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Research Article

Effect of the Flaxseed Supplementation on the BMI, WHR, SBP, DBP, Cholesterol, and Triglycerides in Mild Hypertensive Patients

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Abstract

Flaxseed (*Linum Usitatissimum*) is an oilseed rich in dietary fiber, alpha-linolenic acid, and lignans. It is a well-known nutritional supplement for weight loss and other health ailments. The study was conducted to see the effect of flaxseed intake on the Body Mass Index (BMI), Waist Hip Ratio (WHR), Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP), cholesterol, and triglyceride in mild hypertensive patients. Likewise, the study also intends to test the effect of the duration of dietary supplementation on the BMI, WHR, systolic blood pressure, diastolic blood pressure, cholesterol, and triglyceride. This study hypothesized that the intake of 10 gm/day of roasted flaxseed as a dietary supplement would significantly moderate the BMI, WHR, systolic blood pressure, diastolic blood pressure, cholesterol, and triglyceride in mild hypertensive patients. We performed a two-way repeated measure ANOVA test on finding using the SPSS tool to test the hypothesis. The result reveals that the 10gm per day of flaxseed intake as a dietary supplement significantly impacts the BMI, WHR, systolic blood pressure, diastolic blood pressure, cholesterol, and triglyceride.

Keywords: Flaxseed; Oilseed; Hypertension; Prehypertensive Patients; Cholesterol; Body Mass Index; BMI; Waist Hip Ratio; WHR; Triglycerides; Cholesterol; Cardiovascular Diseases; Systolic Blood Pressure; Diastolic Blood Pressure

Abbreviations

BMI: Body Mass Index; BP: Blood Pressure; WHR: Waist Hip Ratio; CVD: Cardiovascular Disease; HR: Heart Rate; HTN: Hypertension; SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure; ALA, Omega-3 α-Linolenic Acid, C18:3n-3

Introduction

This section discusses the adverse effect of hypertension and classifies its categories. Then, we review the therapeutic properties of flaxseed (*Linum Usitatissimum*) with nutritive values and its role in risk factor management.

Effect of hypertension

Hypertension or high blood pressure is one of the major risk factors for cardiovascular and kidney diseases [1]. Hypertension is one of the chronic medical conditions leading to cardiovascular diseases, and it contributes significantly to myocardial infarction, heart failure, and stroke. Every year worldwide, it is one of the major causes of health problems and mortality, leading to yearly 10.4 million deaths [2-3]. The blood pressure is generally measured with two readings systolic and diastolic. According to the 8th JNC (Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure), the range of the systolic blood pressure and diastolic blood pressure is in the prehypertension category of 120-139 mmHg and 80-89 mmHg, respectively [4].

The complete classification of hypertension is shown in table 1.

Classification (JNC8)	Systolic pressure	Diastolic pressure
	mmHg	mmHg
Normal	90-119	60-79
High normal or prehypertension	120-139	80-89
Stage 1 hypertension	140-159	90-99
Stage 2 hypertension	≥ 160	≥ 100
Isolated systolic hypertension	≥ 140	< 90

Table 1: JNC 8 Classification of hypertension [4].

In most patients, hypertension stays asymptomatic for several years; as a result, it is also contributed to major secondary stage diseases such as CVD and kidney diseases, etc. Hypertension is categorized into two categories primary and secondary hypertension. Around 90-95% of the cases of hypertension are in the category of primary hypertension [1]. The symptoms like headache, dizziness, palpitations/racing heart, sweating, neck pain, nausea or vomiting, lightheadedness, chest pain, vertigo, tinnitus, and fainting episodes indicate the presence of primary hypertension. Secondary hypertension is primarily due to elevated blood pressure and other health conditions such as kidney, arteries, heart, or endocrine system ailments contributing around 5-10% to overall hypertension cases [3].

The cholesterols and triglycerides are grouped as a blood lipid profile. Any rise in the blood lipids may give rise to the condition of hyperlipidemia. As blood flows through arteries and the plaque deposition due to cholesterol and calcium makes the arteries harder and narrower [5], it may increase the chances of cardiovascular diseases in the patient [6]. Studies show that alternative therapies and diet play a vital role in improving blood lipid levels [7]. Recent studies show that preventable environmental factors such as nutrition and dietary management contribute to more than 90% of all myocardial infractions [8]. Altering the intake of saturated and polyunsaturated fats may affect the patient's health condition. Having more polyunsaturated fats and limiting the amount of saturated fat in the diet have shown remarkable improvement in cardiovascular disease, as cardiovascular disease recurrence rates are reduced by 30-70%. This is due to these diets having rich ALA content [9-10]. The study shows that a diet with high PUFA and ALA content significantly affects primary and secondary cardiovascular disease and has a cardioprotective effect [11].

Therapeutic properties of Flaxseed *(Linum Usitatissimum)*

The nutritional intervention studies play a vital role in combating cardiovascular and other lifestyle diseases. Diet and nutrition management are used to control and cure lifestyle diseases. One of the most ancient medicinal science scriptures, Ayurveda, is based on diet and herbs to heal and prevent diseases. The global pandemic of obesity and sedentary lifestyle gives rise to lifestyle diseases such as hypertension and cardiovascular disease. Dietary flaxseed supplementation helps improve symptoms of cardiovascular disease, cancer, diabetes, inflammation, and hot flashes. It also lowers LDL cholesterol levels [12]. Flaxseed is an ancient crop; considering its health benefits in the 8th century, King Charlemagne passed laws requiring his subjects to consume it [12]. It belongs to the family of Linaceae and the genus Linum. It is also known as Alsi in Hindi, Agasi in Kannada, Atasi/Jawas in Marathi, Pesi in Oriya, Ali Vidai in Tamil, Tishi in Bengali, Cheruchana Vithu in Malayalam, Avise Jinjalu in Telugu, Flax, and Flax Weed. There are about 100 species of flaxseed all over the world. It is cultivated for its fiber, seed, and oil [13].

Flaxseed contains 22.81mg/100g total Omega-3 (C18:3) Fatty Acid sand 5.91g/100g Total Omega6 (C18:2) Fatty Acids respectively and 255mg/100g Calcium, 813 mg/100g Potassium, and 0.31mg/100g Vitamin E (Alpha Tocopherol) [14,15].

Flaxseed is also a rich source of Omega-3 fatty acid, ALA, and secoisolariciresinol diglucoside (SDG) lignans [16].

However, flaxseed may be consumed in various forms like Raw flaxseed, powder, oil, etc. It impacts both anthropometric, biophysical, and biochemical assessments of the patients. The study by Djousse., *et al.* on 4584 patients (age 25 - 99 years) of both sexes with the mean intake of linolenic acid 0.81g/d for men and 0.69g/d for women found that the dietary linolenic acid is inversely related to triacylglycerol concentration [17]. Several studies are available in the literature showing a positive impact of flaxseed on BMI and WHR [18-21]. Flaxseed also showed a positive impact on the reduction of biophysical (systolic and diastolic blood pressure) assesment [22-26]. Several authors reported that consumption of flaxseed had shown a significant effect on cholesterol and triglycerides [27,28].

The objective of the study

In order to assess the impact of Flaxseed supplementation on the BMI, WHR, Triglycerides, Cholesterol, and Blood Pressure in mild hypertensive patients, the study is broadly divided into the following objectives:

- To identify and enroll the patients with mild hypertension conditions.
- To assess the impact of roasted flaxseed supplementation on biochemical (Cholesterol and Triglycerides) assessment of the patients.
- To assess the impact of roasted flaxseed supplementation on biophysical (Systolic blood pressure (SBP) and Diastolic Blood Pressure (DBP)) assessment of the patients.
- To assess the impact of roasted flaxseed supplementation on the patients' anthropometrical (BMI and WHR) measurements.
- Divide enrolled patients into two groups, i.e., flaxseed and control groups, to see the effectiveness of roasted flaxseed supplementation.

Methodology

The study was conducted at Haldiram Moolchand Govt. Cardiovascular Science and Research Center, an associated hospital of S. P. Medical College and P. B. M. Hospitals, Bikaner, Rajasthan, India. An approval from the ethical committee was taken to conduct the intervention study on mild hypertensive patients. Approximately 60 patients with mild hypertensive conditions willing to participate in the study were selected from the hospital's Outdoor Patient Department (OPD). The willing patients were informed about the purpose and course of the study, and a signed informed consent form (ICF) was collected from enrolled patients. The study was carried out for two months. The patients were divided into two groups, i.e., 30 patients in the control group without any supplementation and 30 patients in the flaxseed group with 10 gm of roasted flaxseed supplementation daily. The patients' demographic information was recorded at the time of enrollment. The patients' pre-intervention, mid-intervention, and post-intervention anthropometric, biophysical (Systolic and diastolic blood pressure), and biochemical (cholesterol and triglycerides) measurements were recorded for both groups.

Patient selection criteria

The patients were selected based on the following criteria:

- Presence of mild hypertension (systolic BP 120-139 mmHg and diastolic BP 80-89 mmHg).
- Patients of both sexes.
- Patients age < 55 years.
- The patient was willing to participate and cooperate during the study.

Results and Discussion

Data processing and statistical analysis

Unless otherwise stated, all data values were expressed in the mean ± SD (standard deviation). The data analysis was carried out using a Two-Way Repeated Measures Analysis of Variance (ANOVA) test to test the significance of the findings using IBM's SPSS statistics tool. Measurements within the group and between the group were carried out at a 5% significance level. The repeated measure was carried out to compare the changes within the group during the duration of the study. The significance (ρ) and partial eta square (η^2_p) were observed. The ρ *-value* may provide insight into the main effect, whether the interaction was statically significant or not, while the partial eta square (η^2_p) which measures the proportion of variance associated with each interaction effect or main effect and provides details on the magnitude of these effects.

Demographic analysis of the patients

The recorded data of both groups were categorically processed in age, gender, education qualification, occupation, income status, and marital status. Also, the data about the type of the family, food habits, physical activity patterns, other habits (smoking, alcohol, tobacco consumption), and family history of diseases (history of hypertension, other conditions, and hypertension with other diseases) were recorded and processes. The ratio of age for both groups is evenly distributed with distribution as < 35 (control 30%, flaxseed 60%), 35-45 (control 50%, flaxseed 33.33%), and > 45 (control 20%, flaxseed 6.6%) age groups. Similarly, almost equal nos. of males (21, 19 individuals for control and flaxseed groups, respectively) and females (9, 11 individuals for control and the flaxseed groups, respectively) were enrolled. The educational qualifications for both groups were well distributed. Mostly, patients were married (96.66% for the control group and 93.33% for the flaxseed group) and living in the nuclear family in both groups. In the control group, 80% and 16.66% of patients were vegetarian and ovo-vegetarian. While for the flaxseed group, the patients were distributed amongst vegetarian (73.33%), nonvegetarian (16.66%), and ovo-vegetarian (10%). Patients of both groups had a sedentary lifestyle. The control group had 26.66% patients with a family history of hypertension, while the flaxseed group patients had a 10% hypertension family history. The control and flaxseed group's 40% and 63.33% patients had other diseases with hypertension.

Anthropometric, biochemical, and biophysical assessment of the patients

The details of the main effect of the 10gm per day flaxseed intake as a dietary supplement on the BMI, WHR, systolic blood pressure, diastolic blood pressure, cholesterol, and triglycerides are shown in the group below:

Body mass index (BMI)

The results of the two-way repeated-measures ANOVA revealed that there is a significant (using Greenhouse-Geisser correction) main effect of 10gm/day Flaxseed intake on participants' BMI, F (1.38, 80.55) = 4.063, $\rho < .05$ ($\rho = .034$), $\eta^2_p = 0.06$. Likewise, the results also shows that there is a significant (using Greenhouse-Geisser correction) within-subject interaction between the period and flaxseed supplementation on participants' BMI, F (1.38, 80.55) =98.60, $\rho < 0.001$, η^2_p = 0 .63. But, there is no significant interaction between the both groups (control and flaxseed), F (1,58) =1.47, $\rho >$ .05 (ρ = .230), $\eta^2_p = 0.025$. The control group's mean score increases from the pre-intervention (M = 26.87) to the post-intervention phase (M = 27.44). In contrast, the mean score for the flaxseed group decreases from the pre-intervention phase (M = 26.74) to the post-intervention phase (M = 25.91). These findings support the fact that 10gm/day flaxseed supplementation had a significant effect on BMI.

Graph 1: Pre and Post intervention means of the Control group.

Waist hip ratio (WHR)

The results of the two-way repeated-measures ANOVA revealed that there is a main effect of 10gm/day Flaxseed intake on participants' WHR, F (2, 116) = 3.54, $\rho < .05$ ($\rho = .032$), η^2_p = .058. likewise, the results also show that there is a significant within-subject interaction between the period and flaxseed supplementation on WHR, F (2, 116) = 41.14, $\rho < .001$, $\eta^2_p = .415$. There is also significant interaction between both groups (control and flaxseed), F (1, 58) =4.00, $\rho = .05$, η^2_p= .065. The control group's mean score increases from the pre-intervention (M = .874) to the post-intervention (M = .881) phase, while the mean score for the flaxseed group decreases from the pre-intervention (M = .866) to the post-intervention phase (M = .853). These findings suggested

Graph 2: Pre and Post intervention means of the flaxseed group.

that 10gm/day flaxseed supplementation has a significant effect on the Waist Hip Ratio (WHR).

Systolic blood pressure (SBP)

The results of the two-way repeated-measures ANOVA revealed that there is a significant (using Huynh-Feldt correction) main effect of 10gm/day Flaxseed intake on participants' SBP, F (1.58, 91.91) = 4.23, $\rho < .05$ ($\rho = .025$), $\eta^2_p = .068$. likewise, the results also shows that there is a significant (using Huynh-Feldt correction) within-subject interaction between the period and flaxseed supplementation on SBP, F (1.58, 91.91) = 120.37, $\rho < .001$, $\eta^2_p = .675$. There is also significant interaction between both groups (control and flaxseed), F (1, 58) = 27.14, $\rho < .001$, $\eta^2_p = .319$. The control group's mean score increases from the pre-intervention (M = 131.97) to the post-intervention (M = 134.13) phase, while the mean score for the flaxseed group decreases from the pre-intervention (M = 132.37) to the post-intervention phase (M = 129.23). These findings suggested that 10gm/day of flaxseed supplementation significantly affects the Systolic Blood Pressure (SBP).

Graph 3: Pre and Post intervention means of both groups.

Diastolic blood pressure (DBP)

The results of the two-way repeated-measures ANOVA revealed that there is a Significant (using Greenhuse - Geisser correction) main effect of 10gm/day Flaxseed intake on participants' DBP, F (1.27, 73.75) = 5.88, $\rho < .05$ ($\rho = .012$), $\eta^2_p = .092$. likewise, the results also shows that there is a significant (using Greenhuse -Geisser correction) within-subject interaction between the period and flaxseed supplementation on DBP, F (1.27, 73.75) = 53.29, $\rho < .001$, $\eta^2_p = .479$. There is also significant interaction between both groups (control and flaxseed), F (1, 58) = 6.04, $\rho < .05$ ($\rho < .017$), $\eta^2_p = .094$. The control group's mean score increases from the pre-intervention (M = 87.47) to the post-intervention (M = 88.73) phase, while the mean score for the flaxseed group decreases from the pre-intervention (M = 87.80) to the post-intervention phase (M = 85.30). These findings suggested that 10gm/day flaxseed supplementation significantly affects the Diastolic Blood Pressure (DBP).

Cholesterol

The two-way repeated-measures ANOVA results revealed a significant (using Huynh-Feldt correction) main effect of 10gm/day Flaxseed intake on participants' cholesterol, F (1.82, 105.98) =3.181, $\rho = .05$, $\eta^2_p = .052$. Likewise, the result shows that there is a significant interaction between the period and flaxseed supplementation on cholesterol F (1.82, 105.98) =3.59, $\rho < 0.05$ ($\rho = .035$), $\eta^2_p = .058$. However, there is no significant interaction between both groups (control and flaxseed), F (1, 58) =.010, $\rho > 0.05$ ($\rho = 0.92$), $\eta^2_p = .000$. The control group's mean score increases from the pre-intervention (M=181.67) to the post-intervention (M=185.67) phase, while the mean score for the Flaxseed group decreases from the pre-intervention (M=190.07) to the post-intervention phase (M=165.20). These findings suggested that

Graph 4: Percentage change in the anthropometric, biochemical, and biophysical mean measurement for both groups of patients.

10gm/day of flaxseed supplementation has a more significant effect on cholesterol.

Triglycerides

The two-way repeated-measures ANOVA results revealed a significant (using Huynh-Feldt correction) main effect of 10gm/day Flaxseed intake on participants' triglyceride, $F(1.74, 101.12) = 3.833$, $\rho < 0.05$ ($\rho = .030$), $\eta^2_p = 0.062$. Likewise, the result shows that there is a Significant (using Huynh-Feldt correction) interaction between the period and flaxseed supplementation on triglycerides, $F(1.74, 101.12) = 3.30$, $\rho < 0.05$ ($\rho = .047$), $\eta^2_p = 0.054$. However, there is no significant interaction between both groups (control and flaxseed), $F(1, 58) = 1.55$, $\rho > 0.05$ ($\rho = .218$), $\eta^2_p = 0.026$. The control group's mean score increases from the preintervention (M=182.30) to the post-intervention (M=188.30) phase, while the mean score for the flaxseed group decreases from

Variables	Benchmark	IV diff	Error Diff	F Value	*p-value*	η^2_p
BMI	Within the Group (Time)	1.389	80.559	4.063	0. 034	0.065
	Interaction (Time * Treatment)	1.389	80.559	98.600	<.001	0.630
	Between the Group (Treatment)	1	58	1.474	0.230	0.025
WHR	Within the Group (Time)	2	116	3.547	0.032	0.058
	Interaction (Time * Treatment)	2	116	41.141	<.001	0.415
	Between the Group (Treatment)	1	58	4.005	0.050	0. 065
Systolic blood pressure	Within the Group (Time)	1.585	91.913	4.232	0.025	0.068
	Interaction (Time * Treatment)	1.585	91.913	120.370	<.001	0.675
	Between the Group (Treatment)	1	58	27.141	<.001	0.319
Diastolic blood pressure	Within the Group (Time)	1.272	73.759	5.881	0.012	0.092
	Interaction (Time * Treatment)	1.272	73.759	53.298	<.001	0.479
	Between the Group (Treatment)	1	58	6.043	0.017	0.094
Cholesterol	Within the Group (Time)	1.827	105.98	3.181	0.050	0.052
	Interaction (Time * Treatment)	1.827	105.98	3.594	0.035	0.058
	Between the Group (Treatment)	1	58	0.010	0.921	0.000
Triglyceride	Within the Group (Time)	1.743	101.122	3.833	0.030	0.062
	Interaction (Time * Treatment)	1.743	101.122	3.305	0.047	0.054
	Between the Group (Treatment)	1	58	1.552	0.218	0.026

Table 2: Two way repeated measure ANOVA test results for the anthropometric, biochemical, and biophysical assessment of the patients.

the pre-intervention (M=189.60) to the post-intervention phase (M=167.97). These findings suggested that the impact of 10gm/day of flaxseed supplementation is a more significant effect on triglyceride.

Discussion

Mild hypertension is manageable with the help of lifestyle modification and natural dietary supplementation. As a result, the need for drugs and medicines to treat mild hypertension may be prolonged. The result of the present study indicated a significant decrease ($\rho < 0.05$) in the Systolic and Diastolic blood pressures along with the Body Mass Index (BMI), Waist Hip Ratio (WHR), cholesterol, and Triglyceride. We used the two-way repeated ANOVA test to see the effect of supplementation on the anthroponotic, biophysical and biochemical measurements. The result also showed a significant effect on the duration of supplementation as all the parameters were significantly decreased ($\rho < 0.05$). The descriptive analysis also showed the positive changes in the mean values of Body Mass Index (BMI), Waist Hip Ratio (WHR), Cholesterol, Triglyceride, Systolic blood pressure, and Diastolic blood pressure for the Flaxseed group as compared to the Control group. The results present in this study are similar to the interventions studied carried on the flaxseed supplementation in the various forms of managing risk factors like anthropometric (WHR and BMI [18-21] risk factors, bio-physical (SBP and DBP [22-26] risk factors, and biochemical (Cholesterol and triglycerides [27,28].

Conclusion

Overall, the result of the present study suggests that 10gm/day supplementation of the roasted flaxseed had a significant effect on the management of mild hypertension without medication. It reduces other risk factors like cholesterol, triglycerides, Body Mass Index (BMI), and Waist Hip Ratio (WHR). With the help of a DASH diet, roasted flaxseed supplementation, and physically active patients prolong the effect of hypertension and leave healthy life without any medication or drug for a more extended period.

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Conflict of Interest

There are no conflicts of interest.

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