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# Mediterranean diet and hypertension: relationship between adherence to a Mediterranean diet and arterial hypertension

Mario Daidone<sup>1,2</sup>, Tiziana Di Chiara<sup>1,2</sup>, Alessandro Del Cuore<sup>2</sup>, Alessandra Casuccio<sup>1,2</sup>, Giovanni Salamone<sup>1,2</sup>, Domenico Di Raimondo<sup>1,2</sup> and Antonino Tuttolomondo<sup>1,2\*</sup>

## Abstract

**Background and aims** No study has examined the relationship between the presence of hypertension and the Mediterranean diet (MeDi) concerning other cardiometabolic risk factors.

We conducted a retrospective study to evaluate the presence of lower adherence to the Mediterranean diet in hypertensive subjects and analyze the correlation between adherence to the Mediterranean Diet and other cardiovascular risk factors.

**Materials and methods** We analyzed the records and collected the data of the patients admitted to our Internal Medicine ward from 2010 to 2020 with a discharge diagnosis of metabolic syndrome according to the NCEP ATP-III criteria. We divided patients in two groups: hypertensive and no hypertensive. The Mediterranean Diet Score was used to evaluate the consumption and frequency of the foods characterizing a Mediterranean-type diet.

**Results** Hypertensive patients were older ( $73 \pm 11.5$  vs.  $57.2 \pm 5.7$ ;  $p < 0.0005$ ) and had a higher mean BMI ( $29.9 \pm 5.2$  vs.  $25 \pm 2.4$ ,  $p < 0.0005$ ) compared to control group. The degree of adherence to the Mediterranean diet, evaluated by the Mediterranean diet score (MDS), was significantly higher in the control group than in the hypertensive group ( $3.8 \pm 1.6$  vs  $6.9 \pm 1.5$ ;  $p < 0.0005$ ). Various comorbidities were more prevalent in hypertensives, such as type 2 diabetes mellitus, heart failure, ischemic heart disease, and chronic renal failure. Lower adherence to the Mediterranean diet was significantly associated with an increased prevalence of dyslipidemia, cardiovascular diseases, chronic renal insufficiency, and PAD/carotid atherosclerosis, and significantly worse lipid profiles.

**Conclusion** Our findings show that a lower adherence to a Mediterranean Diet Style is associated with a worse cardiovascular risk factor profile in hypertensive patients.

Thus, Mediterranean diet adherence in hypertensive subjects is associated with a wider cardiometabolic scenario.

**Keywords** Hypertension, Mediterranean Diet, Cardiovascular risk, Adherence

\*Correspondence:

Antonino Tuttolomondo  
bruno.tuttolomondo@unipa.it

Full list of author information is available at the end of the article



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## Introduction

Hypertension is the main risk factor for cardiovascular disease (CVD) and all-cause mortality. Some studies have reported that foods that are typical of the Mediterranean diet (MedDiet), such as whole grains, vegetables, fruits, nuts, and extra virgin olive oil, have a favorable effect on the risk of hypertension, whereas foods that are not typical of this dietary pattern, such as red meat, processed meat, and poultry, have an unfavorable effect [1].

A recent review summarized observational and intervention studies, meta-analyses, and systematic reviews that have evaluated the effects of MedDiet on patterns of blood pressure (BP) [2] showing a relationship between low adherence to Mediterranean diet and hypertension. In general, MedDiet has a favorable effect in reducing BP in hypertensive or healthy people, but we do not have enough data to declare how strong this effect is [3, 4].

Many more studies are required to understand fully the BP changes that MedDiet induces.

Several studies have highlighted a direct correlation between adherence to the MedDiet and cardiovascular risk reduction [4–7].

Among the studies that analyzed the association between the Mediterranean diet and hypertension, the Greek EPIC (European Prospective Investigation into Cancer and Nutrition) study included 20,343 non-hypertensive subjects showing that higher rates of adherence to the Mediterranean diet (measured by the MedDiet Score) were associated with reduced incidence of arterial hypertension [8].

A prospective cohort study conducted by the Seguimiento Universidad de Navarra evaluated the evolution of blood pressure values over six years in 9,408 subjects, highlighting that good adherence to the Mediterranean diet (MedDiet) correlated with slight variations in tension values over time, suggesting that the MedDiet may play a role in preventing age-related increases in blood pressure [9]. Another study called the ATTICA study, evaluated 3,042 subjects in Greece, highlighting how subjects with higher tension values showed a low adherence to the Mediterranean diet [10].

Hypertension is a major cardiovascular risk factor and it appears to be strongly suggestive that a higher degree of the relationship between cardiovascular and cerebrovascular events, such as ischemic stroke, congestive heart failure, and intracranial hemorrhage, may be mediated by a more direct interplay between diet and hypertension occurrence [1–5].

In study of our own group we previously reported among subjects who were less adherent to the Mediterranean diet, those with lower MediScores, had strokes that were more frequently caused by thrombosis of the large

arteries compared to lacunar or cardioembolic strokes [11].

Two other studies conducted by our study group showed that in the patients with lower adherence to the MedDiet brain hemorrhages were more frequent and mainly occurring the lobar rather than at the level of the nuclei of the base or capsule and that subjects suffering from heart failure compared to the subjects in the control group [12, 13].

Nevertheless, only a few current studies have analyzed the relationship between hypertension and the degree of adherence to the MedDiet. Moreover, no study has examined the relationship between the presence of hypertension and the Mediterranean diet concerning other cardiometabolic risk factors, such as the other factors comprising the diagnostic criteria of metabolic syndrome. Thus, we conducted a study to address these issues with the scientific hypothesis that low adherence to Mediterranean Diet is associated to hypertension and to other cardiometabolic risk factors strictly associated to hypertension.

## Aims of the study

- The first aim of this study was to evaluate MedDiet adaptation status of patients with high blood pressure/diagnosis of hypertension.
- The second aim was to analyze the correlation between the MDS and cardiovascular risk factors, such as hypercholesterolemia, previous cardiovascular events, blood cholesterol levels, triglyceride levels, blood glucose levels, C-reactive protein (CRP) levels, uricemia, weight, body mass index (BMI), ischemic heart disease, chronic renal failure, and atherosclerosis, in patients with arterial hypertension.
- The third aim was to analyze the relationship between cardiovascular risk factors and the level of adherence to the Mediterranean diet in hypertensive patients.

## Materials and methods

Since 2010, our Internal Medicine ward, which serves Palermo and its district—the most populous city in Sicily, Italy—has administered a validated food frequency questionnaire (FFQ) tailored to the Sicilian population. This FFQ is used to evaluate the nutritional profiles of all consenting patients of our Internal Medicine Ward or their relatives if the patients are unable to respond [14].

## Study design and population

This study involves a retrospective analysis of patient records from 2010 to 2020. We focused on patients who were discharged with a diagnosis of metabolic syndrome

according to the NCEP ATP-III criteria [15]. The cohort consists of 353 patients: 178 diagnosed with arterial hypertension and 175 control patients admitted for reasons other than hypertension or its related conditions (e.g., pneumonia, syncope, trauma, and other infections).

#### Data collection and measurements

Upon admission, comprehensive measurements were taken for each patient, including blood pressure, serum glucose, creatinine, uric acid, cholesterol, triglycerides, ferritin, and CRP levels. Clinical histories and diagnostic imaging techniques such as CT and MRI, along with instrumental examinations including echocardiography, ECG, and ultrasound, were used to identify comorbid conditions. These conditions included type 2 diabetes mellitus, cirrhosis, heart failure, atrial fibrillation, chronic ischemic heart disease, cerebrovascular disease, COPD/OSAS, renal failure (staged according to NFK-DOQI criteria), and atherosclerotic disease (AOCP/carotid atherosclerosis).

Diabetes was defined by the ADA 2007 criteria or previous dietary, oral antidiabetic or insulin treatment before hospital admission [16].

Arterial hypertension was assessed using the ESC/ESH 2007 criteria [17].

Hypercholesterolemia was defined as serum total cholesterol levels  $\geq 5.1$  mmol/L, and hypertriglyceridemia as levels  $\geq 1.7$  mmol/L, following the NCEP-ATP III criteria [18]. Stroke was defined as a clinical presentation of focal neurological signs or symptoms believed to be of vascular origin, persisting for more than 24 h, and confirmed by brain CT and MRI at baseline and follow-up CT after 48–72 h.

#### Mediterranean diet adherence

Adherence to the Mediterranean diet was evaluated using a semi-quantitative food frequency questionnaire (FFQ) adapted for the southern Italian population [14]. The Mediterranean Diet Score, based on guidelines by Trichopoulou et al., was used to assess the frequency and consumption of foods typical of the Mediterranean diet. Scores ranged from 0 to 5 for each food group, with higher scores indicating greater adherence [19].

The key components of the diet included:

- Abundant use of olive oil for cooking and dressing dishes.
- Consumption of  $\geq 2$  daily servings of vegetables (at least one fresh serving in a salad).
- $\geq 2$ –3 daily servings of fresh fruits (including natural juices).
- $\geq 3$  weekly servings of legumes.

$\geq 3$  weekly servings of fish or seafood (at least one serving of fatty fish).

$\geq 1$  weekly serving of nuts or seeds.

Preference for white meats (poultry without skin or rabbit) over red meats or processed meats.

Regular cooking with tomato, garlic, and onion, either with or without other aromatic herbs.

Negative recommendations included limiting or eliminating the consumption of cream, butter, margarine, cold meat, pâté, duck, carbonated or sugared beverages, pastries, industrial bakery products, industrial desserts, French fries or potato chips, and pre-cooked cakes and sweets.

Alcohol consumption was also considered, recommending wine as the primary source, with a maximum of 300 ml per day (1–3 glasses). Optimal alcohol consumption scores were given for less than 300 ml per day, with lower scores for no consumption or consumption exceeding 700 ml per day.

Patients were categorized based on their adherence to the Mediterranean diet, with scores as follows: Low adherence: 0–7 points; Moderate adherence: 8–10 points; High adherence: 11–17 points.

The adherence scores were then correlated with the presence of metabolic syndrome and its individual components.

#### Ethical considerations

The study protocol was approved by the Ethics Committee of Paolo Giaccone University Hospital of Palermo. Due to the retrospective nature of the study, informed consent was not obtained. All methods were carried out in accordance with relevant guidelines and regulations.

#### Statistical analysis

Statistical analysis of quantitative and qualitative data, including descriptive statistics, was performed for all items. Continuous data are expressed as the mean  $\pm$  SD unless otherwise specified. Baseline differences between groups were evaluated by the chi-squared or Fisher's exact test, as appropriate for categorical variables, and by independent Student's t-test for continuous parameters. Spearman correlation analysis was conducted to examine the association between the MDS score and risk factors, and each categorical variable was converted to dummy variables, as appropriate. Univariate analysis of variance (ANOVA) was performed for parametric variables, and post hoc analysis with Tukey's test was used to determine if there were pairwise intragroup differences. Multinomial logistic regression analysis examined the correlation between patient characteristics (independent variables)

and the MDS score (dependent variable) in simple and multiple regression models.

**Results**

We analyzed the data of 178 hypertensive patients and 175 control subjects without hypertension.

The comparison between the demographic variables of the hypertensive and control groups showed that the hypertensive patients were older ( $73 \pm 11.5$  vs.  $57.2 \pm 5.7$ ;  $p < 0.0005$ ) and had a higher mean BMI ( $29.9 \pm 5.2$  vs.  $25 \pm 2.4$ ,  $p < 0.0005$ ) and that the degree of adherence to the Mediterranean diet, evaluated by the Mediterranean diet score, was significantly higher in the control group ( $p < 0.0005$ ) (Table 1).

Hypertensive subjects also showed significantly lower mean GFR values ( $56.8 \pm 30$  vs.  $87.7 \pm 35.1$   $p < 0.0005$ ), higher uric acid (mg/dl) ( $6.9 \pm 6.9$  vs.  $3.9 \pm 1.3$ ;  $p < 0.0005$ ), total cholesterol (mg/dl) ( $159.2 \pm 46.2$  vs.  $145.4 \pm 38.8$ ;  $p = 0.003$ ), LDL (mg/dl) ( $89.7 \pm 34$  vs.  $78.7 \pm 30.6$ ;  $p < 0.0005$ ), and triglyceride values (mg/dl) ( $132.5 \pm 55.3$  vs.  $99.1 \pm 44$ ,  $p < 0.0005$ ) and lower HDL values (mg/dl) ( $41.2 \pm 13.8$  vs.  $45.8 \pm 20.4$ ;  $p = 0.016$ ), as reported in Table 2.

Hypertensive subjects also showed significantly lower mean glomerular filtration rate (GFR) values (ml/min/1.73m<sup>2</sup>) ( $56.8 \pm 30$  vs.  $87.7 \pm 35.1$ ), higher uric acid (mg/dl) ( $6.9 \pm 6.9$  vs.  $3.9 \pm 1.3$ ;  $p < 0.0005$ ), total cholesterol (mg/dl) ( $159.2 \pm 46.2$  vs.  $145.4 \pm 38.8$ ;  $p = 0.003$ ), LDL (mg/dl) ( $89.7 \pm 34$  vs.  $78.7 \pm 30.6$ ;  $p < 0.0005$ ), and triglyceride values (mg/dl) ( $132.5 \pm 55.3$  vs.  $99.1 \pm 44$ ,  $p < 0.0005$ ) and lower HDL values ( $41.2 \pm 13.8$  vs.  $45.8 \pm 20.4$ ;  $p = 0.016$ ), as reported in Table 2.

Considering the comorbidities of hypertensive subjects compared to controls, it was highlighted that various

**Table 2** Laboratory variables in subjects with hypertension vs. Controls

	Subjects with hypertension n = 178)	Controls (n = 175)	
<b>Creatinine (mg/dL) (Mean + -dS</b>	1.6 ± 1.4	1.1 ± 0.9	<b>&lt; 0,0005</b>
<b>GFR (CKD-EPI) (mL/min) (Mean + -dS</b>	56.8 ± 30	87.7 ± 35.1	
<b>Total cholesterol (mg/dL) (Mean + -dS</b>	159.2 ± 46.2	145.4 ± 38.8	<b>0,003</b>
<b>HDL (mg/dL) (mean/dS)</b>	41.2 ± 13.8	45.8 ± 20.4	<b>0.016</b>
<b>LDL (mg/dL) (mean/dS)</b>	89.7 ± 34	78.7 ± 30.6	<b>&lt; 0.005</b>
<b>Triglycerides (mg/dL) (mean/dS)</b>	132.5 ± 55.3	99.1 ± 44	<b>&lt; 0.0005</b>
<b>Uric acid (mg/dL) (mean/dS)</b>	6.9 ± 6.9	3.9 ± 1.3	<b>&lt; 0.0005</b>
<b>Serum iron (mcg/dL) (mean/dS)</b>	53.6 ± 36.6	58.2 ± 17.2	0.140
<b>Ferritin (ng/L) (mean/dS)</b>	259.3 ± 73.8	132.7 ± 99.7	<b>0.026</b>

HDL high-density lipoprotein, LDL low-density lipoprotein

comorbidities were more prevalent among the former group, such as type 2 diabetes mellitus ( $p < 0.0005$ ), heart failure ( $p < 0.0005$ ), ischemic heart disease ( $p < 0.0005$ ), and chronic renal failure ( $p < 0.0005$ ); on the other hand, atrial fibrillation and carotid arteriosclerosis/PAD were more common among the subjects in the control group (Table 3).

Then, to analyze the hypertensive group, we stratified the patients in relation to their adherence to a Mediterranean-type dietary regimen, identifying two groups: a group of subjects who were more adherent to the Mediterranean diet (Mediterranean diet scores of 5–9) and a group of subjects who were less adherent (MDS of 0–4). The analysis of the clinical data of both groups highlighted that a lower adherence to the MDS was significantly associated ( $p < 0.0005$ ) with an increased prevalence of diseases such as dyslipidemia, cardiovascular

**Table 1** Demographic and clinical variables in subjects with hypertension and in control subjects without hypertension

	Subjects with hypertension (n = 178)	Controls (n = 175)	p
<b>Age</b>	73 ± 11,5	57.2 ± 5.7	
<b>Sex (n%)</b>			
Males	85 (47.75)	76 (43.42)	
Females	93 (52.24)	99 (56.57)	
<b>BMI (mean + -dS) (kg/m<sup>2</sup>)</b>	29.9 ± 5,2	25 ± 2.4	<b>&lt; 0,0005</b>
<b>Smoker (n/%)</b>			
Active	118 (66.29)	83 (47.42)	
Ex-smokers	48 (26.96)	59 (33.71)	
Nonsmokers	11 (6.19)	33 (18.85)	
<b>Mediterranean Diet Score (MDS):</b>	3.8 ± 1.6	6.9 ± 1,5	<b>&lt; 0,0005</b>
Low adherence (1–4)	125 (70)	9 (5)	
High adherence (5–9)	53 (30)	166 (95)	
<b>Mediterranean Diet Score (MDS) Mean</b>	3.8 ± 1.6	6.9 ± 1.5	<b>&lt; 0,0005</b>

**Table 3** Prevalence of comorbidities in subjects with hypertension and in controls without hypertension

	Hypertension patients (N= 178)	Controls (N= 175)	P
Dyslipidemia (n%)	105 (59)	41 (23.43)	
Diabetes (n%)	131 (73)	53 (30)	< 0.0005
COPD (n%)	60 (34)	31 (17.7)	
Atrial fibrillation (n%)	53 (30)	82 (47)	< 0.001
CAD (n%)	70 (40)	34 (19)	< 0.0005
Heart failure (n%)	80 (45)	40 (23)	< 0.0005
CKD (n%)	98 (55)	31 (18)	< 0.0005
PAD (n%)	62 (35)	80 (46)	0.037
Cirrhosis (n%)	15 (8)	/	

COPD Chronic obstructive pulmonary disease, PAD Peripheral artery disease, CKD Chronic kidney disease, CAD Coronary artery disease

diseases, chronic renal insufficiency and PAD/carotid atherosclerosis (Table 4).

In addition to the clinical-anamnestic data, the laboratory data collected during hospitalization in the ward were also analyzed, and it was highlighted that subjects with lower MDS had significantly worse lipid profiles (Table 5), whereas mean serum uric acid values were significantly higher in subjects who adhered to the Mediterranean diet.

**Discussion**

This study enrolled 178 hypertensive patients and 175 non-hypertensive control subjects with the aim of assessing their cardiovascular risk based on their adherence to the Mediterranean diet; albeit with the intrinsic limitations of our study, some interesting evidence has been highlighted.

**Table 4** Prevalence of comorbidities in hypertension patients with regard to the degree of adherence to a Mediterranean Diet style

	Subjects with low adherence (MED-SCORES of 0–4) (N= 125)	Subjects with high adherence (MED-SCORES of 5–9) (N= 53)	P
Dyslipidemia (n%)	93 (74)	12 (23)	< 0.0005
COPD (n%)	37 (30)	23 (43)	0.075
Diabetes (n%)	93 (74)	38 (72)	0.585
Heart failure (n%)	56 (45)	24 (45)	0.953
CAD	52 (42)	18 (34)	0.340
CKD	81 (65)	17(32)	< 0.0005
PAD	57 (46)	5 (9)	< 0.0005
Cirrhosis	9 (7)	6 (11)	0.365

COPD Chronic obstructive pulmonary disease, PAD Peripheral artery disease, CKD Chronic kidney disease, CAD Coronary artery disease

**Table 5** Laboratory variables in hypertension patients with regard to the degree of adherence to a Mediterranean Diet style

	Subjects with low adherence (MED-SCORES 0–4) (N= 125)	Subjects with high adherence (MEDSCORES of 5–9) (N= 53)	p
Total cholesterol (mg/dL)	169.8 ± 46.3	134.3 ± 35.1	< 0,0005
HDL-cholesterol (mg/dL)	39.3 ± 13.2	45.7 ± 14.2	0,004
LDL cholesterol (mg/dL)	93.6 ± 42.4	80.64 ± 32.1	0,48
Triglycerides(mg/dL)	139.1 ± 58.2	117 ± 44.4	0,14
Uric Acid (mg/dL)*	6.2 ± 2.4	8.8 ± 12.2	0,035
Hb1Ac**	8.3 ± 3	7.5 ± 1.6	0,424

HDL High-density lipoprotein, LDL Low -density lipoprotein, Hb1Ac Glycated hemoglobin

\*p < 0.005

\*\*p > 0.0001

In our study hypertensive subjects presented more comorbidities than normotensive subjects; in fact, among the hypertensive patients, we reported a lower mean glomerular filtration rate (GFR) value, higher serum uric acid, higher mean serum total cholesterol and LDL cholesterol, higher mean triglyceride values and lower mean serum l HDL cholesterol values .

Thus, the hypertensive subjects also presented a worse cardiovascular profile, as evidenced by the higher average BMI and worse lipid profile of these subjects compared to those in the control group (Table 2). Such evidence is already widely reported in the literature; we can cite several studies that demonstrate a higher prevalence of comorbidities in hypertensive subjects, such as the ‘Korea National Health and Nutrition Examination Survey 2007–2013’, which evaluated more than 30.000 subjects and highlighted that hypertensive people had a higher prevalence of obesity, dyslipidemia and altered fasting glycemia [20].

The control subjects compared to the hypertensive group and a higher frequency of PAD and AF have found (Table 3). One possible explanation could be that many of the control subjects, although not superior to the hypertension group, were smokers, as smoking is an independent risk factor for both PAD and AF [21, 22].

Among the hypertensive subjects we evaluated, those who were less adherent to the Mediterranean diet showed a higher prevalence of chronic renal failure than those who were more adherent to it (65% vs. 32%, p < 0.0005, Table 2); these data are in agreement with what has been highlighted by some other studies, such as the Northern Manhattan Study (NOMAS), a prospective study conducted with 3.298 subjects of different ethnicities; the NOMAS was conducted from 1993 to 2008, evaluated the evolution of the GFR and showed that, in subjects

with MediScores > 5, there was a 50% lower probability of having a GFR < 60 ml/min/1.73 m<sup>2</sup> [23]. Another recent study conducted by the Department of Internal Medicine of the University of Groningen highlighted how greater adherence to the Mediterranean diet was associated with better renal function outcomes in patients undergoing kidney transplantation. [24].

Our study also highlighted that subjects with better adherence to the Mediterranean diet were less affected by dyslipidemia (23% vs. 74%) and they showed a better lipid profile in terms of total cholesterol, high-density lipoprotein (HDL), low-density lipoprotein (LDL) and triglyceride values (Table 4). These data are also in line with what is reported in the literature; in fact, there are various studies that have highlighted the positive impact of the Mediterranean diet on the lipid profile, such as the Aragon Workers Health Study, which compared the lipid profile of subjects adhering to the Mediterranean diet with that of subjects with a Western-type diet rich in red meat and dairy products [25].

Hypertensive patients with greater adherence to the Mediterranean diet had higher serum uric acid levels (Table 2). The ATTICA study showed that the Mediterranean diet reduced uric acid levels and hyperuricemia [11]. Our results do not seem to be in line with that study. Within the population of hypertensives there were patients with higher BMI, higher prevalence of diabetes and liver cirrhosis. It has been shown that despite its antioxidant properties, moderate red wine consumption in patients with NAFLD increases triglyceride and uric acid levels and might worsen liver disease [26]. A further study showed that tea consumption might increase uric acid levels [27]. Red wine is present in the Mediterranean diet in modest amounts, usually consumed with meals, while, tea is present in low quantities in the Mediterranean diet. Although NAFLD was not reported in the group of hypertensive patients, the presence of increased BMI, worse lipid profile, and higher prevalence of diabetes may suggest that NAFLD may be widespread in this population. This could explain why despite the higher adherence to the Mediterranean diet in these hypertensive patients there is an increase in serum uric acid levels.

Another element of interest highlighted by our study is undoubtedly the greater average adherence to the Mediterranean diet of nonhypertensive subjects compared to hypertensive subjects (Table 1); this is interesting because there is not yet consolidated evidence in the literature regarding the protective role of the Mediterranean diet against arterial hypertension, even from some important studies, such as the aforementioned ATTICA study, “The Greek EPIC” 30 study, or the study conducted by the Seguimiento Universidad de Navarra [8–10]. This result suggests the opportunity to conduct new studies

that can better clarify and highlight the role of the Mediterranean diet not only in the prevention of cardiovascular risk, understood generically but also in the prevention of arterial hypertension *sensu stricto*.

Finally, the findings highlighted by our study satisfied our initial purpose, that is, to evaluate whether the risk factors for hypertension and other various comorbidities had a relationship with the better adherence to a Mediterranean diet style based on the identified cutoff of the MDS (< 5, > 5); what emerged in this sense was that lower adherence to the Mediterranean diet was associated with a higher BMI, worse lipid profile, and higher prevalence of metabolic and vascular comorbidities such as diabetes and peripheral artery disease (PAD) and CKD (chronic kidney disease) in the subjects we evaluated, thus showing an increased prevalence of metabolic syndrome, accelerated atherosclerosis and, consequently, cardiovascular risk (Table 4).

This worse metabolic and consequently pro-atherogenic profile associated to a lower adherence to a Mediterranean Diet is furtherly demonstrated by our findings concerning the higher median serum levels of mean serum total cholesterol and serum uric acid and lower mean serum HDL cholesterol, in our subjects with lower adherence to Mediterranean Diet indicating as this worse lipidemic profile represents the metabolic phenotype of lower adherence to this dietetic style.

Although not yet unanimously recognized and accepted, and in consideration of our study and other studies that have investigated this issue, it is reasonable to hypothesize that the Mediterranean diet can play an important role not only in terms of reducing cardiovascular risk but also in terms of the prevention and management of arterial hypertension. Compared to the Western diet, the Mediterranean diet is characterized by the use of olive oil as the main source of fat; the latter is rich in polyphenols, which some studies, such as the study conducted by Rafael Moreno-Luna and colleagues, have shown to have a hypotensive effect [28]. The aforementioned study compared the blood pressure values of participants subjected to the intake of olive oil rich in polyphenols with those of subjects who took polyphenol-free olive oil, highlighting that the former showed lower tension values than the latter after adhering to this diet for four months (PAS < 7.79 mm Hg; PAD < 6.65 mm Hg); this was probably due to the vasoprotective action mediated by the stimulation of nitric oxide secretion, whose antioxidant action would contribute to the reduction of oxidized LDL and PCR serum values and consequently reducing endovascular damage and inflammation, thus contributing to the restoration of correct vascular reactivity [29]. Olive oil, in addition to other components of

the Mediterranean diet such as walnuts, almonds, and olives, is rich in monounsaturated fatty acids (MUFAs), which are known to be associated with an improvement in the lipid profile and insulin sensitivity. Then, in analyzing the characteristics of the Mediterranean diet compared to those of the Dietary Approaches to Stop Hypertension (DASH) diet, which is currently the only diet whose hypotensive value is unanimously recognized, we can see how these show different points of contact; both diets are, in fact, rich in fruits, vegetables, seeds, and unsaturated oils and require a reduced intake of red meat. The main differences between the two dietary regimes are the attention to a reduced intake of salt, provided by the DASH diet and less by the Mediterranean diet, and the greater intake of white meats and low-fat dairy products in the DASH diet, which, according to some studies, could be associated with a reduction in arterial pressure values [29]. The above characteristics, concerning the antioxidant function of the Mediterranean diet, obviously explains the reduction, as a consequence of the practice of this dietary regime of oxidative stress and therefore of vascular degeneration processes such as atherosclerosis, as demonstrated by various studies such as the just mentioned Northern Manhattan Study, which, in addition to evaluating the effects of the Mediterranean diet on renal function, also assessed those on atherosclerosis, demonstrating a reduction in the intima-media carotid thickness in subjects strictly adhering to the Mediterranean diet [23, 24].

Ultimately, from our study, even with all the limitations of the study, it emerged that the Mediterranean diet, when understood not only as a food scheme but also as a real lifestyle, is, by its cultural and healthy connotations, a practice to be preserved and placed at the center of any public prevention plan, especially in situations such as ours; the Mediterranean diet represents not only a healthy lifestyle but also a precious tradition in historical and sociocultural terms. However, this is undermined by culinary globalization, which is a harbinger of some eating habits that are not only foreign but also potentially harmful to our health.

### Limitations

The first limitation of our study is its retrospective nature. Another possible limitation relies on our findings concerning the higher frequency of males and smokers. Furthermore, a limitation is the fact that it was conducted in a single institution. Additionally, the data could be affected by recall bias and the control group is not age-comparable.

In conclusion, (Please give a conclusion paragraph that gives the results of this study as a summary.)

### Conclusions

Our findings showed that hypertensive patients in comparison to control were more likely to be older, to have a higher BMI and a lower adherence to a Mediterranean Diet style as expressed by the Mediterranean Diet Score. We also showed that a lower adherence to the Mediterranean diet in hypertensive subjects is significantly associated with an increased prevalence of dyslipidemia, cardiovascular diseases, chronic renal insufficiency, and peripheral and carotid atherosclerosis, and to a worse lipid profile. Thus, we report that in hypertensive subjects a lower adherence to a Mediterranean Diet Style is associated with a worse cardiovascular risk factor profile in hypertensive patients.

### Acknowledgements

This is not a clinical trial.

### Informed consent

Informed consent was not obtained owing to the retrospective nature of the study.

### Authors' contributions

M.D: wrote the manuscript; T.D.C: wrote the main manuscript text; A.D. C: collected the data and revised the manuscript A.C: statistical analysis and reviewed the manuscript; G.S: collected the data; D.D.R: collected the data; A.T: wrote and reviewed the manuscript.

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### Data availability

Data from our database are available to be provided on request

### Declarations

#### Ethics approval and consent to participate

The study protocol was approved by the Ethics Committee of the Policlinico P. Giaccone, University Hospital.

all methods were carried out in accordance with relevant guidelines and regulations.

Informed consent was not obtained owing to the retrospective nature of the study.

Hospital Ethics Committee of the Policlinico P. Giaccone, University Hospital.

waived the need for informed consent that was not obtained owing to the retrospective nature of the study.

N.A. (retrospective article).

The study protocol was approved by the Ethics Committee of the Policlinico P. Giaccone, University Hospital.

#### Consent for publication

N.A. (retrospective article).

#### Competing interests

The authors declare no competing interests.

#### Author details

<sup>1</sup>Internal Medicine and Stroke Care Ward, Policlinico P. Giaccone University Hospital, Palermo, Italy. <sup>2</sup>Department of Health Promotion, Mother and Child Care, Internal Medicine and Medical Specialties (ProMISE), University of Palermo, Piazza Delle Cliniche N.2, 90127 Palermo, Palermo, Italy.

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