig, C.; Lord, J.M.; Armstrong, M.J.; Cooper, S.C. Sarcopenia in Inflammatory Bowel Disease: A Narrative Overview. *Nutrients* **2021**, *13*, 656. [CrossRef] [PubMed] [PubMed Central]
43. Yao, Q.; Cohen, S.A.; Oaks, B.M.; Vadiveloo, M.K. Brief Diet Screener for Assessing Adherence to the Dietary Approaches to Stop Hypertension (DASH) Diet: Development and Validation. *Curr. Dev. Nutr.* **2025**, *9*, 107593. [CrossRef] [PubMed] [PubMed Central]
44. Kyle, U.G.; Bosaeus, I.; De Lorenzo, A.D.; Deurenberg, P.; Elia, M.; Manuel Gómez, J.; Lilienthal Heitmann, B.; Kent-Smith, L.; Melchior, J.C.; Pirlich, M.; et al. Bioelectrical impedance analysis-part II: Utilization in clinical practice. *Clin. Nutr.* **2004**, *23*, 1430–1453. [CrossRef] [PubMed]

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