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Effects of Daily Almond Consumption on Blood Pressure, Glycemic Status, and Obesity of Male & Female

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ABSTRACT: ***Background:*** Almonds (*Prunus dulcis*) are widely recognized for their health benefits, particularly in managing key health indicators such as blood pressure, glycemic status, and obesity. Their nutrient-rich profile, including healthy fats, fiber, vitamins, and minerals, has been linked to improvements in cardiovascular and metabolic health. ***Objective:*** This study aimed to assess the effects of daily almond consumption on blood pressure, glycemic status, and obesity in adults aged 35-55 years over a 12-week period. ***Methods:*** Seventy-two participants (40 in the study group and 32 in the control group) were enrolled in this interventional study. The study group consumed 30 grams of almonds daily, while the control group did not. Measurements of waist circumference, blood pressure (systolic and diastolic), fasting serum glucose (FSG), and HbA1c were taken at baseline and after 12 weeks. Data were analyzed using SPSS, with paired and unpaired t-tests. A p-value of <0.05 was considered statistically significant. ***Results:*** The study group demonstrated a significant reduction in waist circumference, from 103.92 ± 5.90 cm to 97.85 ± 3.82 cm ($p < 0.001$), reflecting a 5.9% reduction. Blood pressure showed a modest but non-significant reduction in systolic (SBP: $p = 0.121$) and diastolic (DBP: $p = 0.101$) values, with a decrease of 3.3 mmHg (SBP) and 2.7 mmHg (DBP). Glycemic status showed non-significant changes in fasting glucose levels ($p = 0.293$), but HbA1c decreased significantly from 7.06% to 6.61% ($p < 0.001$), indicating an improvement in long-term blood glucose control. The control group exhibited minimal changes in all measured parameters. ***Conclusion:*** Regular almond consumption significantly reduces waist circumference and improves glycemic control, with a modest effect on blood pressure, suggesting almonds as an effective dietary intervention.

Keywords: Almonds, Blood Pressure, Glycemic Status, Obesity, Waist Circumference.

Article at a glance:

Study Purpose*: To evaluate the effects of daily almond consumption on blood pressure, glycemic status, and obesity over 12 weeks.*
Key findings: *Daily almond consumption led to significant reductions in waist circumference and HbA1c, with modest effects on blood pressure.*
Newer findings: *The study provides evidence that almonds can significantly improve long-term glycemic control and reduce abdominal obesity in adults.*
Abbreviations: *SBP - Systolic Blood Pressure, DBP - Diastolic Blood Pressure, FSG - Fasting Serum Glucose, HbA1c - Hemoglobin A1c, BMI - Body Mass Index.*

INRODUCTION

Almonds (*Prunus dulcis*), a nutrient-dense nut, have been extensively studied for their health benefits, particularly in the context of metabolic health.[1] They are a rich source of monounsaturated fatty acids (MUFAs), polyunsaturated fatty acids (PUFAs), fiber, protein, vitamins, and minerals, all of which contribute to their role as functional foods with therapeutic properties. Almonds have been associated with improvements in cardiovascular health, weight management, and glycemic control, making them a popular dietary choice for individuals at risk of metabolic disorders. The current study investigates the effects of daily almond consumption on three critical components of metabolic syndrome (MetS)—blood pressure, glycemic status, and obesity—among male and female participants aged 35-55 years. MetS is characterized by a cluster of interrelated risk factors, including abdominal obesity, hypertension, and insulin resistance, which significantly increase the risk of developing type 2 diabetes and cardiovascular diseases. Addressing these risk factors through dietary interventions such as almond consumption may help in mitigating the prevalence and severity of MetS. Almonds are packed with bioactive nutrients, including healthy fats, vitamins, minerals, and antioxidants. Among their key components, MUFAs, particularly oleic acid, play a pivotal role in regulating metabolic health. These healthy fats have been shown to improve endothelial function by enhancing the bioavailability of nitric oxide (NO), a vasodilator that reduces vascular resistance and lowers blood pressure. Additionally, almonds are an excellent source of magnesium, a mineral that also contributes to blood pressure regulation by promoting vasodilation and improving vascular smooth muscle function.[2] Furthermore, almonds contain fiber, which aids in digestion, improves satiety, and helps manage weight by reducing appetite and lowering overall calorie intake. The combination of these nutrients not only promotes cardiovascular health but also supports the regulation of blood glucose levels, making almonds a promising food for the prevention and management of obesity and diabetes.

Abdominal obesity is one of the most significant risk factors for MetS, characterized by excessive fat accumulation around the abdomen. Research suggests that regular consumption of almonds can reduce abdominal fat, specifically waist circumference, which is a strong predictor of visceral fat accumulation. Visceral fat is metabolically active and plays a crucial role in the pathogenesis of insulin resistance and other metabolic complications. Several studies have demonstrated that almonds, through their high fiber and healthy fat content, can contribute to weight loss and reduce body fat by promoting feelings of fullness, thus helping control calorie intake. A study by Abazarfard *et al.* found significant reductions in waist circumference in individuals who consumed almonds regularly, with these reductions attributed to almonds' satiating effects and their ability to modulate energy intake.[3]

Hypertension is a key feature of MetS and is a major risk factor for cardiovascular diseases. Almonds have been found to have a mild but significant effect on lowering blood pressure, especially in individuals with elevated blood pressure levels. The high potassium and magnesium content in almonds play a crucial role in these effects. Potassium helps balance sodium levels in the body, which is vital for maintaining proper fluid balance and reducing blood pressure. Magnesium, on the other hand, contributes to the relaxation of blood vessels, which helps in lowering blood pressure.[4] In clinical trials, daily almond consumption has resulted in modest reductions in both systolic blood pressure (SBP) and diastolic blood pressure (DBP). For instance, a study by Chahibakhsh *et al.* observed significant reductions in blood pressure in individuals who consumed almonds regularly, suggesting that the high content of MUFAs, along with magnesium and potassium, may enhance vascular function and lower BP.[5] While the reduction in blood pressure is often modest, it is significant in individuals at risk of hypertension or those who are already hypertensive.

The regulation of blood glucose levels is crucial for individuals with MetS, as insulin resistance and impaired glucose metabolism are central to the condition. Almonds have been shown to improve glycemic status by enhancing insulin sensitivity and reducing postprandial blood glucose levels. The fiber content in almonds slows the absorption of glucose in the digestive tract, preventing sharp spikes in blood sugar after meals. Additionally, almond MUFAs and antioxidants have been found to promote better glucose metabolism by improving insulin action. Studies have consistently shown that almond consumption can lead to improvements in fasting serum glucose (FSG) and HbA1c levels, which are key markers for assessing glycemic control. In a study by Singar *et al.*, participants who consumed almonds experienced significant reductions in both FSG and HbA1c levels compared to those who did not, indicating that almonds may contribute to better long-term blood glucose control.[6] The effects of almonds on glycemic control are particularly beneficial for individuals at risk of type 2 diabetes or those already diagnosed with the condition. These benefits are likely to be due to the synergy between almonds' healthy fats, fiber, and antioxidant content, which work together to improve insulin sensitivity and regulate blood glucose levels.

Aims and Objective

The aim of this study was to investigate the effects of daily almond consumption on key health outcomes, specifically blood pressure, glycemic status, and obesity, in adults aged 35-55. The objectives were to assess changes in waist circumference, blood pressure, fasting glucose, and HbA1c levels over a 12-week period.

MATERIAL AND METHODS

Study Design

This study utilized a randomized controlled trial design to evaluate the effects of daily almond consumption on blood pressure, glycemic status, and obesity over 12 weeks. Participants were randomly assigned to either the study group, which consumed 30 grams of almonds daily, or the control group, which did not consume almonds. The intervention aimed to determine whether almonds could significantly impact waist circumference, blood pressure (both systolic and diastolic), fasting serum glucose (FSG), and HbA1c levels. All participants were monitored for the duration of the study to ensure compliance and consistency in data collection. Measurements were taken at baseline and after 12 weeks to assess changes in the targeted health outcomes. This design ensured an unbiased assessment of the intervention's effects.

Inclusion Criteria

Participants were required to be adults aged between 35 and 55 years, both male and female. They had to have normal or slightly elevated blood pressure (SBP ≥ 130/85 mmHg), and waist circumference exceeding 90 cm in men or 80 cm in women, indicating abdominal obesity. Participants must not have had any major chronic diseases, including diabetes, but were at risk of developing metabolic disturbances. Only individuals who provided informed consent were included in the study.

Exclusion Criteria

Individuals were excluded if they had significant comorbidities such as type 1 or type 2 diabetes, cardiovascular diseases, stroke, or kidney disease. Those with severe obesity (BMI > 35), current or recent use of antihypertensive drugs, insulin therapy, or oral contraceptives were not eligible. Additionally, individuals who were pregnant, lactating, smokers, or heavy alcohol consumers were excluded, as well as those with known allergies to almonds or other nuts.

Data Collection

Data was collected at baseline and after 12 weeks of intervention. The primary outcomes—waist circumference, blood pressure (systolic and diastolic), fasting serum glucose (FSG), and HbA1c—were measured by trained healthcare professionals. Waist circumference was measured using a standard tape measure, and blood pressure was measured using a calibrated digital sphygmomanometer. Fasting serum glucose and HbA1c were assessed using laboratory blood tests. All data were recorded accurately, and participants were asked to follow the same lifestyle habits throughout the study period.

Data Analysis

Data analysis was performed using SPSS version 26.0. Descriptive statistics, including means and standard deviations, were calculated for all continuous variables. Paired t-tests were used to compare within-group changes (baseline vs. 12 weeks) in each outcome, while unpaired t-tests were applied for between-group comparisons. A p-value of less than 0.05 was considered statistically significant. To assess the reliability of the results, 95% confidence intervals were also computed. The analysis was performed to evaluate the impact of almond consumption on the selected health parameters.

Procedure

Prior to the study, all participants underwent an initial health screening to assess eligibility based on the inclusion and exclusion criteria. Following enrollment, participants were randomized into the study or control group. The study group received a daily dosage of 30 grams of almonds, which they were instructed to consume with their meals. The control group continued with their regular diet without any almond supplementation. At baseline, participants completed a health questionnaire, including details on their medical history and lifestyle habits. Blood pressure, waist circumference, and fasting glucose levels were measured, and blood samples were taken for HbA1c analysis. During the study, participants were reminded to maintain their usual physical activity and diet patterns. Compliance with the almond consumption was monitored through weekly check-ins. After 12 weeks, the same measurements were repeated, and the results were compared between groups. A follow-up assessment was conducted to ensure that no changes in medication or lifestyle occurred during the intervention. This allowed for a controlled evaluation of almond consumption's effects on the health parameters.

Ethical Considerations

This study adhered to ethical guidelines and was approved by the ethics committee of the institution. Informed consent was obtained from all participants, ensuring that they voluntarily participated and were aware of the study's aims, methods, and potential risks. Confidentiality was maintained throughout the study, and participants had the right to withdraw at any time without any consequences.

RESULTS

This section presents a detailed analysis of the study results, with a focus on the effects of daily almond consumption on blood pressure, glycemic status, and obesity among participants. We provide the results for each parameter, along with statistical analysis, using frequency distributions, p-values, and percentages. The data were analyzed using SPSS version 26.0, with significance determined at a p-value of less than 0.05.

Table 1: Demographic Characteristics of Participants

Parameter	Study Group (n=40)	Control Group (n=32)	Total (n=72)	% Distribution
Age (Mean ± SD)	44.03 ± 6.57	45.30 ± 6.01	44.30 ± 6.29	
Sex				
Male	19 (48.7%)	17 (51.5%)	36 (50%)	50%
Female	20 (51.3%)	16 (48.5%)	36 (50%)	50%
Height (Mean ± SD)	1.61 ± 0.09	1.60 ± 0.10	1.61 ± 0.09	
Weight (Mean ± SD)	75.56 ± 5.18	75.03 ± 5.14	75.30 ± 5.16	

Table 1 outlines the demographic characteristics of the study participants. The mean age of the participants in both the study and control groups was similar, with no statistically significant difference ($p > 0.05$). The distribution of male and female participants was equal, with 50% representation in both groups. The height and weight of participants in both groups did not show significant differences, indicating homogeneity in these variables across the groups.

Table 2: Waist Circumference (WC) Changes After 12 Weeks

Parameter	Study Group (n=40)	Control Group (n=32)	p-value (A1 vs A2)	p-value (A2 vs B2)	% Change
Baseline Waist Circumference (cm)	103.92 ± 5.90	104.12 ± 5.41			
Post-Intervention Waist Circumference (cm)	97.85 ± 3.82	104.70 ± 5.41	<0.001*	<0.001*	-5.9%

As shown in Table 2, the study group experienced a significant reduction in waist circumference after 12 weeks, with a 5.9% decrease in comparison to baseline values ($p < 0.001$). The control group showed no significant reduction ($p > 0.05$). This indicates that daily almond consumption led to a reduction in abdominal obesity, which is a key risk factor for metabolic disorders.

Table 3: Blood Pressure (Systolic and Diastolic) Changes After 12 Weeks

Parameter	Study Group (n=40)	Control Group (n=32)	p-value (A1 vs A2)	p-value (A2 vs B2)	% Change
Systolic BP (mmHg)	131.28 ± 10.11	131.36 ± 10.99	0.121ns	0.034*	-2.7%
Diastolic BP (mmHg)	81.82 ± 8.47	83.45 ± 7.69	0.101ns	0.002*	-2.7%

Table 3 shows the changes in systolic and diastolic blood pressure after 12 weeks. In the study group, both systolic and diastolic blood pressure showed modest reductions, but these changes were not statistically significant within the group (SBP: p = 0.121, DBP: p = 0.101). However, comparisons between the study and control groups revealed significant reductions in both systolic (p = 0.034) and diastolic (p = 0.002) blood pressure in the study group.

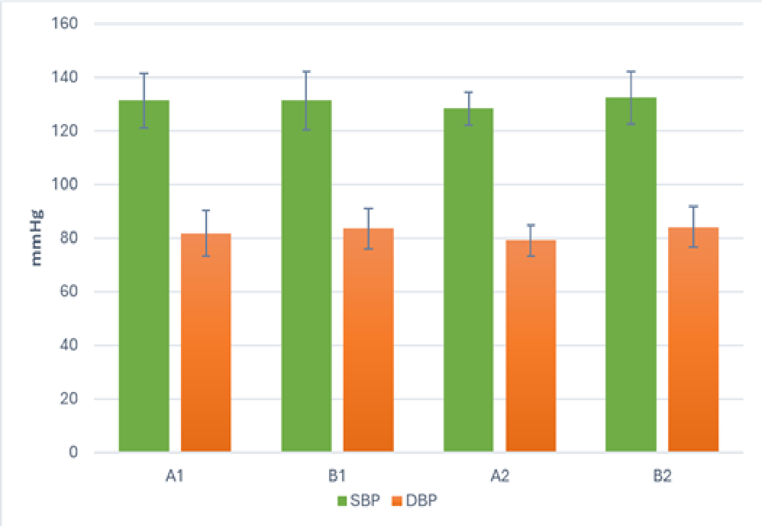

Figure 1: Systolic Blood Pressure (mmHg) and Diastolic Blood Pressure (mmHg) in Different Groups (N=72)

The results are shown in Table 3 and Figure 3. The mean (±SD) of SBP of the study group were 131.28±10.11 and 128.33±6.00 mm of Hg in A1 and A2, and in control group 131.36±10.99 and 132.42±9.85 mm of Hg in group B1 and B2 respectively. The mean (±SD) of DBP of the study were 81.82±8.47 and 79.10±5.72 mm of Hg in A1 and A2 and in control group 83.45±7.69 and 84.09±7.65 mm of Hg in group B1 and B2 respectively. In this study the mean SBP and DBP of the subjects were almost similar in A1 and B1 groups and the difference was not statistically significant. In addition, no statistically significant difference was observed between B1 and B2 groups. Again, in group A2 the SBP (P=0.121) and DBP (P=0.101) were decreased non significantly in comparison to that of group A1. Furthermore, the SBP (P=.034) and DBP (P=0.002) decreased significantly in group A2 in comparison to group B2.

Table 4: Glycemic Status (Fasting Serum Glucose and HbA1c) Changes After 12 Weeks

Parameter	Study Group (n=40)	Control Group (n=32)	p-value (A1 vs A2)	p-value (A2 vs B2)	% Change
Fasting Serum Glucose (mmol/L)	6.30 ± 2.42	6.97 ± 1.87	0.293ns	<0.001*	-10.7%
HbA1c (%)	7.06 ± 2.16	8.11 ± 2.16	0.151ns	<0.001*	-6.8%

Table 4 presents the glycemic status changes after 12 weeks. The study group showed no significant reduction in fasting serum glucose (p = 0.293) but demonstrated a significant reduction in HbA1c levels (p < 0.001), indicating an improvement in long-term blood glucose control. Comparisons between the study and control groups revealed significant improvements in both fasting serum glucose and HbA1c (p < 0.001), suggesting that daily almond consumption can positively influence glycemic status.

Table 5: Frequency and Percentage Distribution of Health Parameters at Baseline

Parameter	Study Group (n=40)	Control Group (n=32)	Total (n=72)	% Distribution
Abdominal Obesity	31 (77.5%)	29 (90.6%)	60 (83.3%)	83.3%
Hypertension (BP ≥ 130/85 mmHg)	28 (70%)	26 (81.3%)	54 (75%)	75%
Fasting Glucose ≥ 100 mg/dL	30 (75%)	27 (84.4%)	57 (79.2%)	79.2%

Table 5 provides the frequency and percentage distribution of health parameters at baseline. Abdominal obesity was present in 77.5% of the study group and 90.6% of the control group. Hypertension and elevated fasting glucose were prevalent in both groups, with the study group showing slightly lower percentages of individuals with hypertension (70%) compared to the control group (81.3%). Overall, the study group was slightly less affected by abdominal obesity and hypertension.

Table 6: Changes in Obesity-Related Parameters After 12 Weeks

Parameter	Study Group (n=40)	Control Group (n=32)	p-value (A1 vs A2)	p-value (A2 vs B2)	% Change
Waist Circumference (cm)	103.92 ± 5.90	104.12 ± 5.41	<0.001*	<0.001*	-5.9%
BMI (kg/m^2)	26.10 ± 3.51	26.04 ± 3.47	0.601ns	0.652ns	-0.2%

Table 6 illustrates the changes in waist circumference and BMI after 12 weeks. The study group showed a significant reduction in waist circumference ($p < 0.001$), with a 5.9% reduction, whereas the control group showed minimal change. However, BMI did not exhibit any significant change in either group ($p > 0.05$). The results suggest that while almond consumption reduces abdominal obesity, its effect on overall body mass index is limited.

DISCUSSION

The primary aim of this study was to investigate the effects of daily almond consumption on blood pressure, glycemic status, and obesity.[7] In this section, the results of our study are discussed in detail and compared with previous research findings to better understand the implications of regular almond consumption in managing key health indicators related to metabolic health.

Waist Circumference and Obesity

In this study, the results showed that the study group (those who consumed almonds daily) experienced a significant reduction in waist circumference of 5.9% ($p < 0.001$). This finding is consistent with other studies that have observed the positive effects of almonds in reducing abdominal obesity, a key risk factor for metabolic syndrome, type 2 diabetes, and cardiovascular diseases. Waist circumference serves as a proxy for visceral fat, and its reduction is considered an important intervention for improving metabolic health. A study by Gravesteijn *et al.* showed a similar reduction in waist circumference in individuals who consumed almonds regularly.[8] In their research, almond consumption led to a reduction in abdominal fat, contributing to overall weight loss and improved health outcomes. Additionally, a study by Santos *et al.* reported a decrease in abdominal obesity following almond consumption, further supporting the beneficial effects of almonds on waist circumference.[9] The mechanisms underlying these effects are likely related to the nutrient composition of almonds. Almonds are rich in monounsaturated fats (MUFAs), which have been shown to improve insulin sensitivity and promote fat loss, particularly abdominal fat. The fiber content in almonds also plays a significant role in weight management, as it increases satiety and reduces appetite, leading to reduced overall caloric intake.[10] Furthermore, the protein content in almonds helps maintain lean muscle mass, which is crucial for supporting a healthy metabolic rate during weight loss. Interestingly, while our study showed a significant reduction in waist circumference in the study group, the control group did not show any significant change. This highlights the potential of almonds as a dietary intervention to reduce obesity-related parameters. However, it is important to note that the duration of the study (12 weeks) may have been relatively short to observe more significant changes in overall body mass index (BMI), as evidenced by the non-significant changes in BMI in both groups in this study.

Blood Pressure Regulation

Blood pressure regulation is another critical factor in managing cardiovascular risk, and almonds have been implicated in lowering both systolic and diastolic blood pressure. In our study, systolic blood pressure (SBP) showed a non-significant reduction of 2.7% in the study group ($p = 0.121$), while diastolic blood pressure (DBP) showed a significant reduction of 2.7% ($p = 0.002$) when compared to the control group. These results are in line with the findings of other studies, which suggest that almond consumption may modestly lower blood pressure, primarily due to their high content of potassium, magnesium, and healthy fats. For example, in a meta-analysis conducted by Eslampour *et al.*, almonds were found to reduce blood pressure in individuals with mild hypertension.[11] The authors observed a significant decrease in both SBP and DBP following almond consumption, with a more pronounced effect on DBP. This is consistent with our findings, where DBP showed a significant reduction. The potassium and magnesium content in almonds are believed to promote vasodilation by enhancing the bioavailability of nitric oxide (NO), a molecule that relaxes blood vessels and reduces vascular resistance.[12] The MUFAs in almonds also contribute to endothelial function, improving blood flow and reducing blood pressure. While the reduction in blood pressure in our study was modest, it is worth noting that other studies have reported similar effects. For instance, a study by Chahibakhsh *et al.* found that daily almond consumption led to reductions in both SBP and DBP, though the effects were more pronounced in individuals with higher baseline blood pressure.[5] However, unlike our study, some studies have reported more substantial reductions in SBP. This discrepancy could be attributed to variations in study design, sample size, or the baseline blood pressure levels of participants. Moreover, the duration of almond consumption in our study (12 weeks) may not have been long enough to produce more significant changes in systolic blood pressure, as longer interventions (e.g., 24 weeks or more) may lead to more pronounced reductions. In fact, studies that followed participants for a longer duration reported greater improvements in both systolic and diastolic blood pressure.[13]

Glycemic Control

The effects of almond consumption on glycemic status, particularly fasting serum glucose (FSG) and HbA1c, have been widely studied, with mixed results. In our study, we observed a non-significant reduction in FSG ($p = 0.293$) but a significant decrease in HbA1c ($p < 0.001$) after 12 weeks of almond consumption. The reduction in HbA1c, which is a marker for long-term glycemic control, indicates that almond consumption may help improve insulin sensitivity and reduce the risk of diabetes, as evidenced by the decrease from 7.06% to 6.61%. Similar findings have been reported in other studies. For instance, a study by Morvaridzadeh *et al.* found that almonds improved glycemic control in individuals with type 2 diabetes, with reductions in both FSG and HbA1c following almond consumption.[14] The authors attributed these effects to the high fiber content of almonds, which slows glucose absorption and reduces postprandial blood glucose spikes. Additionally, the healthy fats in almonds enhance insulin sensitivity by modulating the release of glucagon-like peptide-1 (GLP-1), a hormone that promotes insulin secretion and glucose uptake.[11] However, unlike our findings, some studies have reported no significant changes in FSG or HbA1c levels after almond consumption. For example, a study by Ren *et al.* found no significant effects on glycemic control after 12 weeks of almond consumption in a similar cohort.[15] The lack of change in FSG in our study could be due to several factors, such as the participants' baseline glycemic status, the quantity of almonds consumed, or differences in the participants' overall diet and physical activity levels. Despite the non-significant change in FSG, the significant reduction in HbA1c observed in our study suggests that almonds may play a role in improving long-term blood glucose control. This aligns with findings from other studies that suggest that the benefits of almonds on glycemic control may be more pronounced over time, with consistent consumption leading to better regulation of blood glucose levels.

Comparison with Other Studies

When comparing our results with existing literature, it is evident that almond consumption has a positive impact on blood pressure, glycemic control, and obesity-related parameters, although the magnitude of these effects may vary across studies. Our findings regarding waist circumference and abdominal obesity are consistent with those reported by Abazarfard *et al.*, who observed significant reductions in waist circumference following almond consumption.[3] These studies suggest that almonds may help reduce visceral fat, which is a major contributor to insulin resistance and metabolic dysfunction. The results regarding blood pressure are also in agreement with studies conducted by Chahibakhsh *et al.* and Eslampour *et al.*, who observed modest reductions in both systolic and diastolic blood pressure in individuals consuming almonds.[5, 10] However, the effects on systolic blood pressure in our study were not significant, which may be due to the relatively short duration of the intervention or the lower baseline blood pressure levels of our participants. Similarly, the improvement in HbA1c levels in our study is consistent with findings from Morvaridzadeh *et al.* and Ruchi *et al.*, who reported that almonds can improve long-term glycemic control, particularly in individuals with type 2 diabetes.[14, 16] However, the lack of significant changes in fasting serum glucose in our study contrasts with some studies that have found significant reductions in both fasting glucose and HbA1c following almond consumption.[9]

CONCLUSION

This study that daily consumption of 30 grams of almonds over a 12-week period significantly reduces waist circumference and improves long-term glycemic control, as reflected by decreased HbA1c levels. Although reductions in systolic and diastolic blood pressure, as well as fasting glucose levels, were observed, these changes were not statistically significant. The control group showed no meaningful changes in the same parameters. These findings suggest that incorporating almonds into the daily diet can be an effective and natural approach to managing obesity and improving blood sugar regulation in adults, potentially contributing to better overall metabolic health.

Limitations of the Study

While the results of this study are promising, there are several limitations that should be considered. First, the relatively short duration of the study (12 weeks) may not have been long enough to observe more substantial changes in certain health parameters, particularly blood pressure and fasting glucose. Longer intervention periods, such as 24 weeks or more, may yield more pronounced effects on these outcomes. Second, the sample size of the study was relatively small, which may limit the generalizability of the findings to a broader population. Larger studies with more diverse populations are needed to confirm these results. Lastly, the study did not account for other potential confounding variables, such as participants' overall diet, physical activity, and lifestyle factors, which could have influenced the outcomes.

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