REVIEW ARTICLE

Medycyna Środowiskowa – Environmental Medicine
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The role of a diet including flaxseed in modifying risk factors for metabolic and cardiovascular diseases – literature review

Znaczenie diety zawierającej siemię lniane w modyfikacji czynników ryzyka chorób metabolicznych i sercowo-naczyniowych – praca poglądowa

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Biegańska O, Przywara G, Biczak E, Barska-Kobylińska H, Byrska M, Weimann M, Janura M. The role of a diet including flaxseed in modifying risk factors for metabolic and cardiovascular diseases – literature review. Med Srodow. doi:10.26444/ms/215007

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Abstract

Introduction and Objective. Flaxseed is known for its wide range of health benefits. The aim of this literature review is to gather current scientific evidence regarding the effects of flaxseed consumption on risk factors for metabolic and cardiovascular diseases, such as blood pressure, lipid profile, glucose and insulin metabolism, and body weight.

Brief description of the state of knowledge. Research indicates that flaxseed can lower both systolic and diastolic blood pressure, affecting peripheral as well as central measurements. It also appears to improve the lipid profile by reducing total cholesterol, LDL- (including small dense LDL), VLDL-, and non-HDL cholesterol, as well as triglycerides. Additionally, it decreases the total cholesterol to HDL ratio, as well as the LDL to HDL ratio. Flaxseed consumption may also raise HDL cholesterol levels. Its positive effects extend to glucose and insulin metabolism – lowering fasting blood glucose and glycated haemoglobin levels, reducing insulin resistance, increasing insulin sensitivity, and improving post-meal blood sugar control. Including flaxseed in the diet might also help reduce body weight, BMI, waist and hip circumference, waist-to-hip ratio, and body fat mass. Furthermore, it may increase adiponectin levels.

Summary. Flaxseed has beneficial effects on blood pressure, lipid profile, glucose and insulin metabolism, and body weight. These benefits suggest that flaxseed may represent a valuable component of the daily diet supporting metabolic and cardiovascular health.

Key words

blood pressure, body weight, flaxseed, glucose level, linseed oil, lipid profile

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Streszczenie

Wprowadzenie i cel pracy. Siemię lniane jest znane ze swojego szerokiego spektrum właściwości zdrowotnych. Celem niniejszego przeglądu literatury jest zebranie aktualnych dowodów naukowych na temat wpływu spożycia siemienia lnianego na czynniki ryzyka chorób metabolicznych i sercowo-naczyniowych: ciśnienie tętnicze krwi, profil lipidowy, wskaźniki gospodarki węglowodanowej oraz masę ciała.

Opis stanu wiedzy. Badania wykazują, że siemię lniane obniża zarówno skurczowe, jak i rozkurczowe ciśnienie tętnicze krwi, mierzone w pomiarach obwodowych, jak również centralnych. Ponadto poprawia profil lipidowy poprzez obniżenie poziomu cholesterolu całkowitego, cholesterolu LDL (w tym małych, gęstych LDL), cholesterolu VLDL oraz cholesterolu nie-HDL. Spożycie siemienia lnianego obniża także poziom trójglicerydów i może podnosić poziom cholesterolu HDL, a także obniża stosunek cholesterolu całkowitego do HDL oraz stosunek LDL do HDL. Korzystne właściwości siemienia lnianego dotyczą także gospodarki węglowodanowej, a mianowicie obniża ono poziom glukozy na czczo i hemoglobiny glikowanej, zmniejsza insulinooporność, zwiększa wrażliwość na insulinę oraz poprawia kontrolę glikemii poposiłkowej. Wprowadzenie siemienia lnianego do diety może także pomóc w redukcji masy ciała, obniżeniu BMI, zmniejszeniu obwodu talii i bioder oraz stosunku talii do bioder, jak również w redukcji masy tkanki tłuszczowej. Co więcej, spożycie siemienia lnianego może podwyższać poziom adiponektyny.

Podsumowanie. Siemię lniane wykazuje korzystny wpływ na ciśnienie tętnicze krwi, profil lipidowy, wskaźniki gospodarki węglowodanowej oraz masę ciała. Korzyści te sugerują, że siemię lniane może stanowić wartościowy składnik codziennej diety, wspierający zdrowie metaboliczne i sercowo-naczyniowe.

Słowa kluczowe

ciśnienie tętnicze krwi, masa ciała, siemię lniane, poziom glukozy, olej lniany, profil lipidowy

INTRODUCTION

Flaxseed (*Linum usitatissimum*), also known as linseed, is widely known for its numerous health-promoting properties. It is a rich source of alpha-linolenic acid (ALA), which is an essential omega-3 fatty acid displaying cardio-protective and anti-inflammatory activity [1–3]. Flaxseed is also a rich source of dietary fibre, which is used to ease constipation [3–5]. According to the results of numerous studies, flaxseed exhibits anti-inflammatory properties. Its consumption has reduced markers of systemic inflammation – C-reactive protein (CRP) levels and tumour necrosis factor-alpha (TNF-α) [6–12]. Flaxseed may also enhance endothelial function, thereby supporting vascular health and reducing cardiovascular risk [13]. Flaxseed also exhibits antioxidant properties [12]. Scientific evidence suggests that flaxseed may support liver health, particularly in patients with non-alcoholic fatty liver disease (NAFLD) [14–16], and has been shown to improve metabolic parameters in polycystic ovary syndrome (PCOS) [6, 7, 17]. Flaxseed may also be beneficial for metabolic syndrome patients, as it may help lower systolic blood pressure, fasting plasma glucose, triglycerides level, and waist circumference [18, 19].

Because of different bioactive components and its promising effects, flaxseed has become a subject of interest in the treatment of some diseases.

OBJECTIVE

The aim of this literature review is to gather current scientific evidence regarding the effects of flaxseed consumption on risk factors for metabolic and cardiovascular diseases, such as blood pressure, lipid profile, glucose and insulin metabolism, and body weight.

MATERIALS AND METHOD

Original open-access articles in English concerning the effects of flaxseed on blood pressure, lipid profile, glucose and insulin metabolism, and body weight regulation were searched. For this purpose, the term 'flaxseed' was used in combination with the following key words: 'blood pressure', 'lipid profile', 'glucose', 'insulin', and 'body weight'. The PubMed, Google Scholar, and ScienceDirect databases were used and publications from 2015–2025 were considered.

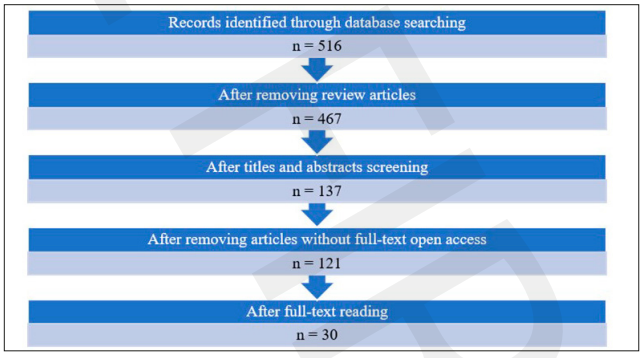

Figure 1. The literature selection process

DESCRIPTION OF THE STATE OF KNOWLEDGE

Blood pressure. Flaxseed supplementation can be effective in reducing blood pressure. In patients diagnosed with hypertension, a 12-week intervention involving the daily intake of 30 g of flaxseed powder (milled flaxseed) led to significant reductions in both systolic blood pressure (SBP) and diastolic blood pressure (DBP). Specifically, SBP decreased by 13.38 units, whereas in the placebo group, which received 30 g of wheat flour daily for 12 weeks, it increased by 1.72 units. Likewise, DBP decreased by 5.6 units, while rising by 2.39 units in the placebo group [20]. Similarly, patients with metabolic syndrome, consuming 30 g of whole flaxseed powder daily for 12 weeks experienced reductions in both SBP and DBP. Patients were advised to consume the flaxseed powder twice daily in 2 divided doses, either combined with 250 ml of water or added to a salad for lunch or dinner [18].

In another study, a reduction in SBP and DBP was observed in patients with metabolic syndrome as a result of consuming 25 ml of flaxseed oil daily for 7 weeks. The mean change in SBP was -14.0±22.41, while DBP decreased by -4.26±7.44. This study also compared the effects of flaxseed oil with sunflower seed oil, but no statistically significant reduction in blood pressure was observed in the group of patients consuming sunflower seed oil [21]. In another investigation, patients with ulcerative colitis were divided into 2 intervention groups. One group received 30 g of ground flaxseed daily, while the other group was supplemented with 10 g of flaxseed oil daily, both for a period of 12 weeks. Significant reductions in both SBP and DBP were observed in each group [22].

A notable decrease in SBP was recorded among healthy, elderly individuals who were classified into a subgroup with initial SBP ≥140 mm Hg. At the beginning, their mean SBP was 155±13 mm Hg, which decreased to 140±11 mm Hg following 24 weeks of intervention. The participants received a dosage of 600 mg of secoisolariciresinol diglucoside from a flaxseed complex rich in lignans, BeneFlax, once a day for 24 weeks. The supplement was mixed with mashed apples or another food, such as yoghurt. Additionally, the participants received 1,000 IU of vitamin D3 daily, compared to a control group who received whey protein at a weight equivalent to BeneFlax, alongside the same vitamin D3 dosage. The flaxseed group exhibited a significant reduction in SBP. There was no change in DBP in the subgroup of individuals with SBP ≥140 mm Hg. Among participants with initial SBP <140 mm Hg, no difference in blood pressure was observed after intervention, neither between the treatment and control group, nor the treatment group after 24-week period [23].

In contrast, another study found that flaxseed resulted in a decrease only in DBP, with no effect on SBP. The trial involved overweight youths who were either given 28 g a day of brown or golden flaxseed in various forms, at school every weekday for 11 weeks, or the equivalent amount of wheat bran in the control group. Both flaxseed groups demonstrated a significant DBP decrease: from 76.18±8.06 to 69.71±10.68 mmHg in the brown flaxseed group, and from 78.03±10.36 to 70.53±6.21 in the golden flaxseed group. It is worth noting, however, that the participants ingested only around half of the intended flaxseed dose, which might have been insufficient to achieve all the potential health effects [24].

Beyond its impact on peripheral blood pressure, the effect of flaxseed on central blood pressure was also specifically examined. The patients diagnosed with peripheral artery

disease were given one specially formulated food product a day for one year, either containing milled flaxseed (30 g), or placebo produced using wheat with various dietary oils. The food options included snack bars, tea biscuits, buns, pasta, bagels, and muffins. Central SBP (cSBP) decreased in both the flaxseed and placebo groups, though the effect was more pronounced in the flaxseed group, showing decreases of 3.4 mm Hg at 6 months and 4.9 mm Hg at 12 months. In contrast, the placebo group saw a decrease of 1.7 mm Hg and 3.3 mm Hg at the respective time points. Regarding central DBP (cDBP), only the flaxseed group showed a significant reduction – 1.3 mm Hg at 6 months and 2.6 mm Hg at 12 months, whereas the placebo group experienced an increase in cDBP of 1.1 mm Hg at 6 months and 1.5 mm Hg at 12 months. Additionally, the blood pressure-lowering effects of flaxseed were more pronounced among hypertensive patients. The reduction in cSBP from baseline was 7.9 mm Hg at 6 months and 14.2 mm Hg at 12 months. The reduction in cDBP from baseline was 5.3 mm Hg at 6 months and 8.7 mm Hg at 12 months. Although cDBP changes from baseline in hypertensive subjects were significant, comparisons with the placebo group did not reach statistical significance. The study concluded that flaxseed-induced reductions in central blood pressure occurred without cardiovascular impact, but through decrease in plasma oxylipins [25].

Lipid profile. Flaxseed may improve lipid profile. Numerous studies have demonstrated that flaxseed effectively lowers total cholesterol levels [5, 10, 11, 13, 20, 21, 26–33]. In several of these studies, such an effect was achieved through the consumption of milled flaxseed, most commonly in the amount of 30 g per day for 12 weeks, but also over shorter periods, such as 40 days, or longer durations, such as one year, as well as with smaller amounts, such as 16 g per day for 90 days [11, 20, 29, 30, 32, 33]. A reduction in total cholesterol was also achieved through flaxseed oil consumption, administered in varying doses and durations – 10 g/day for 12 weeks, 20 g/day for 10 weeks, or 25 ml/day for 7 weeks [21, 26, 27]. In one of these studies various food products, such as buns, milk powder, sausage, and crunchy wafer layered with chocolate cream, were supplemented with flaxseed oil [27]. Total cholesterol-lowering effects were also observed with various flaxseed-based interventions, including: flaxseed oil capsules containing 400 mg of α-linolenic acid each; lower dosage of flaxseed mucilage ingested twice a day for 12 weeks; sugar-free, sugarless maltodextrin-based biscuits with an orange taste enriched with 2.5 g of flaxseed each (2 biscuits taken twice daily for 12 weeks); and biscuits providing 28 g per day of milled flaxseed, ingested over a 10-week period [5, 10, 28, 31].

There is scientific evidence indicating that flaxseed lowers low-density lipoprotein (LDL) cholesterol, including small dense LDL (sd-LDL) particles [5, 21, 26, 27, 30–32, 34, 35]. Moreover, milled flaxseed enhanced the LDL-cholesterol-decreasing effects of hypocholesterolaemic drugs, as evidenced by an 8.5% reduction in LDL cholesterol after 12 months of flaxseed supplementation combined with pharmacotherapy, compared to a 3.0% increase in the group using pharmacotherapy alone [30]. Interestingly, biscuits from flaxseed flour significantly reduced LDL cholesterol levels in individuals with the TT genotype of rs11076023, whereas no such effect was observed in those with the AA or AT genotypes, suggesting a genetically modulated reaction [35].

Flaxseed can also lower non-high-density lipoprotein (non-HDL) cholesterol and very low-density lipoprotein (VLDL) cholesterol [10, 26]. In Japanese men, a 12-week supplementation with 10 g of flaxseed oil once daily with dinner resulted in significantly lower non-HDL cholesterol concentrations, compared with the group receiving corn oil [26]. In women with gestational diabetes who consumed flaxseed oil supplements, after 6 weeks of intervention VLDL cholesterol levels were significantly reduced by 8.10 mg/dL, compared to the placebo group [10].

Only a few studies have shown an increase in high-density lipoprotein (HDL) cholesterol following flaxseed consumption. In one study, participants (elderly individuals aged 60 and above) were randomly assigned to receive either flaxseed oil capsules (3 g/day) or a placebo (gelatin powder) for 90 days. The supplementation was administered as 6 capsules of 500 mg daily – 3 before lunch and 3 before dinner. All participants adhered to a healthy diet, and subgroups were stratified by saturated fat consumption: low (<7% of total energy content) or high (>7% of total energy content). In the control group, following the diet without flaxseed supplementation, no significant increase in HDL cholesterol was observed. Only the combination of the diet and flaxseed supplementation resulted in a significant elevation in HDL levels. The effect was especially pronounced among participants with lower saturated fat consumption, highlighting the synergistic benefit of flaxseed oil supplementation alongside dietary modification [36]. In another study, metabolic syndrome patients with ulcerative colitis of mild to moderate severity consumed 30 g per day of brown milled flaxseed for 12 weeks, divided into 2 doses of 15 g each, taken at lunch and dinner with yoghurt, salad or cold drinks. Compared to the control group, flaxseed supplementation resulted in a significant rise in HDL cholesterol levels [33].

Flaxseed supplementation has also been shown to reduce the total cholesterol to HDL ratio, as well as the LDL to HDL cholesterol ratio [5, 10, 27]. Among women with gestational diabetes who consumed flaxseed oil supplements, the total cholesterol to HDL ratio was significantly reduced after 6 weeks of intervention, with an average decrease of 0.58 compared to the placebo group [10]. In another study, a 10-week consumption of biscuits providing 28 g of milled flaxseed per day resulted in a reduction of 1.3 in the mean total cholesterol to HDL ratio [5]. Regarding the LDL to HDL ratio, it was significantly decreased in the above-mentioned study in which participants consumed various food products supplemented with flaxseed oil, such as buns, milk powder, sausage, and a crunchy wafer layered with chocolate cream [27].

Numerous studies have demonstrated that flaxseed also effectively lowers triglycerides [10, 11, 18, 19, 21, 28, 29, 31–33, 37]. In several studies, triglyceride levels decreased following the daily consumption of 30 g of milled flaxseed for 12 weeks. In one study, the reduction in triglycerides in the flaxseed group was 69.87 mg/dL greater than in the control group [18]. In another study, the decrease was 53.71 mg/dL greater, similar, to a third study, in which it was 53.03 mg/dL greater than in the control group [11, 19]. In a fourth study, the decrease was only 7.87 mg/dL greater compared to the control group [33]. In another study, participants also consumed 30 g of raw flaxseed powder daily, but for a shorter period of 40 days, which resulted in a 67.13 mg/

dL greater reduction in triglyceride levels compared to the control group [32]. In the study where participants consumed biscuits containing flaxseed meal for breakfast for 60 days, a 38.97 mg/dL greater reduction in triglyceride levels was observed than in the control group [37]. A triglyceride-lowering effect was also demonstrated for a high dose of flaxseed mucilage, administered twice daily for 12 weeks, which reduced triglyceride levels by 35.43 mg/dL more than in the control group [28]. A similar effect was observed following the consumption of supplements containing n-3 fatty acids from flaxseed oil, administered at a dose of 1,000 mg twice daily for 6 weeks. A 40.49 md/dL greater reduction in triglyceride levels was then achieved compared to the control group [10].

It is worth noting that flaxseed consumption combined with lifestyle adjustment had stronger effects than lifestyle adjustment alone [11, 19, 36].

Glucose and insulin metabolism. Flaxseed may have a positive effect on glucose and insulin metabolism parameters. It has been shown to reduce fasting plasma glucose and glycated haemoglobin [5, 10, 18, 29, 35].

Flaxseed supplementation reduces HOMA-IR, indicating a decrease in insulin resistance [10, 18, 19, 33]. It also increases QUICKI or the Matsuda Index, indicating an increase in insulin sensitivity [10, 18, 19]. Additionally, flaxseed intake is associated with lower levels of insulin and C-peptide, as well as a reduction in the HOMA-β index, suggesting decreased pancreatic insulin secretion [10, 12, 18, 33].

Flaxseed has been shown to consistently improve postprandial glycaemic response across various populations and study designs. In male patients with diabetes mellitus (type 2), ingestion of milled raw golden flaxseed (15 g) prior to breakfast significantly reduced the 2-hour post-prandial glycaemia, specifically with a 17% decrease in glucose peak elevation and a 24% reduction in the 2-hour area under the curve (AUC) [38]. Among individuals with an elevated risk of developing type 2 diabetes, administration of puddings made with starch and maltose syrup with soluble flaxseed gum added, resulted in lowered post-meal glucose and insulin peaks. This effect appears to be mediated by the increased gastrointestinal viscosity induced by soluble dietary fibre, likely delaying food passage from the stomach rather than affecting starch hydrolysis or sugar transport [39]. Likewise, in healthy adults who underwent a glucose challenge (50 g), with the inclusion of 31.5 g of milled flaxseed, the intervention led to a marked attenuation of post-prandial glycaemia, including a 60.0±19.7 mmol/l·min reduction in glucose AUC, and a 0.44±0.12 mmol/l decrease in average plasma glucose during 120 minutes, along with a lower peak glucose elevation by 0.73±0.24 mmol/l [40]. Moreover, in participants' everyday life settings, daily consumption of muffins with flaxseed (each containing 10 g of flaxseed), either as a single morning dose or distributed across 3 meals (totalling 30 g/day), significantly reduced the 24-hour incremental AUC, with the greatest benefit observed when flaxseed was consumed in smaller, spaced portions. Both flaxseed strategies also led to significantly lower nocturnal glucose levels compared to the control group [41].

Flaxseed has also shown beneficial effects on metabolic parameters in cases of gestational diabetes. Following a 6-week, twice a day supplementation of 1,000 mg of n-3 fatty acids from flaxseed oil (each capsule containing 400 mg of α-linolenic acid), participants exhibited reductions in fasting plasma glucose, HOMA-IR, along with an increase in QUICKI, compared to the placebo group (sunflower oil) [10].

The combination of flaxseed with lifestyle adjustment proved to be more effective in improving metabolic parameters than lifestyle adjustment implemented in isolation [26]. Furthermore, in individuals with type 2 diabetes, supplementing on-going metformin treatment with 16 g of flaxseed daily over a 3-month period resulted in better normalization of blood glucose and glycated haemoglobin levels, compared to metformin treatment alone [29].

A beneficial effect on glucose and insulin metabolism has been demonstrated not only for milled flaxseed powder, but also for buns with flaxseed mucilage, flaxseed biscuits, biscuits with de-fatted flaxseed flour, or flaxseed muffins [5, 35, 41].

The effect of flaxseed on glycaemia may depend on the genotype of the individual. It was demonstrated that the consumption of biscuits from flaxseed flour significantly reduced levels of fasting plasma glucose in individuals with the CC genotype of the NPY rs16147 polymorphism, whereas the effect was less pronounced in T-allele carriers (TT + TC), with a significant interaction observed between diet and genotype [35].

Body weight regulation. Flaxseed may be beneficial for overweight and obese patients. It was demonstrated that flaxseed mucilage, administered twice daily for 12 weeks, led to reductions in body weight, Body Mass Index (BMI), waist circumference, hip circumference, and fat tissue mass in patients with overweight and moderate obesity. The group consuming flaxseed mucilage at higher dosage experienced an average weight loss of 4.96±1.89 kg, while the group taking lower dosage lost 3.70±2.57 kg, both significantly more than the placebo group which followed a calorie-restricted diet without any supplementation (1.33±2.05 kg). Additionally, 68% of participants in the higher dosage group and 46% in the lower dosage group achieved at least 5% of weight reduction, in comparison to only 9% in the placebo group [28].

Also in many other studies, flaxseed consumption has been associated with significant reductions in body weight and BMI [5, 11, 19–21, 32, 35, 37]. Participants typically consumed 30 g of milled flaxseed daily for a duration of 12 weeks [11, 19, 20]. In one study, participants consumed 30 g of flaxseed daily for a shorter period of 40 days, which also led to reductions in body weight and BMI [32]. In another study, patients experienced weight loss by consuming 25 ml of flaxseed oil daily for 7 weeks [21].

There is an interesting and attractive form of flaxseed product that may also be effective in combatting overweight and obesity – biscuits. In one study, participants consumed sugarless maltodextrin-based biscuits with an orange taste enriched with 2.5 g of flaxseed each (2 biscuits taken twice daily for 12 weeks), resulting in a total daily intake of 10 g of flaxseed [5]. In other studies, participants consumed biscuits (100 g) made with low-fat flaxseed meal, at breakfast for 60 days, or 8 weeks [35, 37]. In all the above-mentioned studies, flaxseed biscuits led to significant reductions in body weight and BMI among the participants.

Integrating flaxseed supplementation with lifestyle adjustment yields greater efficacy in managing metabolic syndrome and promoting weight loss, compared to lifestyle adjustment alone [11, 19]. Individuals who were given flaxseed

noticed a decrease in appetite, a lower sense of hunger, and fewer food-related intrusive thoughts [11, 37]. Furthermore, flaxseed could decrease visceral fat accumulation and obesity risk by enhancing adiponectin levels [3].

It is worth highlighting that the effect of flaxseed on body weight and BMI may depend on gene polymorphisms associated with hunger and the feeling of fullness. Significant reductions in body weight and BMI were observed in individuals carrying the A allele (AA + AT) of the FTO gene (rs11076023) and the A allele (AA + AG) of the BDNF gene (rs6265). A similar weight reduction was seen in participants carrying T-allele (TT + TC) of the PCSK1 gene (rs155971), and not in individuals not-carrying this allele. These findings suggest that the effectiveness of flaxseed in managing body weight may be influenced by individual genetic differences, highlighting the potential for individualized nutrition plans based on genetic profile [35].

Apart from the impact on body weight and BMI, consumption of milled flaxseed or flaxseed oil has been shown to reduce waist circumference [3, 19, 21, 22]. In the studies by Morshedzadeh et al., Ahmadniay Motlagh et al., and Yari et al., the consumption of 30 g of milled flaxseed daily for 12 weeks resulted in a reduction in waist circumference that was 1,29 cm, 4,52 cm, and 6,25 cm greater, respectively, compared to the control group [3, 19, 22]. In the aforementioned study by Morshedzadeh et al., a group that consumed 10 g of flaxseed oil daily for 12 weeks was also examined, showing a 1.11 cm greater reduction in waist circumference, compared to the control group [22]. Similarly, in the study by Akrami et al., the group that consumed 25 mL of flaxseed oil daily for 7 weeks achieved a statistically significant reduction in waist circumference, with a mean decrease of 2.26 cm. No such statistically significant reduction was observed in the group consuming sunflower seed oil in the same amount and for the same duration as in the flaxseed group [21]. Flaxseed may also reduce waist-to-hip ratio. In the aforementioned study by Ahmadniay Motlagh et al., apart from the decrease in waist circumference, the consumption of 30 g of milled flaxseed daily for 12 weeks also resulted in a statistically significant reduction in the waist-to-hip ratio, which was 0.03 greater than in the control group [3].

Flaxseed also positively affected satiety indicators such as fullness, hunger, general appetite, and need to eat [40].

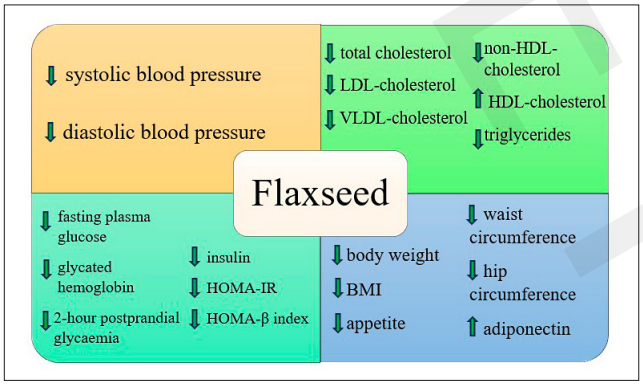

Figure 2. Beneficial effects of flaxseed on blood pressure, lipid profile, glucose and insulin metabolism, and body weight regulation

DISCUSSION

This review presents studies demonstrating the effects of flaxseed on blood pressure, lipid profile, glucose and insulin metabolism parameters, body weight, BMI, and anthropometric measurements such as waist circumference and waist-to-hip ratio. However, some studies have not demonstrated a statistically significant impact of flaxseed consumption on these parameters.

Evidence from some trials suggests a lack of effect of flaxseed on blood pressure regulation [19, 33, 37, 42]. In numerous studies, flaxseed consumption was not associated with improvements in total cholesterol, LDL, non-HDL, VLDL, or HDL cholesterol, nor in the total cholesterol to HDL cholesterol ratio, LDL to HDL cholesterol ratio, or triglyceride levels[3,5,7,13,19,23,24,28,32,36,37,43]. In one study, flaxseed even resulted in a significant reduction of HDL cholesterol, indicating a worsening of its levels [26].

In other studies, flaxseed did not lower fasting plasma glucose or glycated haemoglobin [5, 21, 24, 28, 34, 37, 43]. No significant effect was observed on fasting insulin levels or insulin resistance [43]. In one study, flaxseed even worsened (increased) insulin resistance [11]. Flaxseed also did not improve post-prandial glucose and insulin levels [43].

Furthermore, several studies have reported no effect of flaxseed on body weight and BMI [8, 10, 22, 30, 33]. Interestingly, one study even reported an increase in participants' body weight [24]. The use of flaxseed did not contribute to a smaller waist circumference or an improved waist-to-hip ratio [11, 24, 30, 33, 37].

The reason for the markedly different conclusions drawn in studies on flaxseed may lie in the highly varied methodologies used. Some studies examined the effects of ground flaxseed, administered in varying daily amounts, with different frequencies throughout the day, and over different durations. In some studies, participants were instructed to add flaxseed to their meals themselves, while in others, they were provided with prepared meals containing flaxseed. In many cases, raw flaxseed was used, whereas in others, it was baked into products such as biscuits or muffins. In some cases flaxseed flour was used for baking, while in others whole seeds. Additionally, some studies investigated the effects of flaxseed oil, also administered in different daily doses and for varying durations. The studies also differed in terms of sample size and participant characteristics – some included healthy individuals, while others focused on patients with various health conditions.

In addition to these factors, the genotype of the participants may also play a significant role. It appears that individuals with certain alleles respond more favourably to flaxseed consumption than those with other genetic variations [35, 44].

Generally, flaxseed is economical, palatable and simple to include in daily meals, and usually satisfactorily tolerated by patients [5, 28, 38]. However, it may be poorly tolerated by some patients and can cause side-effects such as gastrointestinal cramps or excess gas [41, 45].

SUMMARY

In summary, flaxseed can lower both systolic and diastolic blood pressure, affecting peripheral as well as central measurements. It also appears to improve the lipid profile by

reducing total cholesterol, LDL- (including small dense LDL), VLDL-, and non-HDL cholesterol, as well as triglycerides. Additionally, it improves the total cholesterol to HDL and LDL to HDL ratios. Flaxseed consumption may also raise HDL cholesterol levels. Its positive effects extend to glucose and insulin metabolism – lowering fasting blood glucose and glycated haemoglobin levels, reducing insulin resistance, increasing insulin sensitivity, and improving post-meal blood sugar control. Including flaxseed in the diet might also help reduce body weight, BMI, waist and hip circumference, waist-to-hip ratio, and body fat mass. Furthermore, it may increase adiponectin levels. These benefits suggest that flaxseed may represent a valuable component of the daily diet supporting metabolic and cardiovascular health.

More well-designed, high-quality, large-scale studies are needed to better understand the impact of flaxseed on metabolic health and other clinical outcomes.

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