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A novel obesity-prevention dietary score is associated with favorable metabolic status and lower blood pressure in obesity

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Abstract

Background Obesity is a major worldwide health problem and is associated with numerous diseases including diabetes, cardiovascular diseases, and some types of cancers. In the current cross-sectional study, we aimed to evaluate the association between a novel dietary obesity prevention score (DOPS) with metabolic parameters including serum lipid profile, glycemic markers, electrolyte status and blood pressure in individuals with obesity.

Methods Three hundred and four individuals with obesity aged 18–65 years old were recruited through convenient sampling; anthropometric and dietary assessments were performed and blood pressure was measured. Biochemical parameters including serum lipids, glycemic markers, some of liver function tests and electrolyte status were measured by standard laboratory methods.

Results Lower adiposity including lower body mass index (BMI) and fat mass and low systolic and diastolic blood pressures were observed at higher tertiles of versus lower tertiles of DOPS ($P < 0.05$). Also, lower low density lipoprotein cholesterol (LDL-c) and higher serum albumin concentrations were observed at higher tertiles of DOPS. There was no significant difference between other parameters across DOPS tertiles.

Conclusion In our study, higher adherence to dietary obesity preventive score reduced obesity risk, blood pressure and serum LDL in individuals with obesity. Future longitudinal and interventional studies are needed to establish causal relationships.

Clinical trial number Not applicable.

Keywords Obesity, Diet, Obesity prevention, Metabolic status, Glycemic markers

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Introduction

Obesity is a global health crisis and its prevalence is escalating at an alarming rate over the past few decades; according to recent statistics, more than 1.9 billion adults worldwide are classified as overweight, and over 650 million are obese [1]. This condition is a significant risk factor for numerous chronic diseases, including cardiovascular diseases, type 2 diabetes, hypertension, and certain types of cancer. Beyond its direct impact on physical health, obesity is also associated with psychological burdens such as depression and anxiety, as well as substantial economic costs for healthcare systems [2, 3].

One of the most influential factors in the development of obesity is diet. Both healthy and unhealthy dietary patterns play crucial roles in determining an individual's risk of becoming obese, making it essential to explore the connection between diet and weight gain; nutrient-rich foods, such as fruits, vegetables, whole grains, lean proteins, and healthy fats, help regulate metabolism and reduce the likelihood of developing obesity and its associated diseases, whereas, an unhealthy diet, often high in processed foods, sugary snacks, refined carbohydrates, and unhealthy fats, can lead to weight gain and contribute significantly to obesity [4–6].

The Dietary Obesity Prevention Score (DOPS) is a tool first suggested by Gomez-Donoso et al. [7] developed to assess the quality of an individual's diet in relation to the prevention of obesity. Scoring of DOPS is based on positive score for healthy food items with weight-reducing effects including fruits, vegetables, legumes, yogurt, nuts, fishes, and vegetable to animal protein ratio and negative score to unhealthy food items with weight-increasing effects including ultra-processed foods, saturated animal fats, sugary beverages, red meat, processed meat, refined grains and beer and spirits; a higher DOPS indicates a diet that aligns more closely with recommendations that support a healthy weight, while a lower score suggests dietary habits that may predispose individuals to weight gain [7, 8]. The number of studies in this filed are very scarce; the first study that focused on its development in 2018, in a Mediterranean cohort of university graduates with overweight and obesity and concluded that after a median follow-up period of 9.3 years, a higher adherence to DOPS was significantly associated with "lower risk of overweight/obesity and lower average annual weight gain" [7]. In the second study by other researchers, the association between DOPS and polycystic ovary syndrome (PCOS) in a case–control study was examined and according to their results, higher DOPS scores were in negative association with inflammatory factors like c-reactive protein, while, there was no association between DOPS and incidence of PCOS [8].

According to literature review, there are very limited number of studies that evaluated the association between DOPS and diseases status and no study is available to evaluate the association between DOPS and metabolic status among individuals with obesity. Therefore, the current status had following hypothesis: first, to measure DOPS in individuals with obesity and to assess its association with anthropometric parameters, and second to assess the association between DOPS and metabolic parameters including serum lipids, glycemic markers, some of liver function tests, electrolyte status and blood pressure among individuals with obesity.

Methods and materials

Subjects and setting

This cross-sectional study recruited 304 participants with obesity aged 18–65 years old through public advertisements, clinical referrals, or community outreach programs in Iraq. Eligibility criteria included a body mass index (BMI) ≥ 30 kg/m^2, stable weight (± 2 kg) over the past three months, and no history of major chronic illnesses (e.g. cardiovascular diseases, diabetes, hypertension, dyslipidemia, cancers, gastrointestinal problems or endocrine disorders) or recent weight-loss treatments. Participants were excluded if they were pregnant, lactating, or taking medications affecting metabolic or cardiovascular health and weight. Written informed consent was obtained from all subjects prior to participation. Data collection took place from June 2023 to July 2024 in a controlled environment. Participants underwent a comprehensive assessment, including anthropometric measurements, dietary intake evaluation, and laboratory tests, supervised by trained professionals.

Sample size calculation

The sample size of 304 participants was determined using G*Power software ensuring adequate statistical power to detect meaningful associations at a 95% confidence level with an expected effect size of 0.3 and a power of 80% ($\beta = 0.2$). The calculation accounted for a potential dropout rate of 10% [7].

Anthropometric assays

Body weight was measured using a calibrated digital scale (Tanita BC-558, accuracy ± 0.1 kg). Height was measured using a stadiometer (Seca 213, accuracy ± 0.5 cm). WC was measured using a flexible, non-stretchable tape (Gulick II Tape Measure). The measurement was taken at the midpoint between the lower rib and the iliac crest and HC was measured at the widest part of the hips, typically around the buttocks, using the same flexible tape. WC and HC were recorded to the nearest 0.5 cm. Fat mass (FM) and fat free mass (FFM) were measured using

bioelectrical impedance analysis (BIA) (Tanita BC-601 body composition monitor).

Dietary assessment and DOPS calculation

Dietary intake was assessed using a validated semi-quantitative Food Frequency Questionnaire (FFQ) designed to evaluate habitual dietary patterns over the past year [9]. The FFQ included 105 food items commonly consumed in the target population. The questionnaire has an acceptable validity and reliability with a strong correlation with the results of food record. Participants reported the frequency of consumption for each food item using standard portion sizes, with response options ranging from "never" to "≥6 times per day." Nutrient and food group intakes were calculated by multiplying the frequency of consumption by portion sizes and nutrient values derived from USDA Food Composition Database or a national database. To enhance data reliability, participants were asked to review their responses during the interview process, and inconsistencies were clarified immediately. Energy intake values outside the plausible range (e.g., < 800 kcal/day or > 4,000 kcal/day for women; < 1,200 kcal/day or > 5,000 kcal/day for men) were excluded. The FFQ was administered by trained dietitians to ensure accuracy and minimize reporting errors. DOPS was calculated based on previous researches [7]. Accordingly, DOPS was a combined score based on foods that were previously reported to be associated with weight changes. DOPS assigned positive weights to the intake of vegetables, fruits, legumes, yogurt, nuts, fish, and the vegetable-to-animal protein ratio. In contrast, the consumption of red meat, processed meat, saturated animal fats, refined grains, ultra-processed foods, sugary beverages, beer, and spirits was assigned negative weights. To calculate the score, the daily intake (g/d) of each of the 14 food groups was adjusted for total energy intake using the residual method, separately for men and women [10]. The energy-adjusted values (residuals) were then ranked into sex-specific tertiles. For food groups associated with an increased risk of weight gain or overweight/obesity, tertile rankings were reversed (assigning a score of 3 to the lowest tertile and 1 to the highest). The DOPS was computed by summing the tertile scores of positively weighted food groups and the reversed tertile scores of negatively weighted groups. The final score ranged from 14 (indicating lowest adherence) to 42 (indicating highest adherence). Adherence to the DOPS was categorized into tertiles. Summary of DOPS components and its calculation is provided in Fig. 1.

Laboratory assessments and blood pressure measurement

Blood samples were collected after a 12 h overnight fast using standard venipuncture techniques. Samples were immediately centrifuged at 3,000 rpm for 10 min and stored at − 80°C until analysis. Serum levels of glucose, total cholesterol (TC), triglycerides (TG), low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), aspartate aminotransferase (AST), alanine aminotransferase (ALT), albumin, creatinine and urea levels were determined using Dimension RXL analyzer (Dade Behring-Dimension RxL -Chemistry Analyzer −64,850; USA). Serum insulin and hemoglobin (Hb) A1C were measured by a microenzyme immunoassay using IMX analyzer (Abbott Diagnostics; GmbH. Max-Planck-Ring 2 65,205 Wiesbaden, Germany). Serum sodium, potassium, calcium and phosphorus levels were analyzed using spectrophotometric assays. Systolic and diastolic blood pressure (SBP and DBP) were measured using a validated automatic blood pressure monitor (Omron HEM-7120, Vietnam), following a 5-min rest period in a seated position. Three measurements were taken at 1-min intervals, and the average of the last two readings was used for analysis. All assays were conducted in a certified laboratory with internal and external quality control procedures to ensure accuracy and precision.

Statistical analysis

Statistics of the current work were performed using SPSS™ statistics version 23.0 (IBM, Armonk, NY, USA). The analysis included biochemical and metabolic risk factors. Discrete variables are presented as absolute values (percentages) and quantitative variables are presented as mean ± standard deviation. The comparison of quantitative and categorical variables across DOPS tertiles were performed by Chi-square test and one way analysis of variance (ANOVA) respectively. One way analysis of covariance (ANCOVA) test was used to compare quantitative variables across DOPS tertile considering adjusting for confounders. Multinomial logistic regression analysis was performed for P-for trend analysis.

Results

General demographic and anthropometric features of study participants are represented in Table 1. As shown in this table, significantly lower BMI and fat mass was observed in those with higher adherence to DOPS ($p < 0.05$). Also, those at the higher tertiles of DOPS were significantly younger than those at the lowest tertiles ($P = 0.035$). No other significant difference was shown for other parameters. The comparison of dietary energy, macronutrients and energy-adjusted food groups is presented in Table 2. Lower dietary energy, carbohydrate, fat, grains, red meat and higher dietary fat, fiber, fruits, vegetables, nuts, beans and dairy products' intake were sown in highest versus lowest DOPS tertile ($P < 0.05$). In comparison of biochemical parameters and blood

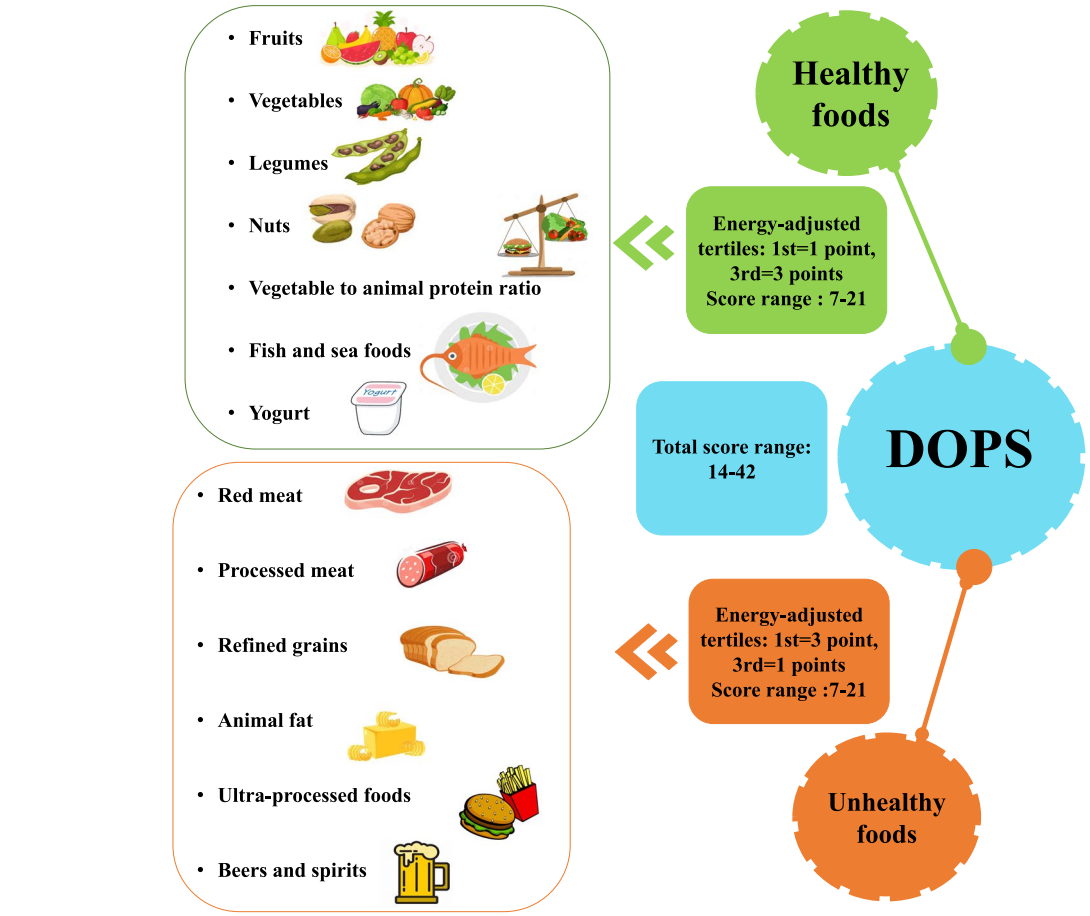

Fig. 1 An illustrative summary of study findings

Table 1 Comparison of general demographic characteristics across DOPS tertiles among study participants

Variable	All participants		DOPS tertiles						*P** Value
	(*N* = 304)		T1 (*n* = 101)		T2 (*n* = 102)		T3 (*n* = 101)		
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Age (y)	39.85	9.74	40.93	9.26	40.54	9.73	37.34	9.94	**0.035**
Sex (% male)	119	39.44	31	30.69	44	43.13	44	43.56	0.980
Weight (kg)	92.68	14.23	95.25	17.73	92.15	12.42	91.13	13.51	0.166
Height (cm)	163.89	13.93	163.52	8.88	163.20	17.27	165.66	9.99	0.445
BMI (kg/m2)	34.33	4.72	35.59	0.67	34.26	4.26	33.20	3.99	**0.007**
WC (cm)	107.40	9.85	108.02	11.42	108.09	8.59	105.39	10.37	0.126
HC (cm)	118.03	12.16	120.11	0.071	117.16	11.80	117.91	13.83	0.272
WHR	0.91	0.095	0.90	0.071	0.92	0.088	0.90	12.21	0.078
FM (%)	36.97	9.97	40.06	10.79	37.23	9.35	34.15	9.47	**0.003**
FFM (%)	57.10	11.81	57.00	10.79	56.90	12.02	57.55	12.47	0.930

Statistically significant values are bolded

DOPS dietary obesity prevention score, *BMI* body mass index, *WC* waist circumference, *WHR* waist to hip ratio, *FM* fat mass, *FFM* fat free mass

* *P* values are obtained from one-way ANOVA

Table 2 Comparison of dietary energy intake and energy-adjusted nutrients and food groups' intake across DOPS tertiles among study participants

Variable	All participants		DOPS tertiles						
	(*N* = 304)		T1 (*n* = 101)		T2 (*n* = 102)		T3 (*n* = 101)		*P** Value
Energy (kcal/d)	2292.46	1011.80	3028.36	1022.20	3058.99	1082.49	2540.25	729.64	**0.001**
Carbohydrate (%)	56.26	9.08	58.90	8.37	56.18	9.82	53.76	7.44	**0.001**
Protein (%)	13.10	2.46	13.44	2.67	12.90	2.45	13.16	2.24	0.292
Fat (%)	30.79	7.13	33.41	6.54	30.60	7.40	19.04	6.44	**< 0.001**
Fiber (g/d)	60.93	40.58	47.52	21.70	61.47	37.75	73.07	54.46	**< 0.001**
Red meat (g/d)	11.18	11.29	31.87	33.89	24.09	25.60	11.18	11.29	**< 0.001**
Vegetables (g/d)	389.67	303.49	308.22	127.09	384.50	347.72	480.31	311.26	**0.002**
Fruits (g/d)	541.15	441.69	347.71	246.02	529.33	376.58	755.50	596.11	**< 0.001**
Dairy (g/d)	361.59	246.47	234.24	14.18	384.11	253.99	442.53	242.97	**< 0.001**
Grains (g/d)	515.03	243.22	504.91	272.44	553.31	251.76	448.20	243.22	**0.008**
Beans (g/d)	59.18	62.78	33.11	32.25	61.66	65.98	79.98	70.39	**< 0.001**
Nuts (g/d)	15.69	28.44	11.64	14.29	14.48	18.14	22.10	48.23	**0.049**

Statistically significant values are bolded

DOPS dietary obesity prevention score

* *P* values are obtained from energy-adjusted one-way ANCOVA

Table 3 Comparison of biochemical characteristics across DOPS tertiles among study participants

Variable	All participants		DOPS tertiles							
	(*N* = 304)		T1 (*n* = 101)		T2 (*n* = 102)		T3 (*n* = 101)		*P** Value	*P*** Value
	Mean	SD	Mean	SD	Mean	SD	Mean	SD		
SBP (mmHg)	118.83	17.14	123.78	16.00	117.21	18.21	114.06	12.60	**0.008**	0.838
DBP (mmHg)	78.27	12.35	81.71	10.99	77.62	13.26	73.12	9.31	**0.003**	**0.043**
Glucose (mg/dl)	97.96	23.94	98.61	20.47	97.63	17.84	96.52	25.51	0.959	0.911
Cholesterol (mg/dl)	186.03	37.89	189.62	36.56	185.98	40.94	182.52	32.61	0.517	**< 0.001**
Triglyceride (mg/dl)	140.73	87.43	146.46	101.78	136.33	79.51	143.80	87.72	0.672	**< 0.001**
HDL(mg/dl)	42.04	11.10	41.55	9.35	42.30	11.61	42.01	11.79	0.891	**< 0.001**
LDL (mg/dl)	117.12	35.81	125.25	32.63	115.73	39.32	114.68	30.00	**0.049**	**< 0.001**
Insulin (mIU/l)	16.11	10.58	16.37	8.68	17.07	10.98	14.15	11.05	0.162	0.346
HbA_1C (%)	5.63	0.89	5.75	0.72	5.58	0.97	5.61	0.89	0.399	0.913
Albumin (g/dl)	3.62	0.85	3.27	0.64	3.74	0.87	3.68	0.88	**0.003**	**0.906**
Creatinine (mg/dl)	4.67	6.67	3.94	3.63	5.32	8.58	4.07	3.97	0.310	0.751
Urea (mg/dl)	71.28	54.36	68.33	47.79	70.64	51.72	75.78	65.80	0.722	0.385
ALT (U/l)	36.77	50.42	36.77	46.83	37.83	71.97	44.50	67.95	0.728	0.605
AST (U/l)	41.49	59.90	39.34	46.83	38.17	53.55	50.25	80.23	0.346	0.684
Calcium (mg/dl)	11.41	46.86	8.36	1.23	14.42	66.35	8.50	1.14	0.542	0.319
Sodium (mmol/l)	138.12	11.57	136.39	16.17	138.34	11.08	139.64	3.93	0.253	0.087
Phosphorous (mmol/l)	4.49	1.79	4.75	1.79	4.29	1.76	4.62	1.85	0.151	0.559
Potassium (mmol/l)	4.32	0.73	4.19	0.66	4.41	0.79	4.26	0.66	0.090	0.543

Statistically significant values are bolded

DOPS dietary obesity prevention score, *SBP* systolic blood pressure, *DBP* diastolic blood pressure, *HDL* high density lipoprotein cholesterol, *LDL* low density lipoprotein cholesterol, *Hb* A_1C hemoglobin A1C, *ALT* alanine aminotransferase, *AST* aspartate aminotransferase

* *P* values are obtained from one-way ANCOVA after adjusting for age, sex, BMI and dietary energy.

***P* for trend analysis obtained from multinomial logistic regression analysis

pressure across tertiles of DOPS (Table 3), lower systolic blood pressure, diastolic blood pressure, LDL and higher albumin were shown in highest versus lowest DOPS tertiles, while no significant difference were shown for other biochemical parameters across DOPS tertiles.

Discussion

In the current cross-sectional study, we found that higher adherence to a dietary obesity prevention score is associated with lower BMI, fat mass, blood pressure and LDL and higher albumin among individuals with obesity. This study is the first one that reported a comprehensive assessment of DOPS and its correlates with anthropometric variables and blood biomarkers including metabolic panel, glycemic status, some of liver function tests and electrolytes status in obesity.

Our findings revealed a significant inverse association between the Dietary Obesity Prevention Score (DOPS) and both BMI and fat mass, underscoring the effectiveness of a dietary pattern that emphasizes healthy food components while limiting unhealthy ones. Similar results were reported by other studies; increased fruits and non-starchy vegetables consumption was associated with reduced BMI and body after 24 years of follow-up among Americans [11]. Fruits, vegetables, and legumes provide an abundant array of nutrients, including essential minerals, vitamins, fiber, and bioactive compounds such as flavonoids, polyphenols, and carotenoids. These substances play a vital role in preventing dietary-related diseases, either independently or synergistically when consumed alongside nuts and other plant-based foods [12]. In another study by Tucker LA et al. dietary legume consumption was a good predictor of percent weight change over the past 10 years, and it was also a significant predictor of BMI and abdominal adiposity among 15,185 U.S. adults [13]. Furthermore, Jull F. and colleagues found that higher consumption of ultra-processed foods was positively linked to increased BMI and fat mass and this association was more pronounced for women [14]. Our findings also align with research by Amlashi MA et al., which highlighted the benefits of a high plant-to-animal protein ratio in promoting lean body mass and reducing fat accumulation [15].

In addition to its association with lower BMI and fat mass, a higher DOPS was significantly linked to reduced blood pressure levels in our study. This finding is consistent with the well-documented cardio-protective effects of a diet rich in plant-based foods such as fruits, vegetables, and legumes, which are abundant in potassium, magnesium, and dietary nitrates; reduced systolic and diastolic blood pressure after intervention of fruits and vegetable consumption was reported in John J study [16]. Also, numerous observational studies are available demonstrating increased fruit and vegetable consumption and significant reductions in systolic and diastolic blood pressure [17, 18]. Similarly, the DASH (Dietary Approaches to Stop Hypertension) trial highlighted the role of plant-based diets in effectively lowering blood pressure, particularly when combined with reduced intake of sodium-rich and processed foods, which DOPS also discourages [19]. Moreover, our study revealed an inverse relationship between DOPS and LDL cholesterol levels, further emphasizing the cardiometabolic benefits of this dietary approach. The high intake of fiber-rich foods such as legumes, nuts, and vegetables—key components of DOPS—has been shown to enhance cholesterol metabolism and lower LDL cholesterol concentrations [20].

Another important finding in our study was the higher albumin levels observed in participants in the highest versus the lowest tertiles of the DOPS. Albumin, a key protein synthesized by the liver, is an important marker of nutritional status and overall metabolic health [21]. Low serum albumin is associated with higher mortality rate in health and disease status [22, 23]. Albumin synthesis in the body requires a balanced diet with adequate intake of high-quality protein sources including (lean meats, fish, poultry, dairy, legumes to provide the necessary amino acids for albumin production. Additionally, consuming a variety of fruits, vegetables, and whole grains ensures a diverse range of vitamins and minerals that support overall health [24]. The positive association between higher DOPS and albumin levels reflects the beneficial effects of a diet rich in nutrient-dense, plant-based foods that are known to support liver function and protein synthesis. Specifically, the higher intake of fruits, vegetables, legumes, and nuts—foods that are high in antioxidants, essential amino acids, and healthy fats—could enhance the body's ability to maintain optimal protein levels [25].

This finding is consistent with previous studies that have highlighted the role of a balanced diet in supporting serum albumin levels and improved its function. In the study by de Mello Vanessa DF et al. withdrawal of red meat from the usual habitual diet reduced albumin excretion from urine and improved its function as fatty acid carrier among patients with type 2 diabetes patients [26]. In contrast, diets high in processed meat and animal fats — components negatively weighted in DOPS — have been associated with lower albumin levels, potentially due to the negative impact on overall metabolic function and increased inflammation; in the study by Mirzababaei A et al. [27], high intake of red and processed meat were significantly associated with higher odds of microalbuminuria, severe albuminuria and higher chance of diabetic nephropathy. Therefore,

the observed association between higher DOPS and elevated albumin levels further supports the idea that a nutrient-rich, balanced diet can contribute to better overall health, including the maintenance of protein homeostasis.

This study has several limitations that should be acknowledged. First, the cross-sectional design prevents the establishment of causality between the obesity-prevention dietary score and metabolic status or blood pressure. Longitudinal or interventional studies are needed to confirm these associations. Second, dietary intake was assessed using self-reported methods, which are subject to recall bias and misreporting, particularly among individuals with obesity. Third, although we adjusted for several potential confounders, residual confounding due to unmeasured lifestyle factors, such as stress, or genetic predisposition, cannot be ruled out. Additionally, the study population consisted of specific demographic groups, which may limit the generalizability of our findings to other populations with different dietary habits and lifestyle patterns.

Collectively, our study provides novel evidence that higher adherence to dietary obesity preventive items is associated with lower obesity and adiposity risk and a more favorable metabolic profile, characterized by lower blood pressure, reduced LDL cholesterol levels, and higher serum albumin concentrations. Due to the limited number of studies in this field, we recommend further research to further investigate the potential health benefits of DOPS and its potential role in the prevention and management of metabolic disorders, including metabolic syndrome, diabetes, cardiovascular disease, and certain cancers.

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Authors' contributions
AAMAE wrote the first draft of manuscript, was involved in data analysis and hypothesis generation, MJ, HSA, MK and YFM were involved in data collection, patients' recruitment, hypothesis generation and analysis; MAMA was involved in funding acquisition, study support and hypothesis generation and proposal approving; HSA and MAMA were also involved in supervision, and study supporting. MAMA was also involved in revision. All of the authors read and approved the final version of article for submission and after revision and part of data analysis.

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Data availability
The datasets of the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
Written informed consent was obtained from all of the participants. The protocol of the current study was performed in accordance with the Declaration of Helsinki standards. The study protocol was approved by ethics committee of Al-Maarif University (code: 5/125–814).

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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