Introduction

Cardiovascular disease (CVD) is the most common cause of death in industrialized countries and blood hypertension is the most frequent treatable risk factor for development of cardiovascular diseases (CVD) [1].

In fact, hypertension is closely associated to a major incidence of stroke (ischaemic and haemorrhagic), myocardial infarction, heart failure, chronic kidney disease, peripheral vascular disease, cognitive decline and premature death [2].

The prevalence of hypertension increases in the older age subjects and modest heterogeneity was observed among various European countries. At the standard threshold (i.e. blood pressure 140/90 mmHg or treatment with antihypertensive medication) about 30-40% of overall adult European population resulted affected by hypertension [3].

Though several antihypertensive drugs are today available and clinical trials have demonstrated a reduction of cardiovascular complications and mortality rate consequent to lowering of blood pressure [4-9], only a third of treated hypertensive patients achieves the target values.

Clinical and observational studies also showed that individual lifestyle factors are associated to cardiovascular morbidity and mortality [10,11]. Emerging data suggest that lifestyle changes are useful and effective to reduce blood pressure and global cardiovascular risk.

Moreover, the more recent guidelines for the management of arterial hypertension [12] recommend to institute lifestyle measures, whenever appropriate, in all hypertensive patients, including those who require drug treatment. The non-adoption of appropriate lifestyle in hypertensive subjects can thwart therapeutic effect of drugs and prevent achievement of target values.

In this brief review, we examined the reports, derived from experimental, prospective cohort studies and outcome trials recorded in the main biomedical databases (PubMed, Scopus) and regarding the impact of lifestyle measures on blood pressure and CVD.
Alcohol Intake

It is well known the deleterious effect of alcohol abuse on liver, heart, pancreas, blood pressure and other organ systems. The acute effects of alcohol intake on blood pressure are complex and nonlinear, with both pressor and depressor effects depending on time since administration [13]. Heavy consumption of alcohol has long been associated with increased blood pressure [14] and a linear relationship between alcohol consumption, blood pressure levels and the prevalence of hypertension in population has been reported [15-17]. Fuchs, et al. [18] showed that increase of blood pressure produced by alcohol abuse regards particularly systolic values and it is more evident in black man, independently from type of drink, whether red wine, white wine, beer or liquor.

On the other hand, the role of moderate alcohol intake is still debated.

Sesso, et al. [19] in a prospective study found a J-shaped association between alcohol intake and hypertension in women and a positive and significant relation with hypertension in men. Authors concluded that light-to-moderate alcohol consumption decreased hypertension risk in women and increased risk in men. Similar results were reported by Briasoulis, et al. [20] in a more recent meta-analysis, while the unfavorable role of heavy alcohol consumption both in women and men was confirmed.

Rimm, et al. [21] in a meta-analysis, based on 42 papers published from 1965 to 1988, reported that a moderate alcohol intake (< 30 g/day) is causally related to lower risk of coronary heart disease through changes in lipids and haemostatic factors. The results of this paper were contradictory with results of another meta-analysis [22] and have been criticized on the basis of methodological flaws in the selection of patients.

However, two more recent meta-analyses [23,24], based on strength evidences, confirmed favorable changes in cardiovascular risk associated to moderate alcohol consumption.

Brien, et al. [23] in a systematic review and meta-analysis of intervention studies found that light alcohol intake (< 15 g/day for women and < 30 g/day for men) had favorable effects on levels of several cardiovascular biomarkers (HDL-cholesterol, apolipoprotein A1, adiponectin, and fibrinogen).

Another comprehensive review [25] assessed the effect of alcohol consumption on multiple cardiovascular outcomes. Light to moderate alcohol consumption was associated to reduced incident coronary disease, lower risk of mortality from cardiovascular disease and from all causes. These results provide indirect pathophysiological support for a protective effect of moderate alcohol use on global cardiovascular risk.

In addition, it has been reported that moderate alcohol consumption improves insulin sensitivity [26,27] and is associated to lower risk to develop type 2 diabetes compared with abstaining and heavier drinking [28].

The underlying mechanisms for these beneficial effects on glucose metabolism are not entirely clear but a great part of them appears to be attributable to the changes in adiponectin levels. However, the favorable effects of alcohol on lipid metabolism [21] as well as action of acetate, the end product of ethanol oxidation [29], able to reduce lipolysis and fat oxidation [30] could contribute to indirectly improve insulin resistance and glucose metabolism, explaining the association between light alcohol consumption and type 2 diabetes.

Furthermore, it has also been reported that moderate alcohol intake is associated with lower levels of markers of inflammation and endothelial dysfunction [31,32] suggesting a protective multi-role of light alcohol intake in development of cardiovascular disease.

Nevertheless, the favorable effects on HDL and LDL cholesterol values were counterbalanced by unfavorable action on blood pressure and triglyceride levels [29].

Cumulatively, these studies suggest that the beneficial effect of light alcohol intake should not be emphasized because action of alcohol also depends upon gender and racial differences and cardiometabolic effects are complex and contradictory. In addition, the habitual consumption of alcohol can induce, even unknowingly, a progressive increase of the introduced doses with shift from light to heavy intake.

Salt Intake

The relationship between the intake of sodium and extracellular fluid volume, arterial pressure and neuroendocrine systems is well known [33]. Experimental studies suggest that high sodium intake, independently from arterial pressure, determines increase of left ventricular mass and intima-media thickness of large arteries, severe proteinuria and renal fibrosis [34-38].

Interventional studies demonstrated that an increase in sodium intake produces an increase of circulating endothelin-1, a potent vasoconstrictor and proinflammatory peptide [39,40], while salt reduction determines improvements in artery flow-mediated dilation [41,42].

Then, many of the renal and cardiovascular damages observed in salt-sensitive hypertensive patients could be also due to intrinsic effect of sodium on microvascular vasomotion.

With regard to the role of dietary salt intake on development and treatment of hypertension, several prospective and outcome trials demonstrated that a lower salt intake is related to a reduced risk of CVD.

Among others, two large cohort studies, the Inter-
A meta-analysis of large prospective studies \[45\] revealed that higher salt intake is associated with significantly greater incidence of strokes and total cardiovascular events, with a dose dependent association. A difference of 5 g a day in habitual salt intake is associated with a 23% difference in the rate of stroke and 17% difference in the rate of total cardiovascular disease with evident social and economic benefits.

A computer-simulation study \[46\], based on state-transition model for CVD incidence in the U.S. population, revealed that reducing salt by 3 gm/day, new cases of stroke, myocardial infarction and death for all causes could be greatly reduced.

A more recent meta-analysis \[47\] confirmed that lowering sodium intake reduces blood pressure in adults and children and has no adverse effect on blood lipids, catecholamine levels or renal function.

Nevertheless, in the last years, the association between sodium intake and hypertension has been partially reconsidered.

A recent prospective large cohort study confirmed a significant positive relationship between dietary sodium, estimated by urinary sodium excretion, and blood pressure, but this relation was stronger among study participants with sodium excretion of more than 5 gr. for day and among subjects with hypertension than among those without hypertension \[48\].

Some studies also reported a U-shaped association between sodium consumption and cardiovascular disease and mortality, with increased risk both at low and high sodium intake \[49,50\].

These findings were confirmed by two meta-analyses \[51,52\], suggesting a significant heterogeneity in the association between daily sodium intake and cardiovascular outcome. Moreover, the effect of low dietary sodium in normotensive subjects is very little and negligible. Then, on basis of scientific evidences, appears reasonable and justified to reduce dietary sodium to less than 3-4 g/day in hypertensive patients and in those with heart and/or renal failure. Instead, no clear benefit is proved for reducing sodium intake in normotensive subjects and in the general population. Further prospective investigations are required to clarify this matter.

**Cigarette’s Smoking**

It is completely accepted that cigarette smoking is a major cardiovascular risk factor for the heart and blood vessels because of the effects of some compounds, primarily nicotine and carbon monoxide \[53,54\]. Functional and structural alterations are often observed as a consequence of nicotine and carbon monoxide activity \[55-58\].

In animal and human models, several studies have demonstrated that both active and passive cigarette smoke exposure were associated with a decrease in vasodilatory function.

Cigarette smoke exposure impairs endothelium-dependent vasodilation in macrovascular such as in microvascular beds \[55,59-62\]. Nitric-Oxide (NO) plays a pivotal role in the vasodilatory function of endothelium. It has been showed that smoke exposure decreases NO availability by altering the expression and activity of the endothelial NO synthase enzyme.

Moreover, nicotine and its isomers cause catecholamine release and sympathetic stimulation \[63-65\]. Sympathetic nervous system stimulation acutely determines increased heart rate and systolic blood pressure. These effects are transient but repeatable.

Thus, cigarette smoke has a double action on vascular resistances, acting by an impaired endothelium-dependent vasodilatation and an increased catecholamine-dependent vasoconstriction. In addition, the evidence indicates that smoking produces increased aggregation and adhesiveness of platelets, leading to blood rheology changes with enhanced viscosity and higher risk of thrombosis \[66-68\].

With regard to the association of cigarette smoking with hypertension, results from epidemiological and interventional studies are unclear and contradictory.

Some studies \[69-72\] reported an increased blood pressure and development of hypertension in cigarette smokers compared to non-smokers, suggesting an unfavorable action of smoking on pressure values related to long-term exposure and to number of smoked daily cigarettes.

Recently, a significant improvement in systolic and diastolic pressure in subjects who quit or reduced their tobacco consumption has been reported \[73\].

Others studies \[74-76\], however, reported that smoker status does not directly affect development of hypertension or blood pressure value. Observational analyses found that current smoking is associated with lower blood pressure and lower prevalence of hypertension and did not support a causal association between smoking and blood pressure \[77\].

Regardless of tobacco’s effect on blood pressure, cigarette smoking is considered an independent major
risk factor for development of cardiovascular complications such as stroke, myocardial infarction, renal failure and congestive heart failure. The association of smoking and hypertension increases the cardiovascular risk in an exponential manner. Then, cigarette smoking cessation is strongly recommended in all the people, especially those affected by hypertension, diabetes mellitus, coronary heart disease or other risk factors.

Physical Activity

It has been reported that exercise training plays several hemodynamic and metabolic beneficial effects, reducing global cardiometabolic risk.

It reduces sympathetic responses and affects the hypothalamic-pituitary-adrenal axis with lower cortisol increase, lower cardiovascular reactivity and more rapid cardiovascular recovery in response to psychophysical stress [78-80].

Moreover, physical activity determines a systemic adaptation of the arterial wall which might lead to decrease in peripheral resistance [81]. Exercise training leads to a higher number of capillaries for muscle fiber by increasing a number of pro-angiogenic factors [82,83]. An increasing number of reports [84-88] suggests that physical activity is also able to ameliorate vascular function by reducing arterial stiffness and improving the balance between vasoconstrictor and vasodilator systems.

However, to assess the role of physical activity on blood pressure can be really hard because many confounding factors such as age, magnitude and duration of exercise, muscles involved and comorbidities can lead to mismatch of results.

Must of studies [89-93] reported a significant reduction of blood pressure after an exercise session but results are difficult to compare because they were obtained with different methodologies, depending by the characteristics of the sample (i.e. hypertensive or normotensive subjects), use of antihypertensive medication, training status, whether the exercise is performed intermittently or continuously, the time of day when it is performed and characteristics of measurement performed (whether blood pressure was measured at rest or by ambulatory monitoring).

Although this variability, several meta-analyses and epidemiological evidences have consistently shown a total beneficial effect of a regular physical activity [94-96]. A regularly performed aerobic exercise of mild to moderate intensity is effective in lowering blood pressure in hypertensive individuals for all ages and both genders. The average exercise-related decrease in blood pressure is about 7-10 mmHg for systolic and 4-8 mmHg for diastolic blood pressure.

The reduction of pressure values obtained after onset of regular exercise training could lead in some cases to reduce or to stop the use of antihypertensive drugs [97].

It has also been reported [98-100] that a habitual physical activity is able to prevent the development of hypertension, while sedentary normotensive individuals have a relative risk approximately 35% to 70% higher to develop hypertension when compared to their physically active peers.

In addition, a regular aerobic exercise training shown to be useful to ameliorate lipid profile, glycemic control and overweight, reducing the global cardiovascular risk and mortality [101,102]. For these reasons, a moderate-intensity dynamic aerobic exercise during at least 30 minutes on 5-7 days per week is strongly recommended by current European and American guidelines [103,104].

Dietary Patterns

The effects of modifying whole dietary patterns on blood pressure have been extensively investigated. In addition to reducing alcohol and salt intake, as noted above, a variety of evidence suggest that the adoption of an adequate diet plays a role in lowering blood pressure value. Caloric intake is related to body weight but obesity and overweight are associated to hypertension. Trials have documented that weight loss lowers blood pressure, independently from achievement of desirable body weight [105-107]. In a meta-analysis of 25 trials, an average weight loss of 5.1 kg was associated to reduction in mean 4.4 mmHg systolic and 3.6 mmHg diastolic pressure [108].

It has been also reported that modest weight loss can prevent hypertension in prehypertensive individuals and can facilitate medication step down and drug withdrawal [109-111]. It has been documented that increased potassium intake lowers blood pressure both in non-hypertensive and hypertensive subjects [112-114]. This hemodynamic effect of potassium appears to be more pronounced in individuals with high sodium intake and may be linked to potassium-mediated sodium excretion in the renal distal tubule [113].

Epidemiological evidence suggests that a low dietary intake of calcium and magnesium can increase prevalence of hypertension [115,116]. However, the available data are not exhaustive and a generalized supplementation of calcium and magnesium is not currently recommended in hypertensive patients [117,118].

Moreover, several clinical trials [119-121] have demonstrated that comprehensive dietary changes can play an important role in the etiology, prevention and treatment of hypertension. In particular, a diet rich of fruits, vegetables, fiber and fish oil is effective in reducing blood pressure and its related cardiovascular complications and mortality.

Omega-3 polyunsaturated fatty acids, mainly con-
tained in fish, have demonstrated a benefit for cardiovascular disease risk reduction, supporting higher amounts of fish intake [122]. It has also been reported [123] that omega-3 supplementation improves arterial stiffness and endothelial function. These effects of omega-3 fatty acid are likely due to its ability to incorporate into phospholipid membranes, by partially replacing arachidonic acid as an initial substrate to produce anti-inflammatory eicosanoids. Moreover, some studies [124-126] showed a light but significant decrease of blood pressure values in patients treated with omega-3 supplements. Recently, a meta-analysis, including 8 studies with more than 56,000 participants, showed that normotensive subjects with the highest dietary consumption of omega-3 had a 27% lower risk of developing hypertension than subjects with the lowest intake [127].

Olive oil consumption has been associated to increased antioxidant properties. Extra virgin olive oil contains phenolic compounds, hydroxytyrosol and oleuropein which are potent antioxidant, free radical scavengers and enzyme modulators [128]. Other studies [129-132] showed that olive oil reduces oxidative stress and systemic inflammation and improves endothelial repair. A consistent number of observational data also showed the beneficial effects of a diet rich in fruit and vegetables on blood pressure and on the cardiovascular risk profile.

These benefits of fruit and vegetables could be due to the combined effect of reduced total caloric burden, antioxidant properties, increased flavonol and vitamins intake and nitric oxide synthesis.

Mediterranean diet has all these beneficial properties because it is based on high consumption of olive oil, legumes, cereals, fruits, vegetables, fish and low consumption of meat and meat products [133].

This diet is low in saturated fats and guarantees an adequate intake of vitamins, minerals and beneficial non-nutrient substances such as polyphenols and anthocyanins.

Several epidemiological studies [134-136] have confirmed the effectiveness of this dietary pattern. Then, there is ample evidence that dietary change with reduced caloric intake, whether appropriate, increased consumption of fish, fruits and vegetables and reduced intake of saturated fatty acids offers an additional nutritional approach to the prevention and treatment of hypertension.

### Conclusions

Hypertension has been recognized as a major risk factor for development of several cardiovascular diseases. On basis of literature data today available, there is clear evidence that lifestyle habits may influence blood pressure value. Then, lifestyle changes can provide beneficial effects in hypertensive patients, reducing global cardiovascular risk and all-cause mortality.

### Table 1: Adverse pathophysiological effects of a wrong lifestyle.

<table>
<thead>
<tr>
<th>Heavy alcohol intake</th>
<th>Liver, pancreas and cardiovascular damage</th>
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<tbody>
<tr>
<td>High salt intake</td>
<td>Increased circulating volume</td>
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<td></td>
<td>Increased left ventricular mass</td>
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<td>Raised intima-media thickness</td>
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<td></td>
<td>Elevated plasma endothelin-1</td>
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<td>Reduced flow-mediated dilation</td>
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<td>Cigarette smoke</td>
<td>Impaired vasodilatory function</td>
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<td></td>
<td>Reduced endothelium-dependent vasodilatation</td>
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<td></td>
<td>Reduced nitric oxide availability</td>
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<td></td>
<td>Excessive sympathetic stimulation</td>
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<td></td>
<td>Increased platelet aggregation</td>
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<td>Reduced physical activity</td>
<td>Altered cardiovascular reactivity</td>
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<td></td>
<td>Increased arterial stiffness</td>
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<td></td>
<td>Impaired vasoconstrictor-vasodilator balance</td>
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<tr>
<td>Wrong diet</td>
<td>Overweight and obesity</td>
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<tr>
<td></td>
<td>Reduced antioxidant and anti-inflammatory properties</td>
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<tr>
<td></td>
<td>Reduced nitric oxide synthesis</td>
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<tr>
<td></td>
<td>Inadequate vitamin and mineral intake</td>
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</table>

According to scientific evidence, reduction of alcohol and salt intake, smoking cessation, execution of a regular aerobic physical activity, correction of overweight with adoption of a balanced norm-caloric diet, rich of fresh fruits and verdures and low in saturated fats, are the main lifestyle changes that determine the best results for prevention and treatment of hypertension.

In Table 1, the main pathophysiological alteration associated to a wrong lifestyle are summarized. Positive lifestyle modifications can sometimes involve the reduction or interruption of antihypertensive drugs, reducing the economic impact and avoiding the side effects of the pharmacological treatment.

On the other hand, the lack of these lifestyle measures can prevent the achievement of pressure target in patients undergoing antihypertensive drugs.

For these reasons, we believe that lifestyle changes should precede or accompany the onset of pharmacological treatment.

Physicians should not prescribe drugs without clearly informing patients in detail about the benefits that a desirable lifestyle can bring to their health and provide psychological and motivational support.

Public Health Authorities, by appropriate information campaigns, should promote and encourage the adoption of a correct lifestyle model not only in hypertensive individuals but in the general population.

### Declaration of Interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.
References


