Effects of olive oil on blood pressure: A systematic review and meta-analysis

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SUMMARY: Hypertension is one of the most important risk factors associated with the development of cardiovascular diseases. Numerous studies have revealed that a diet enriched in olive oil can have a beneficial effect on blood pressure. This systematic review includes the effects of olive oil on blood pressure in individuals without previous cardiovascular events. Liquid oil shows a decrease in blood pressure, while capsules have not produced any effect. Diastolic blood pressure decreased after the consumption of olive oil, -0.73 mm Hg, 95% CI (-1.07, -0.40); \( p < 0.001 \), \( I^2 = 86.9\% \), with high heterogeneity among the included studies. This reduction was mainly due to extra virgin olive oil (EVOO) from 10 ml to 50 ml/day: -1.44 mm Hg, 95% CI (-1.89, -1.00); \( p < 0.001 \). Regarding systolic blood pressure the observed decrease is not statistically significant. Further studies on the consumption of EVOO are needed to confirm these results.

KEYWORDS: Diastolic Pressure; Hypertension; Olive oil; Randomized Controlled Trial; Systematic review; Systolic pressure

RESUMEN: Efectos del aceite de oliva en la presión arterial: revisión sistemática y metaanálisis. La hipertensión es uno de los factores de riesgo más importantes asociados con el desarrollo de enfermedades cardiovasculares. Numerosos estudios han revelado que una dieta enriquecida con aceite de oliva puede producir un efecto beneficioso sobre la tensión arterial. En esta revisión sistemática se recogen los efectos del aceite de oliva sobre la tensión arterial en individuos sin eventos cardiovasculares previos. Es el aceite líquido el que ha mostrado los beneficios, mientras que las cápsulas no han producido ningún efecto. La tensión arterial diastólica disminuyó después del consumo de aceite de oliva, -0.73 mm Hg, IC 95% (-1.07, -0.40); \( p < 0.001 \), \( I^2 = 86.9\% \), con elevada heterogeneidad entre los estudios incluidos. Esta reducción se debió principalmente al aceite de oliva virgen extra (AOVE) de 10 ml a 50 ml/día: -1.44 mm Hg, IC 95% (-1.89, -1.00); \( p < 0.001 \). En lo que se refiere a la tensión arterial sistólica el descenso producido no ha sido estadísticamente significativo. Se necesitan más estudios sobre el consumo de AOVE para confirmar estos resultados.

PALABRAS CLAVE: Aceite de oliva; Ensayo controlado aleatorizado; Hipertensión; Presión diastólica; Presión sistólica; Revisión sistemática

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1. INTRODUCTION

Hypertension is one of the most important risk factors associated with the development of cardiovascular disease. The threshold for the diagnosis of hypertension is a systolic blood pressure (SBP) of at least 140 mm Hg, a diastolic blood pressure (DBP) of at least 90 mm Hg, or both (Poulter et al., 2015). Hypertension increases the risk of stroke, coronary heart disease, sudden death, heart failure and peripheral arterial disease (Mancia et al., 2013). A change in lifestyle can be an effective intervention to control blood pressure. The preventive measures to adopt are restriction of salt in the diet, moderation in alcohol consumption, abundant fruit consumption, control of weight, regular physical activity, and smoking cessation (Dickinson et al., 2006).

Several epidemiological studies have analyzed the relationship between monounsaturated fatty acid (MUFA) consumption, such as olive oil, and hypertension (Alonso et al., 2006). In 2005, the OmniHeart study compared three diets: one rich in carbohydrates, another rich in vegetable proteins, and the third with MUFA. The diets rich in vegetable proteins and MUFA compared with the carbohydrate diet reduced blood pressure and improved the lipid profile (Appel et al., 2005). The International Study of Macro/Micronutrients and Blood Pressure (INTERMAP) is a multicenter cross-sectional study of 4680 men and women in which linear regression analyses showed a significant inverse relationship between total MUFA intake and DBP. A Spanish study showed that the consumption of vegetable oleic acid, with a daily intake of 13 g/day, was associated with a decrease in SBP (-0.70 mmHg) and DBP (-0.57mm Hg) (Miura et al., 2013). In the PREDIMED (Prevención con Dieta Mediterránea) clinical trial both SBP and DBP decreased 2.3 and 1.2 mm Hg, respectively, after one year of follow-up (Doménech et al., 2014).

The consumption of olive oil is very common in Mediterranean countries. It is associated with the Mediterranean diet and it is not clear whether the effects of olive oil are due to the oil itself or to the whole diet pattern. The objective of this study is to assess whether the consumption of olive oil reduces blood pressure in adults without previous cardiovascular events.

2. METHODS

2.1. Design

We carried out a systematic review and meta-analysis following the recommendations established by the PRISMA statement (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) (Moher et al., 2009). A systematic review protocol was developed, not registered a priori, and not modified after the beginning of the review process.

2.2. Eligibility criteria

We used the following inclusion criteria: a) participants: adult population with at least 18 years of age without previous cardiovascular events; b) intervention: diet enriched with olive oil for at least 12 weeks vs. diet enriched with other fat; c) outcome measures: SBP or DBP; d) design of included studies: randomized controlled trials (RCTs). We have included both healthy individuals with cardiovascular risk factors or with other non-cardiovascular pathology.

2.3. Exclusion criteria

We exclude studies in which the intervention was carried out in cardiovascular patients because they experience a profound change in their lifestyle, including diet, not comparable with healthy subjects or with other types of diseases. Animal studies were discarded.

2.4. Research methods

The following electronic databases were searched from their inception through April 10, 2018: PubMed, Embase, Cochrane plus, Web of Science, Ovid, Scopus, VHL, TDR. The language of publication was not restricted.

The search strategy was carried out through the combination of keywords related to olive oil intake (olive oil), and the different expected results: hypertension (arterial pressure, hypertension, blood pressure, DBP, SBP), and the design of adequate studies for inclusion (randomized controlled trial, systematic review, meta-analysis). Reference lists of identified original articles were searched manually. Table 1 shows the search strategy for the databases.

<table>
<thead>
<tr>
<th>PubMed, Web of Science, Embase, Ovid, Biblioteca Cochrane plus, Scopus, VHL, TDR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. olive oil</td>
</tr>
<tr>
<td>2. Arterial Pressure</td>
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<tr>
<td>3. Hypertension</td>
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<tr>
<td>4. Blood Pressure</td>
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<tr>
<td>5. Diastolic Pressure</td>
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<tr>
<td>6. Systolic Pressure</td>
</tr>
<tr>
<td>7. 2# OR 3# OR 4# OR 5# OR 6#</td>
</tr>
<tr>
<td>8. 1# AND 7#</td>
</tr>
<tr>
<td>9. 8# AND (Randomized Controlled Trial OR systematic review OR Meta-Analysis)</td>
</tr>
<tr>
<td>10. 9# AND humans</td>
</tr>
</tbody>
</table>

VHL

1. olive oil
2. hypertension
3. Humans

4. 1# AND 2# AND 3#
2.5. Risk of bias in individual studies

We used the Cochrane risk of bias tool to assess risk of bias within the following domains: selection bias, performance bias, detection bias, attrition bias, reporting bias, and other bias (Higgins and Green, 2011). Table 2 shows the studies after the validity analysis.

2.6. Data extraction and management

Two researchers made the selection of articles independently. Discrepancies were discussed with a third review author until consensus was reached. The following data were extracted from each study: authors, year of publication, country of implementation, duration, amount of olive oil intake in the experimental group and fat in the control one, characteristics and number of participants in each intervention applied, SBP and DBP (Table 2).

2.7. Data synthesis

The outcome parameter was the change in blood pressure regarding baseline values; the mean standard error of the change was computed. Mean differences (MDs) were pooled using a fixed effects model. Heterogeneity between studies results was tested using the Q test. The proportion of heterogeneity was quantified with the I^2 parameter. I^2 > 50% was considered to represent considerable heterogeneity. Meta-regression was performed to explore the causes of heterogeneity. We applied Egger’s method to determine the possible existence of publication bias. All data were analyzed using Stata 14 SE program (College Station, TX, USA).

3. RESULTS

3.1. Literature research

The search identified 872 studies, 687 of which were identified in different databases: 119 in PubMed, 23 in Embase, 32 in the Cochrane Plus Library, 167 in the Web of Science, 35 in Ovid, 232 in Scopus, and 79 in VHL; while 185 were located through the grey literature of TDR and hand searched for references. After the exclusion of duplicates, 691 studies were evaluated. 27 studies were reviewed in full text, and 15 studies were finally included. The reasons for exclusion are detailed in Figure 1.

3.2. Characteristics of studies included in systematic review

Fifteen studies were included in the systematic review and meta-analysis (Kristensen et al., 2016, Rozati et al., 2015, Lee et al., 2015, Venturini et al., 2015, Ceriello et al., 2014, Toledo et al., 2013, Singhal et al., 2013, Tapsell et al., 2013, Konstantinidou et al., 2010, Taylor et al., 2006, Rasmussen et al., 2006, Olsen et al., 2000, Ferrara et al., 2000, Prisco et al., 1998, Bonnema et al., 1995). Table 2 shows a summary of the information extracted from the included studies. The designs used by the studies were: double blind parallel RCTs (Kristensen et al., 2016, Lee et al., 2015, Singhal et al., 2013, Taylor et al., 2006, Olsen et al., 2000, Prisco et al., 1998, Bonnema et al., 1995), double-blind, randomized crossover study (Ferrara et al., 2000), and non-blinded RCTs (Rozati et al., 2015, Venturini et al., 2015, Ceriello et al., 2014, Toledo et al., 2013, Tapsell et al., 2013, Konstantinidou et al., 2010, Rasmussen et al., 2006). The follow-up ranged from 12 weeks to 4 years. The countries in which the studies were developed were Spain (Ceriello et al., 2014, Toledo et al., 2013, Konstantinidou et al., 2010), Denmark (Kristensen et al. 2016, Bonnema et al., 1995), Italy (Ferrara et al., 2000, Prisco et al., 1998), United Kingdom (Singhal et al., 2013, Taylor et al., 2006), South Korea (Lee et al., 2015), USA (Rozati et al., 2015), Brazil (Venturini et al., 2015), Australia (Tapsell et al., 2013), and two multinational studies: Denmark, United Kingdom, Sweden, Italy, Netherlands, Belgium, Russia and Norway (Olsen et al., 2000); and Finland, Denmark, Italy, Australia and Sweden (Rasmussen et al., 2006).

The fifteen studies included 6651 participants: 3358 had ingested olive oil and 3293 were fed the control diet. Four studies had more than two arms; in these studies the following branches were discarded for the present review: in the PREDIMED study the branch with Mediterranean diet plus nuts (Toledo et al., 2013), refined olive oil (Konstantinidou et al., 2010), hypocaloric diet plus fish (Tapsell et al., 2013), and pregnant women with fewer weeks of administration (Olsen et al., 2000). Venturini et al., (2015) gives their outcomes as mean and inter-quartile range and they could not be included in meta-analysis. Men and women were pooled in the analyses.

The participants were adults without cardiovascular events. Some participants had cardiovascular risk factors such as overweight or obesity (Rozati et al., 2015, Tapsell et al., 2013, Taylor et al., 2006), diabetes mellitus (Ceriello et al., 2014), incipient or established diabetic nephropathy (Lee et al., 2015, Bonnema et al., 1995) or more than three cardiovascular risk factors (Toledo et al., 2013), hypertension (Ferrara et al., 2000, Prisco et al., 1998), metabolic syndrome (Venturini et al., 2015) and psoriatic arthritis (Kristensen et al., 2016). Three studies were performed in healthy adults (Singhal et al., 2013, Konstantinidou et al., 2010, Rasmussen et al., 2006). Olsen et al., (2000) recruited twin pregnancies and pregnancy induced hypertension.
<table>
<thead>
<tr>
<th>Studies</th>
<th>Country</th>
<th>Design</th>
<th>Duration of intervention</th>
<th>Participants</th>
<th>Treatment group</th>
<th>Control group</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kristensen et al., 2016</td>
<td>Denmark</td>
<td>RCT</td>
<td>24-week</td>
<td>Psoriatic arthritis</td>
<td>Capsules 3 g olive oil /day N = 60</td>
<td>Capsules 3 g n-3 PUFA / N = 68</td>
<td>SBP decrease DBP decrease</td>
</tr>
<tr>
<td>Rozati et al., 2015</td>
<td>USA</td>
<td>RCT</td>
<td>3 months</td>
<td>Overweight and obese</td>
<td>Extra virgin olive oil 39±7g/ day +American diet N = 20</td>
<td>Corn oil, soybean oil and butter: 41 ± 8 g / day plus American diet N = 21</td>
<td>SBP decrease DBP decrease</td>
</tr>
<tr>
<td>Lee et al., 2015</td>
<td>South Korea</td>
<td>Double-blind RCT</td>
<td>12 weeks</td>
<td>Diabetic nephropathy</td>
<td>3 g olive oil / N = 8</td>
<td></td>
<td>SBP decrease DBP decrease</td>
</tr>
<tr>
<td>Venturini et al., 2015</td>
<td>Brazil</td>
<td>RCT</td>
<td>90 days</td>
<td>Metabolic syndrome</td>
<td>3 g olive oil /N = 8</td>
<td></td>
<td>SBP decrease DBP decrease</td>
</tr>
<tr>
<td>Capello et al., 2013</td>
<td>Spain</td>
<td>RCT</td>
<td>16 weeks</td>
<td>Diabetic or ≥ 3 cardiovascular risk factors</td>
<td>Capsules 4g, 4 day olive oil / N = 24,1</td>
<td></td>
<td>SBP decrease DBP decrease</td>
</tr>
<tr>
<td>Singhal et al., 2010</td>
<td>Australia</td>
<td>Double-blind RCT</td>
<td>12 weeks</td>
<td>Non-diabetic, obesity</td>
<td>Healthy adults</td>
<td>Healthy adults</td>
<td>SBP decrease DBP decrease</td>
</tr>
<tr>
<td>Tapell et al., 2013</td>
<td>Spain</td>
<td>RCT</td>
<td>1 year</td>
<td>Mediterranean diet + extra virgin olive-oil-50 ml/day N = 241</td>
<td>Olive oil 84 cal/day</td>
<td></td>
<td>SBP decrease DBP decrease</td>
</tr>
<tr>
<td>Taylor et al., 2006</td>
<td>Finland, Denmark</td>
<td>Double-blind RCT</td>
<td>12 weeks</td>
<td>Healthy adults</td>
<td>Olive oil capsules 3g/day + Mediterranean diet / N = 30</td>
<td></td>
<td>SBP decrease DBP increase</td>
</tr>
<tr>
<td>Rauniasen et al., 2006</td>
<td>France</td>
<td>Double-blind RCT</td>
<td>1 year</td>
<td>Hypertension induced by pregnancy  N = 202 Twin pregnancy group  N = 290</td>
<td>4 capsules of fish oil / N = 20</td>
<td></td>
<td>SBP decrease DBP decrease</td>
</tr>
<tr>
<td>Prisco et al., 1998</td>
<td>Italy</td>
<td>Double-blind RCT</td>
<td>1 year</td>
<td>Hypertensive</td>
<td>4 capsules of fish oil / N = 20</td>
<td></td>
<td>SBP decrease DBP decrease</td>
</tr>
<tr>
<td>Bonnema et al., 1995</td>
<td>Denmark</td>
<td>RCT</td>
<td>6 months</td>
<td>Diabetic with incipient nephropathy 4 capsules of fish oil capsule / N = 14</td>
<td></td>
<td>SBP decrease DBP increase</td>
<td></td>
</tr>
</tbody>
</table>

Caloric/day: cal/day; DBP: diastolic blood pressure; DHA: docosahexaenoic acid; EPA: eicosapentaenoic acid; FA: fatty acid; MUFA: monounsaturated fatty acids; PUFA: polyunsaturated fatty acids; RCT: randomized controlled trial; SBP: systolic blood pressure.
3.3. Types of interventions

The olive oil was administered in capsules of 1-6 g/day (Kristensen et al., 2016, Lee et al., 2015, Singhal et al., 2013, Tapsell et al., 2013, Taylor et al., 2006, Rasmussen et al., 2006, Olsen et al., 2000, Prisco et al., 1998, Bonnema et al., 1995), and in liquid form as extra virgin olive oil (EVOO) from 10 ml to 50 ml/day (Rozati et al., 2015, Venturini et al., 2015, Ceriello et al., 2014, Toledo et al., 2013, Ferrara et al., 2000, Konstantinidou et al., 2010), in the context of different types of diets, such as the American diet (Rozati et al., 2015), or the Mediterranean diet (Konstantinidou et al., 2010, Toledo et al., 2013, Prisco et al., 1998). The studies that supplemented liquid oil provided it as EVOO, while the studies with capsule supplement provided it with olive oil.

The control groups took both capsules, liquid oil, habitual diet and low-fat diet. The controls took capsules with different fatty acids: microalgae and palmitic acid (Singhal et al., 2013), conjugated linoleic acid (Taylor et al., 2006), docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA) (Kristensen et al., 2016, Lee et al., 2015, Tapsell et al., 2013, Bonnema et al., 1995, Rasmussen et al., 2006, Olsen et al., 2000, Prisco et al., 1998). In liquid form the next fats were administered to the control groups: corn oil, soybean oil and butter (Rozati et al., 2015), and sunflower oil (Ferrara et al., 2000). Finally, in four studies, no supplement was provided to the control groups: habitual diet (Venturini et al., 2015, Konstantinidou et al., 2010), and low fat diet (Ceriello et al., 2014, Toledo et al., 2013).

The diet administered was adequate to the energy requirements, except in Tapsell et al. (2013) who administered a hypocaloric diet with 1750 (SD 417) kcal and 1600 (SD 355) kcal in the olive oil and control groups, respectively. Physical activity was not restricted in the included studies; they were requested to maintain their regular routine of physical activity. Tapsell et al. (2013), recommended walking for 30-minutes three days a week, with similar results among groups.

3.4. Outcome measures

Fourteen studies assessed DBP and SBP, and one study only DBP (Olsen et al., 2000). No adverse events were mentioned: only nine participants in the n-3 polyunsaturated fatty acid (PUFA) supplemented group and six participants in the olive oil group reported mild gastrointestinal adverse effects in Kristensen et al., (2016).
3.5. Risk of bias in individual studies

We used the Cochrane risk of bias tool (Higgins and Green, 2011) to assess all studies for their risk of bias within the following domains: selection bias, performance bias, detection bias, attrition bias, reporting bias, and other bias. Figure 2 provides an overview of the risk of bias assessment. Two studies had high risk for selective reporting bias (Venturini et al., 2015, Olsen et al., 2000) and one study was classified as high risk for attrition bias (Tapsell et al., 2013). An intention-to-treat analysis was performed. The included studies were considered as having low risk for bias.

3.6. Results of the meta-analysis

Olive oil did not decrease SBP more than other fat, MDs = -0.11, CI 95% (-0.68, 0.46), $I^2 = 85.1\%$; $p$ heterogeneity < 0.001. The studies dispensed liquid olive oil or capsules. To identify the effect of the two kinds of supplementation meta-analysis was stratified by this variable (capsules and oil) (Figure 3): no significant effect was observed either for capsules or liquid on SBP.

Olive oil showed a significant decrease in DBP with a fixed effects model of -0.73 mm Hg, 95% CI (-1.07, -0.40); $p < 0.001$; $I^2 = 84.5\%$; $p$ heterogeneity < 0.001. This effect was mainly due to liquid

![Figure 2. Risk of bias. For each study, each domain of bias is indicated as: low risk of bias in green, unclear risk of bias in yellow, and high risk of bias, in red.](image)

![Figure 3. Meta-analysis of the effect of olive oil on systolic blood pressure, stratified by type of supplementation. The mean standard error of the change was computed. For each study, the shaded square represents the point estimate of the intervention effect. The individuals who have taken olive oil are located to the left of the forest plot.](image)
The EVOO seems to be the main factor responsible for the decrease in DBP. The PREDIMED trial (Toledo et al., 2013) is the more influential study in the pooled results with a weight of 43.44% and 46.57% for SBP and DBP, respectively, and with more of the 70% of all subjects. The use of a random effects model implies giving a higher weight for much smaller studies, and more prone to bias than the PREDIMED. That is the reason we relied on the fixed effects model.

Considering the individual studies, a higher decrease in SBP was obtained with liquid EVOO, about 40 g in men and 30 g in women, compared to sunflower oil (Ferrara et al., 2000): -8 mm Hg in SBP, CI 95% (-12.5, -3.46), and -6 mm Hg in DBP, CI 95% (-8.22, -3.78). In another study (Rozati et al., 2015), EVOO (39 ± 7 g/day) significantly reduced SBP in -6 mm Hg, 95% CI (-9.62, -2.38), when compared with corn oil, soybean oil and butter together in an American diet. A lower reduction was observed with olive oil capsules (4 g) versus capsules of microalgae and palmitic acid: -2 mm Hg in SBP, CI 95% (-0.63, 1.43), compared with EVOO (39 ± 7 g/day).

### 4. DISCUSSION

In this systematic review of 6651 participants without previous cardiovascular events in 15 RCTs, comparing a diet enriched with olive oil versus a diet enriched with other fats, a significant reduction in DBP was observed, with high heterogeneity. This heterogeneity may be due to differences in the diets of control groups, characteristics of the populations (very different countries, with different risk factors, etc.), and the type of supplementation of olive oil. The EVOO seems to be the main factor responsible for the decrease in DBP. The PREDIMED trial (Toledo et al., 2013) is the more influential study in the pooled results with a weight of 43.44% and 46.57% for SBP and DBP, respectively, and with more of the 70% of all subjects. The use of a random effects model implies giving a higher weight for much smaller studies, and more prone to bias than the PREDIMED. That is the reason we relied on the fixed effects model.

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### 3.7. Risk of bias across studies (publication bias)

Egger’s method showed p values of 0.67 and 0.23 for SBP and DBP, respectively.

### Figure 4. Meta-analysis of olive oil on diastolic blood pressure, stratified by type of supplementation. The mean standard error of the change was computed. For each study, the shaded square represents the point estimate of the intervention effect. The individuals who have taken olive oil are located to the left of the forest plot.
EVOO with a regular diet in participants with metabolic syndrome. They reported a decrease in the mean SBP of -5 mm Hg and -14 mm Hg in DBP.

Other studies with interventions of shorter duration than 12 weeks, not included in this review, showed significant reductions in blood pressure. In a double-blind crossover trial of 24 women, Moreno Luna et al., (2012) examined the influence of oil with high content in polyphenols on blood pressure: EVOO reduced SBP by -7.91 ± 9.51 mm Hg and DBP -6.65 ± 6.63 mm Hg. These effects are similar to those observed in a systematic review on the effect of first-line antihypertensive drugs choice (Wright and Musini, 2009). The effect of polyphenols has also been evaluated in a group of 160 healthy men from the North, Center and South of Europe (Bondia-Pons et al., 2007) in a randomized cross-over trial with three intervention periods: 25 ml/day of olive oil were administered with different concentrations of polyphenols. Both SBP and DBP decreased after consuming olive oil for nine weeks. In addition, the properties of virgin olive oil were evaluated in the SOLOS study in 40 men with stable coronary disease (Fitò et al., 2005): SBP decreased after the intake of EVOO (p < 0.001), with no change in DBP. A systematic review on the effects of virgin olive oil polyphenols found significant differences in SBP and no effect on DBP (Hohmann et al., 2015), although the number of pooled subjects is small, 69.

Olive oil seems to inhibit the activity of angiotensin-converting enzymes, and blocks the binding to angiotensin II receptor, and this hypertensive activity was demonstrated in studies on animals or humans (Patten et al., 2016).

Among the strengths of this study is the exhaustive search developed without language restriction, the number of studies reviewed, and the quality of the included studies. The results could be extended to healthy subjects, with cardiovascular risk factors, type 2 diabetes, hypertension, overweight, obesity, and countries with distinct economic and social development. The main limitation of our systematic review is the heterogeneity among the studies. It could be justified because some studies have been carried out in areas with regular consumption of olive oil and it is possible that the group control has also taken olive oil. In addition, some participants have taken antihypertensive treatment for their underlying disease, thus decreasing the potential benefit of olive oil. Toledo et al., 2013, developed a study on individuals with different cardiovascular risk factors, including hypertension for which they need antihypertensive therapy, although the individuals were distributed into similar percentages between the intervention and control groups, 1666 (68%) patients in the extra virgin olive oil group and 1666 (70.9%) in the control group. Likewise, in Ferrara et al., 2000, did a randomized crossover study in which there were basic conditions for all individuals. At the end of the follow-up, daily drug dosage was significantly reduced in the EVOO group, and 34.7% needed no antihypertensive therapy, while all patients required treatment during the sunflower oil diet. Physical activity may also vary among different populations.

Nevertheless, we consider that the number of studies on olive oil and blood pressure is still small. The intake of EVOO of between 10-50 ml per day can reduce diastolic blood pressure in healthy individuals or those with cardiovascular risk factors, even in hypertensive patients, and can be an important therapeutic tool. Further studies on EVOO are needed to reduce heterogeneity and consolidate the results.

5. CONCLUSIONS

The present meta-analysis provides evidence for a beneficial effect of EVOO on blood pressure in participants without cardiovascular events. Healthy individuals or those with cardiovascular risk factors can benefit from a reduction in DBP if they consume olive oil for at least three months.

REFERENCES


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... trial. Hypertension 64, 69–76. https://doi.org/10.1161/HYPERTENSIONNAHA.113.03553


