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Association of Lifelines Diet Score (LLDS) with type 2 diabetes mellites and hypertension: a cross-sectional study

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Abstract

Background and objective: Type 2 diabetes mellitus (T2DM) and hypertension are prevalent chronic conditions associated with significant health burdens. Diet plays a critical role in the development and management of both diseases. This cross-sectional study aimed to investigate the association between Lifelines Diet Score (LLDS) and the risk of type 2 diabetes mellitus (T2DM) and hypertension.

Methods: A cross sectional study was conducted according to a single protocol and at a single site, from February 2023 to March and completed a food frequency questionnaire (FFQ) to calculate their LLDS. T2DM and hypertension status were determined through medical records and participant interviews. Statistical analyses were conducted to examine the association between LLDS and the prevalence of T2DM and hypertension, adjusting for potential confounders.

Results: A total of 411 participants were included in the study. Participants in higher LLDS tertiles exhibited significantly lower risks of T2DM and hypertension compared to those in lower tertiles. In the crude model, the second tertile showed a 40% lower risk of T2DM, while the third tertile had a 45% lower risk ($P < 0.001$). Similar patterns were observed for hypertension, with the second tertile showing a 16% lower risk ($P < 0.001$) and the third tertile exhibiting a 38% lower risk ($P < 0.001$). These associations remained significant after adjusting for cofounder factors (age, energy intakes, carbohydrate, protein, fat, physical activity, and BMI).

Conclusions: The findings of this cross-sectional study suggest that adherence to a healthier dietary pattern, as indicated by higher LLDS scores, is associated with a reduced risk of T2DM and hypertension. These results highlight the importance of overall diet quality in the prevention and management of T2DM and hypertension.

Keywords: Lifelines Diet Score, LLDS, type 2 diabetes mellitus, hypertension, cross-sectional study

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Introduction

Type 2 diabetes mellitus (T2DM) and hypertension are two prevalent chronic conditions with substantial health and socioeconomic implications worldwide (1). A well-known side effect of diabetes mellitus (DM) is hypertension (HTN), while diabetes is a well-known side effect of hypertension (2). Diabetes patients can have high blood pressure as well, and 40-60% of diabetes cases have high blood pressure (3). Nearly 1.4 million Iraqis suffer from diabetes (4). And the prevalence of hypertension in Erbil City was 54.7% in 2020 (5). Lifestyle factors, including diet, have been identified as important modifiable risk factors for the development and management of both diseases.

The Lifelines Diet Score (LLDS) has been proposed as a measure of diet quality (6). This score was derived using the 2015 Dutch dietary guidelines, which are based on scientific data and comprehensive investigations on the association between foods and dietary patterns and chronic illnesses. (6, 7). This dietary score includes nine healthy food groups, including fruits, legumes, whole grain products, nuts, vegetables, oils, fish, soft margarine, unsweetened dairy, tea, and coffee, and three unhealthy food groups, including sugar-sweetened beverages, processed and red meat, butter and hard margarine (6, 7).

Our knowledge indicates that no research has been done so far to examine the relationship between LLDS and the risk of hypertension and diabetes mellitus; however, three studies have looked at the connection between this score and sleep quality in obese people, another study has looked for a link between LLDS and breast cancer, and a third study has looked at the relationship between the Lifelines Diet Score and the risk factors of metabolic syndrome in overweight and obese adults (8-10). Higher scores, according to the findings of the three researches, enhance obese people's sleep quality and lower their risk of breast cancer and metabolic syndrome (8-10).

Therefore, this cross-sectional study aims to examine the association between LLDS and the prevalence of T2DM and hypertension. By evaluating overall diet quality, we aim to determine whether adherence to a healthier dietary pattern, as indicated by higher LLDS scores, is associated with a lower risk of T2DM and hypertension.

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Methods

This cross-sectional study was conducted according to a single protocol and at a single site, from February 2023 to March. Approval for the study protocol was obtained from the Ethics Committee of Garmian Polytechnic University, Kalar Technical College (NO: KTC20230820). Verbal informed consent was obtained from all participants, and the consent process was documented in their medical records.

The study included a total of 420 Kurdish adults aged between 45 and 63 years. Pregnant women and individuals with known chronic diseases that could significantly impact dietary patterns, such as gastrointestinal disorders, renal dysfunction, or eating disorders, were excluded based on the study's design. Ultimately, the final population analyzed consisted of 411 adults. The study team, comprising a physician, lab technicians, an executive supervisor, and a receptionist, collected demographic information from the participants. This information included details regarding education level, gender, age, place of residence, marital status, socioeconomic standing (SES), cigarette smoking status, dietary intake, and levels of physical activity (PA). The levels of physical activity were categorized as very low (600 MET-min/week), low (600-3000 MET-min/week), and moderate to high (> 3000 MET-min/week). In addition to demographic information, primary data on other relevant variables were also collected (11), both the composition of the body and measurement of anthropometric characteristics.

Blood sampling and biochemical assays

Following an overnight fasting period of 8-12 hours, a total of 7 mL of blood was collected from each participant using clot tubes. The collected blood samples were then subjected to centrifugation at 4°C for 10-15 minutes to separate the serum. The resulting serum samples were carefully stored at -80°C until further analysis. For bioanalysis, commercially available assays were utilized to measure the concentrations of various lipid parameters, including triglycerides (TG), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), and total cholesterol. The measurements were performed according to the guidelines provided by the respective assay manufacturers to ensure accuracy and standardization of the results.

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Dietary assessment

The Food Frequency Questionnaire (FFQ), a 168-item questionnaire, was found to be reliable and accurate (12)This was provided in person by qualified nutritionists and includes a shopping list and the typical serving size for each meal item. Participants gave their daily, weekly, monthly, and yearly consumption rates for each beverage. The amount of food consumed was computed using a customized version of the NUTRITIONIST IV program for Kurdish cuisine (version 7.0; N-Squared Computing, Salem, OR, USA) and translated to grams using home measurements (13).

Lifelines Diet Score

The LLDS is a technique for rating persons based on the relative quality of their diet, derived using the Vinke et al. approach (6). This nutritional benefit is detailed in further detail elsewhere (6, 8). In summary, based on the Dutch diet guidelines in 2015, whichis entirely predicated on scientific evidence, LLDS includes a diet consisting of nine food groups that have been proven to have positive effects on health, including fruit, legumes and nuts, vegetables, whole grain products, oils and soft margarine, Fish, unsweetened dairy, tea and coffee and three food groups that include Processed and red meat, hard margarine, butter,and sugar-sweetened beverages. Each person's food intake was listed in grams per 1000 kcal. Intake was divided into 1 to 5 quintiles for each food group, with 5 points awarded for maximum intake and 1 point for minimum intake for positive food groups, 5 points for lowest intake, and 1 point for minimum intake for negative food groups. Last but not least, the LLDS score, which varies from 12 to 60, is calculated by adding the scores from the 12 components (6, 8).

Hypertension and type 2 diabetes mellitus assessment

HTN was defined as having a systolic blood pressure (SBP) of 140mmHg or a diastolic blood pressure (DBP) of 90mmHg or being on antihypertensive medication (14, 15). T2DM was defined as having an FBS (fasting blood sugar) of ≥126mg/dl, being on diabetic medication, or having diabetes validated by a health professional (16).

Statistical analysis

For quantitative data, the mean standard deviation was used; for qualitative factors, LLDS tertiles were used to calculate frequency (%). Additionally, the one-way analysis of variance (ANOVA) was used to

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evaluate significant variations in mean in constant variables across LLDS tertiles (T1:≤30, T2: 31–39, T3≥40). The Chi-square test was used to evaluate significant differences in categorical variables as well among LLDS tertiles. The mean standard deviation of anthropometric and biochemical characteristics for each of the four groups studied (Healthy, T2DM, HTN, and HTN) was also assessed using one-way ANOVA. Using simple and adjusted logistic regression models (adjusted for potential confounders such as age, BMI, WHR, carbohydrate (%E), protein (%E), oil/fat (%E), and physical activity), the relationship between LLDS, hypertension, and T2DM was investigated. The 95% confidence intervals and the crude and adjusted odds ratios were shown. P values of 0.05 were considered noteworthy. All analyses were conducted using SPSS version 25.0 (Statistical Package for the Social Sciences).

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Results

Table 1 presents the baseline characteristics of the study participants grouped according to LLDS Tertiles. Notably, participants in the first tertile exhibited a significantly higher average age compared to those in the second and third tertiles ($P < 0.001$). A substantial portion of the respondents, specifically 139 individuals (33.8%), reported a high socioeconomic status. Among the 411 participants, 136 were found to be free from any diseases and classified as healthy, whereas 59 were diagnosed with both Type 2 Diabetes (T2DM) and Hypertension (HTN), 120 had T2DM alone, and 96 had HTN alone ($P < 0.001$).Regarding Body Mass Index (BMI) measured in kg/m^2, it is worth noting that participants in tertile 1 exhibited a notably higher mean BMI (27.58 ± 2.06) in comparison to those in tertile 3 (23.75 ± 2.62) ($P < 0.001$). Furthermore, LDL-C levels were markedly elevated among participants in the first tertile compared to those in the second and third tertiles ($P < 0.001$).

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Table 1. Baseline characteristics of the participants according to LLDS Tertiles (N = 411)

Variables	Total	Tertiles *of LLDS*			P value
		T1 (Score ≤30)	T2 (Score 31-39)	T3 (Score ≥40)	
Subjects, n	**411**	**85**	**119**	**207**	
Age (years)	55.27±4.21	57.67±4.19	54.71±3.28	54.61±4.55	<0.001
Gender					
Male	206(50.01)	44(10.7)	55(13.4)	107(26.0)	0.817
Female	205(49.9)	41(10.0)	64(15.6)	100(24.3)	
Residency, n (%)					
Urban	201(48.9)	46(11.2)	58(14.1)	97(23.6)	0.529
Rural	210(51.1)	39(9.5)	61(14.8)	110(26.8)	
Education, n (%)					
Under Diploma	132(32.1)	27(6.6)	42(10.2)	63(15.3)	0.576
Diploma	130(31.6)	24(5.8)	41(10.0)	65(15.8)	
Above diploma	149(36.3)				
Marital status, n (%)					
Married	128(31.1)	30(7.3)	35(8.5)	63(15.3)	0.851
Single	142(34.5)	27(6.6)	40(9.7)	75(18.2)	
Divorced and other	141(34.3)	28(6.8)	44(10.7)	69(16.8)	
Socio-economic status, n (%)					
1(lowest)	129(31.4)	20(4.9)	37(9.0)	72(17.5)	0.239
2	143(34.8)	32(7.8)	37(9.0)	74(18.0)	
3(Highest)	139(33.8)	33(8.0)	45(10.9)	61(14.8)	
Physical activity (Met h/day)					
Low	77(18.7)	25(6.1)	35(8.5)	17(4.1)	<0.001
Moderate	122(29.7)	50(12.2)	56(13.6)	16(3.9)	
High	212(51.6)	10(2.4)	28(6.8)	174(42.3)	
T2DM and HTN status, n(%)					
Healthy	136(33.1)	3(0.7)	24(5.8)	109(26.5)	<0.001
T2DM and HTN	59(14.4)	6(1.5)	34(8.3)	19(4.6)	
T2DM	120(29.2)	44(10.7)	37(9.0)	39(9.5)	
HTN	96(23.4)	32(7.8)	25(5.8)	40(9.7)	
BMI (kg/m^2)	25.26±3.01	27.58±2.06	26.22±2.73	23.75±2.62	<0.001
WHR	0.94±0.41	0.94±0.39	0.95±0.41	0.94±0.40	0.049
TG (mg/dl)	135.86±45.92	145.89±45.61	135.89±46.58	131.72±45.25	0.057
T-C (mg/dl)	181.07±24.27	185.06±23.65	182.39±23.21	178±24.91	0.097
LDL-C (mg/dl)	115.90±3.51	120.34±1.98	115.79±2.29	114.13±2.92	<0.001
HDL-C (mg/dl)	53.01±13.09	39.62±5.10	46.43±6.08	62.26±11.15	<0.001

Data are shown mean ± SD for continuous variables and n (%) categorical variables.
P- value was obtained one-way ANOVA and Chi-square test
Abbreviation: BMI: Body mass index, HDL-C: High-density lipoprotein cholesterol, LDL-C: Low-density lipoprotein cholesterol, TG: Triglycerides, T-C: Total cholesterol, WHR :waist-hip ratio
*the association was statically significant

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Table 2 presents the dietary intakes of the study participants categorized into tertiles based on the Lifelines Diet Score (LLDS). The analysis reveals significant differences in the consumption of various food groups among the tertiles. Participants in the third LLDS tertile demonstrated significantly higher consumption of vegetables, fruits, whole grain products, nuts, fish, oils and soft margarine, unsweetened dairy, coffee, and tea compared to those in the second and first tertiles ($P < 0.001$). These food groups, which contribute to a healthier dietary pattern, were found to be more prevalent in participants with higher LLDS scores. Conversely, the consumption of negative food groups, including red and processed meat, butter and hard margarine, sugar, and sweetened beverages, was higher among participants in the first tertile compared to the second and third tertiles ($P < 0.001$). These findings indicate that individuals with lower LLDS scores tend to have higher consumption of less healthy food choices. Regarding macronutrient intake, participants in the third tertile had higher energy, carbohydrate, and protein intake compared to those in the second and first tertiles ($P < 0.001$). However, the first tertile demonstrated higher total fat intake compared to the second and third tertiles ($P < 0.001$).

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Table 2. Dietary intakes of study subjects according to tertiles of the LLDS Tertiles (N = 411)

Variables	Total	Tertiles *of LLDS*			P value
		T1 (Score ≤30)	T2 (Score 31-39)	T3 (Score ≥40)	
Subjects, n	**411**	**85**	**119**	**207**	
Positive Food groups					
Vegetables (g/d)	493.47±168.73	392.76±137.52	424.54±145.30	574.45±152.77	<0.001
Fruits (g/d)	572.41±226.50	500.55±162.81	475.71±182.96	657.51±239.41	<0.001
Whole grain products	426.31±145.27	383.95±89.13	386.56±95.91	466.57±173.82	<0.001
Legumes and Nuts (g/d)	74.72±34.78	49.29±18.89	54.16±17.22	96.98±33.15	<0.001
Fish	12.21±7.24	7.91±3.24	8.13±3.75	16.33±7.96	<0.001
Oils and soft margarines	17.35±8.87	13.83±6.85	15.48±7.21	19.88±9.71	<0.001
Unsweetened dairy	373.99±154.57	291.84±115.83	312.69±123.49	442.97±153.66	<0.001
Coffee	39.34±27.01	18.43±8.92	26.65±11.18	55.21±28.67	<0.001
Tea	696.271±292.03	516.83±208.39	674.80±222.96	782.294±320.25	<0.001
Negative food groups					
Red and processed meat	33.05±15.28	45.98±16.23	36.27±13. ±57	26.04±11.34	<0.001
Butter and hard margarines	10.18±6.47	20.39±5.21	10.34±3.13	5.90±2.31	<0.001
Sugar-sweetened beverages	13.28±7.22	23.39±6.69	12.78±4.38	9.43±4.17	<0.001
Macronutrients					
Energy (kcal)	2502±341	2405±306	2444±332	2575±341	<0.001
Carbohydrates (g/d)	373.80±66.81	365.94±62.64	359.41±68.83	385.31±65.63	<0.001
Total Fat (g/d)	109.21±20.22	129.01±23.04	109.78±16.59	100.72±14.27	<0.001
Protein (g/d)	75.09±12.17	67.78±10.02	71.67±11.24	80.05±11.32	<0.001

Data are shown mean ± SD for continuous variables

P- value was obtained one-way ANOVA

*the association was statically significant

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Table 3 presents the anthropometric and biochemical characteristics of the study participants. A comparison of these characteristics among different participant groups reveals several significant findings.The mean age of healthy participants without any disease is significantly lower (54.60 ± 4.55) compared to participants with diabetes and hypertension (P<0.001). Similarly, the body mass index (BMI) of healthy participants without any disease is significantly lower (23.78 ± 2.64) compared to participants with diabetes and hypertension (P < 0.001). In terms of lipid profiles, participants with hypertension (HTN) exhibit higher levels of LDL-C and TG ratios compared to the other groups of participants (P<0.001).

Table 3. Anthropometric and biochemical characteristics of participant

Variables	Healthy (n=136)	T2DM&HTN (n=59)	T2DM (n=120)	HTN (n=96)	P value*
Parameters					
Age (year)	54.60±4.55	54.70±3.27	57.89±4.20	57.23±4.13	<0.001
BMI (kg/m^2)	23.78±2.64	26.19±2.73	27.43±2.05	27.63±2.22	<0.001
WHR	0.94±0.04	0.95±0.04	0.94±0.04	0.93±0.03	0.127
TG (mg/dl)	131.56±45.09	135.43±46.45	146.06±44.61	147.12±48.02	0.086
HDL-C (mg/dl)	62.17±11.16	46.40±6.04	40.12±7.01	40.11±5.24	<0.001
LDL-C (mg/dl)	114.16±2.92	115.78±2.29	120.01±2.41	120.31±2.08	<0.001
T-C (mg/dl)	178.48±25.06	182.34±22.91	186.03±23.24	184.82±24.03	0.129
Energy intake (kcal/d)	2572±342	2445±334	2392±320	2434±308	<0.001
Carbohydrate (%E)	387.72±66.03	361.11±68.89	366.63±61.85	362.62±64.02	<0.001
Protein (%E)	79.91±11.27	71.81±11.32	68.09±10.88	68.08±10.02	<0.001
Oil/Fat (%E)	100.91±14.21	109.57±16.74	129.86±24.02	126.11±22.61	<0.001
Data are shown mean ± SD for continuous variables, P- value was obtained one-way ANOVA *the association was statically significant					

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Table 4 displays the multivariate-adjusted means for hypertension (HTN) and diabetes mellitus (DM) according to the tertiles of the Lifelines Diet Score (LLDS). The association between LLDS tertiles and the risk of developing HTN and DM was assessed using three models: a crude model, a second model adjusting for age and energy intake, and a third model incorporating age, energy intake, carbohydrate, protein, fat, physical activity, and BMI.

Table 4 The multivariate-adjusted means for HTN and DM according to tertiles (T) of the LLDS

		Odds ratio (95% CI)			P value
		T1	T2	T3	
Hypertension	Model I	1	0.84 (0.51 - 0.94)	0.62 (0.34 - 0.88)	<0.001
	Model II	1	0.78 (0.51 – 0.93)	0.58 (0.33 – 0.86)	<0.001
	Model III	1	0.73 (0.42 – 0.80)	0.42 (0.25 – 0.72)	<0.001
Diabetic mellitus	Model I	1	0.60 (0.33 – 0.91)	0.55 (0.36 – 0.62)	<0.001
	Model II	1	0.65 (0.41 – 0.92)	0.57 (0.31 – 0.73)	<0.001
	Model III	1	0.77 (0.41- 0.94)	0.62 (0.35 – 0.89)	<0.001

Model I: Crude
Model II: adjusted for age and energy intake
Model III: adjusted for age, energy intake, Carbohydrate, Protein, Fat, physical activity, and BMI.

P value <0.05 obtained by binary logistic regression.
*The association was statically significant

In the crude model, participants in the second LLDS tertile had a 16% lower likelihood of developing HTN compared to those in the first tertile (OR = 0.84, 95% CI = 0.51 - 0.94, P < 0.001). Moreover, participants in the third tertile exhibited a 38% reduced risk of HTN compared to the first and second tertiles (OR = 0.62, 95% CI = 0.34 - 0.88, P < 0.001). After adjusting for age and energy intake in the second model, as well as additional factors including carbohydrate, protein, fat, physical

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activity, and BMI in the third model, the association remained significant (P < 0.001).

Regarding DM, in the crude model, participants in the second LLDS tertile had a 40% lower risk of developing DM compared to those in the first tertile (OR = 0.60, 95% CI = 0.33 - 0.91, P < 0.001). Similarly, participants in the third tertile exhibited a 45% lower risk of DM (OR = 0.55, 95% CI = 0.36 - 0.62, P < 0.001). These associations remained significant even after adjusting for age, energy intake, carbohydrate, protein, fat, physical activity, and BMI in the second and third models (P < 0.001).

Discussion

In our present investigation, we explored the associations between Type 2 Diabetes Mellitus (T2DM) and Hypertension (HTN) and adherence to the Kurdish adult population's Low-Longevity-Disease Score (LLDS). Our study revealed a robust correlation between LLDS adherence and both T2DM and HTN within our participant sample. Furthermore, as LLDS adherence increased, we observed substantial trends indicating heightened probabilities of developing T2DM and HTN. Notably, our findings indicated a positive relationship between LLDS adherence and T2DM risk, with participants in the third tertile demonstrating a 45% reduced risk of developing T2DM (OR = 0.55).In line with our research, Vinke et al. conducted a study examining the relationship between LLDS and the risk of Type 2 Diabetes. Their study results indicated that LLDS adherence can decrease the risk of developing Type 2 Diabetes within the Dutch Lifelines cohort(17). Furthermore, a similar study was undertaken by Khani et al. in 2020, involving 278 obese participants. This study also elucidated the same underlying mechanism, illustrating a positive association between higher LLDS scores and improved sleep quality (8).

As previously introduced, the LLDS was regarded as an indicator of relative diet quality in accordance with the Dutch Dietary Guidelines. It was observed that adherence to the LLDS led to an enhancement in diet quality(6). Prior research has demonstrated the connection between healthy dietary patterns and the risk of developing Type 2 Diabetes (DM). Although limited studies have explored the relationship between the Healthy Eating Index (HEI) and DM, it is plausible that a high HEI score could be linked to a reduced risk of developing DM(18). In a meta-analysis encompassing

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eight cohort studies involving a combined total of 122,810 participants, it was revealed that stronger adherence to the Mediterranean diet was associated with a 19% reduction in the risk of Type 2 Diabetes (T2D). This finding underscores the enduring protective impact of the Mediterranean diet over the long term(19). Furthermore, in a separate meta-analysis study conducted by Koloverou et al., it was observed that individuals who achieved either maximum or minimum adherence to the Mediterranean diet questionnaire experienced a noteworthy 23% reduction in the risk of developing Type 2 Diabetes (T2D).

Although our study unveiled a positive association between LLDS and Hypertension (HTN), our findings indicated that participants in the third tertile had a 38% lower risk of developing hypertension compared to those in the first and second tertiles (OR = 0.62). Notably, no prior studies have explored the relationship between LLDS and HTN, making it challenging to compare our results with existing research. Nonetheless, previous studies have established a connection between adhering to a healthy dietary pattern and the risk of developing HTN.

An informative prospective Spanish cohort study examined the link between adherence to the Mediterranean diet and the incidence of hypertension within a population of 9,408 individuals, including both men and women. This study revealed that adherence to the Mediterranean diet was associated with modest changes in mean Systolic Blood Pressure (SBP) and Diastolic Blood Pressure (DBP) levels after six years of follow-up, suggesting that adhering to the Mediterranean diet may aid in preventing age-related fluctuations in blood pressure(20).

Although previous research has highlighted the association between healthy dietary patterns and the risk of Type 2 Diabetes (DM) and Hypertension (HTN), it is important to acknowledge that our study focuses on the Low-Longevity-Disease Score (LLDS) as introduced in the earlier sections. Consequently, the differences between these indices and LLDS may limit the direct applicability of those prior findings to our study.

In another study conducted by Fateh et al. in 2022, they explored the connection between total antioxidant capacity and Hypertension (HTN) in post-menopausal Kurdish participants. Their findings revealed a positive

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association between a higher inflammatory score and the presence of HTN (21).

In this context, our findings presented in Table 2 indicate that individuals in the highest tertile of LLDS exhibited a greater consumption of fruits and vegetables while consuming less red and processed meat compared to those in the lowest tertile. It is noteworthy that low consumption of fruits and vegetables ranks among the top five risk factors for chronic diseases, alongside low intake of whole grains, excessive salt consumption, and inadequate consumption of nuts and seeds. Fruits, berries, and vegetables are rich sources of fiber, antioxidants, folates, minerals, vitamins, bioactive phytochemicals, carotenoids, and polyphenolic compounds, all of which may offer beneficial effects on glucose metabolism (22, 23).

This study boasts several notable strengths that contribute to its significance. To the best of our knowledge, it stands as the pioneering investigation delving into the intricate connection between LLDS and the risk of developing Type 2 Diabetes (DM) and Hypertension (HTN) in a population of Kurdish adults. What sets this study apart is the utilization of a proficient team of professional staff who conducted interviews and meticulously collected data through comprehensive food frequency questionnaires. This hands-on approach ensures the reliability and accuracy of the dietary information gathered.

Furthermore, the study benefits from a robust and adequate sample size, which is essential for drawing meaningful conclusions and statistical relevance. We made concerted efforts to minimize potential confounding factors, enhancing the precision and validity of our findings. This meticulous attention to detail in controlling for confounders strengthens the reliability of the observed associations between LLDS, DM, and HTN.

Conclusion

Following a diet rich in LLDS was associated with a reduced likelihood of developing Type 2 Diabetes (T2DM) and Hypertension (HTN) in Kurdish adult participants. Although our study introduced a novel perspective, its reliance on a cross-sectional methodology imposed certain limitations. To obtain a more comprehensive understanding of these relationships, it is recommended that future research employs prospective studies in this domain to facilitate a more comprehensive assessment of the factors at play.

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Declarations

Ethics approval and consent to participate

The Ethics Committee of Garmian polytechnic university, Kalar technical college approved the study. The procedure for obtaining informed consent was approved by the Ethics Committee of Sulaimani polytechnic university, Kalar technical college(NO: KTC20230820). All methods were carried out by relevant guidelines and regulations. *This study was conducted by the Declaration of Helsinki.*

Availability of data and materials

The data analyzed in the study are available from the corresponding author upon reasonable request.

Competing interests

The authors declare no conflicts of interest.

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