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Original Article

Effects of 8-weeks cinnamon intake with and without high intensity interval training on blood lipids profile in overweight girls of aged-high school

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Abstract

Background: Obesity and overweight are among the most common complications among high school students, which can be associated with cardiovascular diseases. Modifying the lifestyle through sports activities and herbal medicines is one solution to this problem. This study aimed to evaluate the effect of an 8-week cinnamon consumption with and without high-intensity interval training on blood lipid profiles in high school-aged overweight girls.

Methods: In this semi-experimental study with a pre-test and post-test design, 36 overweight women aged 15-18 years were randomly assigned to one of the 3 groups: intense interval training (n=12), cinnamon supplementation (n=12) and intense interval training+cinnamon (n=12). The intense interval training program was conducted three times a week for 8 weeks in the two intervention groups. Each session, lasting 30-35 minutes, involved high-intensity exercises at 90-95% of peak oxygen consumption. Diet groups received cinnamon supplements at the rate of 6 grams/day for a period of 8 weeks. Body measurements (weight, body mass index) and serum levels of blood fats (cholesterol, triglyceride, high-density lipoprotein, low-density lipoprotein) were measured before and after the study. The data were analyzed using the dependent t-test and analysis of covariance at a level less than 0.05.

Results: After 8 weeks of intervention, a significant decrease in body weight and body mass index and a significant increase in HDL cholesterol were observed in the intense interval training and intense interval training+cinnamon groups compared to the cinnamon alone group ($p \leq 0.05$). However, Bonferroni's follow-up test did not show significant differences in cholesterol, triglyceride and low-density lipoprotein levels between the groups ($p<0.05$).

Conclusion: High-intensity intermittent exercise with cinnamon consumption can reduce body composition and some blood lipids more effectively than cinnamon supplementation in overweight high school girls.

Keywords: Cholesterol, Triglycerides, High-Density Lipoprotein, Low-Density Lipoprotein, Cinnamon, Intense Exercise, Overweight.

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Introduction

Obesity is a chronic malady and its incidence is escalating among children, teenagers, and adults, rendering it a global epidemic. Obesity has become a significant global health problem and is associated with major chronic diseases such as cancer, cardiovascular diseases, and diabetes. Additionally, due to body image concerns, it exerts a negative impact on individuals' self-confidence, which can ultimately result in severe depression and mental health issues (1,2). Given the limited effectiveness of conventional treatments, such as restrictive diets and lifestyle changes (2), individuals are seeking novel, more effective, and accessible approaches. such as supplementing with herbal medicines to achieve their desired physique (3,4). Cinnamon is a flavoring additive that has been used for an extended period to improve the aroma, taste, and color of various foods. The main components found in cinnamon are cinnamic acid, cinnamaldehyde, eugenol and coumarin. These components are reported to possess antimicrobial properties (3,4).

Cinnamon is also rich in antioxidants such as polyphenols and glutathione, which contribute to its potential as a strong anti-inflammatory agent and a possible protector against cancer (3,4). Cinnamon can reduce the risk of heart disease by reducing LDL cholesterol while increasing HDL cholesterol (5,6). Recent studies emphasize the importance of cinnamon as a spice with potential natural therapeutic applications for a range of serious diseases such as type 2 diabetes, chronic digestive problems, cardiovascular diseases and even cancer and Alzheimer's. Cinnamon has been found to have a positive impact on lipid profiles, particularly for individuals who are overweight or struggling with excess fat. Cinnamon causes a significant decrease in insulin resistance, fasting blood sugar, total cholesterol, triglycerides, liver enzymes and the inflammatory factor CRP-hs. Also, cinnamon sap can reduce glucose, insulin and cholesterol levels in people with high serum glucose (7).

Conversely, obesity, often stemming from an increase in the quantity of fat cells (hyperplasia), frequently manifests in early or middle childhood, and is prevalent in individuals with a body mass index exceeding 40 kg/m^2. Therefore, obesity, resulting from shifts in body mass due to sedentary lifestyles and inadequate diets is one of the growing problems of today's generation, especially during adolescence. This concern is swiftly transitioning into a global crisis. Available treatments for obesity and overweight include lifestyle modifications, exercise, nutrition, dietary medications, and surgical interventions.

Throughout the world, traditional treatments involving the utilization of specific plants or plant saps are well-known. Sports activity is a non-pharmacological intervention available to the general populace, which may play a central role in treating overweight and obesity among children and teenagers (8).

Inadequate physical activity and poor dietary habits are the main reasons for obesity in developed countries. Sports activity, especially high-intensity interval training, is a non-drug intervention available to the general public, which is pivotal in addressing overweight and obesity. In addition, high-intensity interval training (HIIT) is an exercise characterized by 30-second sprint intervals interspersed with recovery periods (9). Numerous studies have presented evidence indicating either equivalent or greater enhancements in cardiorespiratory fitness with the utilization of HIIT compared to moderate endurance exercise (9,10). Based on this, it was suggested that HIIT is a valuable substitute for conventional recommendations centered around endurance-based exercise to promote health. While HIIT interventions are frequently perceived as impractical and challenging for middle-aged and elderly individuals, it's important to note that young people, particularly those struggling with excess weight, often face challenges when engaging in prolonged endurance-based activities and may lack significant interest (1). Various sports interventions, including HIIT, defined between short periods of high-intensity interval training and periods of active rest, have shown positive effectiveness in populations with specific clinical conditions (11). Such interventions have been shown to mitigate the risk of cardiovascular diseases and improve metabolic indicators in these populations. (12). Therefore, it shows the potential application of HIIT training in obese people. In addition to exercise therapy, using herbal medicines, especially cinnamon, because of its strong antioxidant and anti-inflammatory properties, can decrease the risk of cardiovascular diseases by reducing LDL cholesterol and increasing HDL cholesterol (5,6).

Studies on the anti-obesity properties of cinnamon are controversial and contradictory. Several clinical trials have shown that using cinnamon positively affects body composition indices (13). Conversely, some studies do not support such a conclusion. To the best of our knowledge, no study has investigated the findings pertaining to this topic. Considering the health benefits of HIIT compared with various sports activities in the treatment of obesity, as well as cinnamon supplementation in controlling the risk factors of cardiovascular diseases it becomes evident that a combined intervention, such as HIIT + cinnamon, is

lacking. This gap raises questions regarding their collective impact on obesity control (14,15).

Additionally, lifestyle modifications stand as the primary approach for treating overweight and obese populations. This study helps close the literature gap regarding the synergistic effects of HIIT and cinnamon on fat profile and body composition in overweight, high school-aged girls, thus providing valuable insights for health professionals. Furthermore, the findings of this study endorse the optimization of sports activity prescription alongside pharmaceutical interventions for this specific population.

Obesity and overweight are prevalent issues among high school students, often linked to cardiovascular diseases. Modifying the lifestyle through sports activities and herbal medicines is one of the solutions to address this concern. This study aimed to evaluate the effect of 8 weeks of cinnamon consumption with and without high-intensity interval training on blood lipid profiles in high school girls.

Therefore, the present study was conducted as a comprehensive and controlled experimental study to evaluate the effects of cinnamon supplementation on body weight, body mass index, and cardiovascular risk factors in overweight female high school students. In this research, the researcher aims to compare the effects of high-intensity interval training with and without cinnamon supplementation on cardiovascular risk factors, including total cholesterol, triglycerides, low-density lipoprotein, and high-density lipoprotein in overweight high school girls participating in exercise routines.

Material and methods

The current research is semi-experimental, practical and cross-sectional, employing a pre-test and post-test design within the overweight high school girls population. For this goal, 36 overweight students were voluntarily selected and then randomly placed in three distinct groups: HIIT training (12 individuals), HIIT training + cinnamon (12 individuals), and cinnamon (12 individuals). Upon providing comprehensive explanations about the research objectives, methodology, and procedures, participants were granted permission to participate and completed informed consent forms. Body measurement characteristics such as height, weight, body mass index, and the studied variables such as TC, TG, LDL, and HDL were measured as a pre-test. An 8-week intervention ensued, involving HIIT training and consuming cinnamon supplements. The latter was administered three times a week, with a dosage

of 1.5 grams encapsulated within 500 mg capsules, consumed after each meal for the entire 8-week duration .The study culminated with measuring all dependent variables as part of the post-test assessment.

The inclusion criteria for this study consisted of being female, aged between 15 and 18 years, having a body mass index between 25 and 29.99 kg/m2, and lacking any allergies to cinnamon supplements. The exclusion criteria encompassed several aspects, including absence from three consecutive training sessions or five alternate sessions, presence of acute diseases such as cardiovascular diseases, uncontrollable high blood pressure, arthritis, respiratory diseases, kidney diseases, COVID-19, acute orthopedic problems, and joint pains. Hormonal disorders, non-participation in any stage of variable measurement, engagement in regular exercise programs, and the use of dietary supplements led to exclusion from the study.

The intended training protocol included three sessions per week, each lasting 35 minutes. This time was divided into 15 minutes of warming up and numbing, followed by 4 repetitions of 4-minute HIIT training sessions, each followed by 1 minute of rest. This training schedule was to be followed for 8 weeks. The 4-minute periods of HIIT consisted of 20 seconds of high-intensity activity, reaching an intensity of 90%-95% of HRmax, followed by 10 seconds of rest. Additionally, after each 4 minutes, there was 1 minute of active rest at 70% of HR_{max} (16). The subject's heart rate was evaluated in all the training sessions using a Polar heart rate monitor made in Finland to apply the overload principle and track the progress rate during the intervention period.

Examples of movements during 35 minutes of training

Place of practice	time (minutes)	Activity: rest (seconds)	Active rest (end of each session with 70% heart rate, minutes)
1	4	10:20	1
2	4	10:20	1
3	4	10:20	1
4	4	10:20	1

Note 1: 1 minute of active rest is considered after every 4-minute activity.
Note 2: The warm-up and cool-down period was about 15 minutes before the start of HIIT training and at the end of the training session**.**

In this research, the height of all students was measured using a SEGA model height meter, and their weight was measured with an Omron digital scale. The BMI of the participants was calculated by dividing their weight in kilograms by the square of their height in meters. In this study, all students were under nutritional counseling under expert

supervision. All the participants were instructed to visit the laboratory at 8:00 AM after an overnight fasting period to evaluate the blood variables. Then, 5 cc of blood was taken from each participant's brachial vein of the left hand while sitting. The following blood parameters were measured: high-density lipoprotein (HDL) using the enzymatic method with a selective solvent and the Byrex Fars kit, which had a sensitivity of 1 mg/dL; low-density lipoprotein (LDL) directly using the selective solvent method and the Byrex Fars kit; triglyceride levels with the Enzymic calorimetry method using the Byrex Fars kit, with a sensitivity level of 3 mg/dL; and cholesterol levels using the enzymatic-calorimetry method with the Byrex Fars kit, with a sensitivity level of 74.7 mg/dL. All blood sampling procedures were performed at the beginning of the study and 48 hours after the last training session in the eighth week by a laboratory technician. After the blood collection, the blood samples were transferred into tubes containing EDTA. To separate the blood plasma, the samples were centrifuged for 15 minutes at 3000 revolutions per minute and at a temperature of 4°C. Also, plasma was kept in a freezer at -70°C until analysis.

Controllable limitations in this research included the participants' gender, as all subjects were obese adolescent girls attending high school. The subjects ranged from 15 to 18 years, and all participants were physically healthy. However, the uncontrollable limitations in this research included the subjects' level of motivation, the inherent genetic status, the subjects' daily diet, the subjects' drugs, the subjects' mental and psychological factors, and the quality of their sleep and rest.

Statistical Analysis

After collecting and refining the raw data, descriptive statistics such as mean, standard deviation, and inferential statistics were used. In the inferential statistics section, according to the level of data measurement, the Shapiro-Wilks test was used to determine the normal distribution of the data, the dependent t-test was used to compare the changes between the averages of each group before and after the study, and the analysis of covariance test was used for inter-group comparisons. If the difference between groups was significant, Bonferroni's post hoc test was used for paired comparison. In this research, SPSS version 23 statistical software was used for data analysis at a significance level of $p \leq 0.05$.

Results

The results of the research showed that there is no significant differences between the average of the investigated variables in all three groups. This implies that the data within all three groups were consistent and comparable prior to the commencement of the study. The physical and physiological characteristics of the studied groups were compared before and after the study, as shown in Tables 1-3.

Table1.The results of the paired t-test to compare the averages before and after in the cinnamon group

Variable	levels	Mean standard diviation	Number	The value of T	Digree the freedom	Significance level
Weight(kg)	Before	56.88 7.48	12	-1.95	11	0.07
	After	57.62 8.08	12			
BMI (kg/m2)	Before	31.08 5.31	12	-1.98	11	0.07
	After	31.48 5.54	12			
Cholesterol(mg/dl)	Before	182.33 36.44	12	-0.45	11	0.65
	After	182.75 42.39	12			
Triglyceride(mg/dl)	Before	132.92 47.30	12	0.41	11	0.68
	After	127.42 49.73	12			
High-density lipoporotein(mg/dl)	Before	36.67 5.42	12	-1.15	11	0.27
	After	37.83 25.97	12			
Low density lipoporetein(mg/dl)	Before	111.17 25.97	12	-0.69	11	0.50
	After	115.33 24.01	12			

As the results of Table 1 show, there is no significant differences between the mean of all the studied variables before and after consuming cinnamon.

Table2. The results of the paired t-test to compare the averages before and after in the cinnamon and HIIT group

Variable	levels	Mean standard diviation	Number	The value of T	Digree the freedom	Significance level
Weight(kg)	Before	62.60 + 7.93	13	4.05	12	0.002
	After	60.69 + 8.46	13			
BMI (kg/m2)	Before	27.32 + 1.65	13	4.01	12	0.002
	After	26.47 + 2.03	13			
Cholesterol(mg/dl)	Before	168.15 + 31.03	13	2.60	12	0.02
	After	157.46 + 27.60	13			
Triglyceride(mg/dl)	Before	141.07 + 31.57	13	2.82	12	0.02
	After	118.77 + 38.84	13			
High-density lipoporotein(mg/dl)	Before	36.38 + 5.01	13	-6.25	12	0.000
	After	42.69 + 5.51	13			
Low density lipoporetein(mg/dl)	Before	103.85 + 25.79	13	2.92	12	0.01
	After	94.69 + 27.08	13			

The results of Table 2 show that there is a significant difference between the mean of all the studied variables before and after the combination of cinnamon consumption and HIIT ($p<0.05$).

Table3.The results of the paired t-test to compare the averages before and after in the HIITgroup

Variable	levels	Mean standard diviation	Number	The value of T	Digree the freedom	Significance level
Weight(kg)	Before	60.61 + 6.75	12	2.43	11	0.03
	After	59.87 + 6.26	12			
BMI (kg/m2)	Before	29.46 + 5.44	12	2.42	11	0.03
	After	29.08 + 5.11	12			
Cholesterol(mg/dl)	Before	182.50 + 32.27	12	0.03	11	0.98
	After	182.25 + 47.33	12			
Triglyceride(mg/dl)	Before	152.92 + 24.99	12	1.42	11	0.18
	After	143.75 + 30.50	12			
High-density lipoporotein(mg/dl)	Before	37.00 + 4.28	12	-2.32	11	0.04
	After	39.92 + 3.89	12			
Low density lipoporetein(mg/dl)	Before	120.00 + 44.00	12	0.89	11	0.39
	After	112.92 + 31.13	12			

According to the findings in Table 3, there is a significant difference between the mean of only weight variables, body mass index and high-density lipoprotein before and after HIIT alone ($p<0.05$).

Subsequently, the statistical method of analysis of covariance was employed to compare the investigated groups in terms of the studied variables. In case of statistical significance, Bonferroni's follow-up test was utilized. According to the results of Table 4, it can be observed that there is a significant difference between the studied groups (cinnamon consumption alone, cinnamon + HIIT consumption, HIIT alone) in the variable of weight with pre-test control. Therefore, the effectiveness of both cinnamon consumption with and without HIIT on the weight of overweight subjects is confirmed.

Table 4.The results of covariance analysis to compare the wight between the post-intervention three group

Source	Sum of squares type third	Degrees of freedom	Mean square	F	Meaningful
Modified model	2005.49	3	668.49	338.02	0.000
Cut off place	1.63	1	1.63	0.82	0.37
Pre-test weight (kg)	1943.39	1	1943.39	982.65	0.000
Group	42.88	2	21.44	10.84	0.000
Error	65.26	33	1.98		
Whole	132750.79	37			
The whole was corrected	2070.76	36			

To evaluate, the significant difference between pairs of groups was determined by Bonferroni's follow-up test, the results of which are reported in Table 5. Accordingly, there is a significant difference between the cinnamon+HIIT and HIIT alone groups in comparison with the cinnamon alone group in the weight variable. In other words, based on the data

obtained in this research, it can be seen that the significant reduction in the subjects' weight was solely attributable to the HIIT training alone.

Table 5.The results of the pairwise comparison of weight variable between groups using Bonferroni test

Group(I)	Group(J)	Average difference(I-J)	Meaningful
Cinnamon and HIIT	cinnamon	-2.76	0.000
	HIIT	-1.20	0.12
HIIT	cinnamon	-1.55	0.04
	HIIT and cinnamon	1.20	0.12

As the results of Table 6 show, the difference between groups in the variable of body mass index is significant. Therefore, the effectiveness of both cinnamon consumption with and without HIIT on the body mass index of high school girls is confirmed.

Table 6.The results of covariance analysis to compare body mass index between three groups after the intervention

Source	Sum of squares type third	Degrees of freedom	Mean square	F	Meaningful
Modified model	815.74	3	271.91	575.05	0.000
Cut off place	0.00	1	0.00	0.000	0.96
Pre-test body mass index	658.55	1	658.55	1392.69	0.000
Group	9.17	2	4.59	9.69	0.000
Error	15.60	33	0.47		
Whole	31830.14	37			
The whole was corrected	831.35	37			

Bonferroni's follow-up test (Table 7) was employed to identify the specific significant differences between pairs of groups which indicates a significant difference between cinnamon +HIIT groups and also HIIT alone in comparison with the cinnamon group alone in the variable of body mass index. Hence, the data derived from this research underscores that the substantial reduction in the subjects' body mass index was solely attributed to theHIIT training alone.

Table7.Bonferroni results for the body mass index variable between group

Group(I)	Group(J)	Average difference(I-J)	Deviation error	Meaningful
Cinnamon and HIIT	Cinnamon	-1.28	0.29	0.000
	HIIT	-0.48	0.28	0.29

According to the results of Table 8, no significant difference was observed among different groups (cinnamon consumption alone, cinnamon consumption + HIIT, HIIT alone) in the cholesterol variable with pre-test control. Therefore, the lack of effect of cinnamon consumption with and without HIIT on cholesterol in overweight girls is confirmed.

Table 8. The result of covariance analysis to compare cholesterol between the three groups after the intervention

Source	Sum of squares type third	Degrees of freedom	Mean square	F	Meaningful
Modified model	38998.48	3	12999.49	20.85	0.000
Cut off place	89.33	1	89.33	0.14	0.70
Pre-test cholesterol (mg/dl)	32986.11	1	32986.11	52.91	0.00
Group	1482.11	2	741.05	1.19	0.32
Error	20571.11	33	623.38		
Whole	1188499.00	37			
The whole was corrected	59570.11	36			

According to the results of Table 9, there is no significant difference evident among the different groups (cinnamon consumption alone, cinnamon consumption together with aerobic exercise, aerobic exercise alone) in the triglyceride variable with pre-test control. Therefore, the lack of effect resulting from 8 weeks of high intensity training in combination with cinnamon supplement on triglycerides of overweight girls is confirmed.

Table 9.The result of covariance analysis to compare triglyceride between the three groups after the intervention

Source	Sum of squares type third	Degrees of freedom	Mean square	F	Meaningful
Modified model	24933.82	3	8311.27	7.93	0.000
Cut off place	1968.99	1	1968.99	1.88	0.18
Pre-test triglyceride (mg/dl)	20949.18	1	20949.99	19.98	0.38
Group	2065.11	2	1032.55	0.98	
Error	34592.29	33	1048.25		
Whole	681710.00	37			
The whole was corrected	59526.11	36			

According to the results of table 10, the difference between groups is significant. Therefore, the lack of effect of cinnamon consumption with and without aerobic exercise on

HDL of overweight girls is rejected and we conclude with 95% confidence that cinnamon consumption along with HIIT has an effect on HDL of overweight girls.

Table 10.The result of covariance analysis to compare HDL between the three groups after the intervention

Source	Sum of squares type third	Degrees of freedom	Mean square	F	Meaningful
Modified model	549.14	3	183.04	14.14	0.000
Cut off place	128.81	1	128.81	9.95	0.000
Pre-test High-density lipoprotein (mg/dl)	400.22	1	400.22	30.92	0.000
Group	164.20	2	82.10	6.34	0.000
Error	427.13	33	12.94		
Whole	60818.00	37			
The whole was corrected	976.27	36			

Bonferroni's follow-up test was used to identify the specific pairs of groups where this significant difference was present (Table 11). Accordingly, there is a significant difference between the cinnamon and HIIT groups in comparison with the cinnamon group in the HDL variable. In other words, based on the data obtained in this research, it becomes apparent that the combined approach of cinnamon consumption and HIIT training was capable of influencing the subjects' HDL levels.

Table 11.The results of the pairwise comparison of HDL variable between groups using Bonferroni test

Group(I)	Group(J)	Average difference(I-J)	Meaningful
Cinnamon and HIIT	cinnamon	0.05	0.000
	HIIT	3.20	0.10
HIIT	cinnamon	1.85	0.65
	HIIT and cinnamon	-3.20	0.10

According to the results of Table 12, there is no significant difference apparent between the group of consuming cinnamon alone and consuming cinnamon together with HIIT in LDL variable with pre-test control. Therefore, the lack of effect resulting from cinnamon consumption with and without aerobic exercise on LDL of overweight girls is acknowledged and it can be concluded that cinnamon consumption combined with HIIT does not have an effect on LDL levels in overweight girls.

Table 12. The result of covariance analysis to compare LDL between the three groups after the intervention

Source	Sum of squares type third	Degrees of freedom	Mean square	F	Meaningful
Modified model	18847.53	3	6282.51	20.37	0.000
Cut off place	3297.89	1	3297.89	10.69	0.000
Pre-test low-density lipoprotein(mg/dl)	15628.15	1	15628.15	50.67	0.000
Group	1556.53	2	778.26	2.52	0.09
Error	10178.20	33	308.43		
Whole	454996.00	37			
The whole was corrected	29025.73	36			

Discussion

This study was conducted with the aim of evaluating the effects of an 8-week intermittent exercise combined with cinnamon supplementation on cardiovascular risk factors in overweight high school girls. The main findings of this study showed significant improvements in weight index, body mass index and HDL while no significant changes in TC, TG, LDL indices after 8 weeks of HIIT training and cinnamon consumption among overweight high school girls. The findings of the current research indicated the effectiveness of HIIT training independent of cinnamon supplementation on weight loss and body mass index in overweight high school girls and the lack of effectiveness of cinnamon alone on both indices, which exhibited inconsistencies in comparison to the present research (17).

Some researchers showed that the consumption of cinnamon extract dissolved in water at a dosage of 500 mg per day improves body composition in pre-diabetic men and women. Also, some researchers showed that cinnamon supplementation can significantly affect obesity caused by hyperinsulinemia. In this regard, another research also suggested incorporating cinnamon oral supplements into the treatment regimen for weight management in type 2 diabetes patients alongside standard treatments. Despite these findings, disparities between these results and the outcomes of the current research exist. Possible factors contributing to these disparities include differences in the studied participant groups, variations in the type of training program employed, and discrepancies in the administered cinnamon dosage. However, the combination of cinnamon consumption with aerobic exercise had a significant effect on the weight of overweight people, and aerobic exercise alone had a significant effect on the weight of overweight people. This means that there is a significant difference between the weight before and after consuming cinnamon along with aerobic activity and aerobic activity alone (17,18).

In addition, these results are in agreement with the findings of a study, which concluded that a 12-week program of regular aerobic exercise with moderate intensity can play an important role in controlling the weight of obese people. They are also consistent with other studies that reported significant reductions in body mass index, body weight, and waist-to-hip circumference ratio, along with notable increases in maximum oxygen consumption as a result of engaging in aerobic exercises. Likewise, other studies have indicated the positive effects of intense intermittent exercises for overweight children, with appropriate precautions in place. In the comparison between the three groups of cinnamon consumption alone, the combination of cinnamon consumption with HIIT and HIIT alone, it was observed that there is a significant difference between the cinnamon alone group and the cinnamon groups combined with HIIT exercise and also the HIIT exercise group in the weight variable. This difference between cinnamon groups with HIIT training and aerobic training alone was not significant (19,20).

One of the effective adaptations resulting from aerobic activities is the increase in mitochondria volume followed by the activity of lipolysis enzymes, which increases the capacity of fat catabolism during exercise. The evidence indicates that during physical activities, the levels of catecholamine hormones and growth hormone increase, subsequently promoting heightened lipolysis. In addition, during sports activity, the secretion of 17-beta estradiol increases in women, which increases the use of fat reserves as an energy source during physical activity (21). An increase in the amount of lipolysis followed by an increase in the consumption of fatty acids for metabolism and muscle energy production decreases the triglyceride reserves within stored fat tissue and subsequently results in weight loss (22).

On the other hand, cinnamon extract activates glycogen synthase enzyme, increases glucose absorption and inhibits glycogen synthase kinase 3-β (23). Cinnamon extract also activates insulin receptor kinase and prevents insulin receptor dephosphorylation, which leads to maximum insulin receptor phosphorylation (24). Collectively, these effects contribute to an elevation in insulin sensitivity. Also, cinnamon sap acts as a strong antioxidant, thereby conferring the health benefits of this substance (25).

Maintaining a low level of serum lipids, even after a 20-day period without cinnamon consumption, indicates the lasting effects of cinnamon, which shows that daily consumption of cinnamon is not imperative. Since cinnamon does not contribute to calorie intake, individuals grappling with obesity or high levels of triglycerides, LDL cholesterol, or total

cholesterol may benefit from regularly including cinnamon in their daily diet. In addition, cinnamon holds promise as a preventive measure to manage elevated blood lipid levels for a broader population.

The present study showed that cinnamon alone did not affect the cholesterol of overweight teenagers, which was consistent with the findings of some studies (26,27). The results of the present research are contrary to the research of Some studies (28), which observed a decrease in cholesterol in people with type 2 diabetes across varied cinnamon dosage groups. In Some studies, cinnamon had a lowering effect on cholesterol in the studied mice. Discrepancies between these results could be attributed to differences in the statistical samples (people with type 2 diabetes, mice, patients with fatty liver), varying cinnamon dosages, and the way of consuming cinnamon (20). The consumption of cinnamon with aerobic exercise showed a decrease in cholesterol, which is consistent with some research (21) finding that in the comparison between the studied groups, the amount of cholesterol decreased in the cinnamon consumption group with aerobic exercise compared to the aerobic exercise group.

In addition, according to the results of the present research, cinnamon consumption alone did not have a significant effect on the triglycerides of overweight adolescents, which is in line with the findings of some studies (26) no notable difference in triglyceride levels between placebo and cinnamon consumption groups after 12 weeks of cinnamon intake among individuals with type 2 diabetes. Consistent with and contrary to some research (28), which observed a decrease in triglycerides of people with type 2 diabetes in groups with different doses of cinnamon (29), some studies found that cinnamon sap reduces the number of triglycerides in an animal model with type 2 diabetes (20). Some other studies showed that the consumption of cinnamon causes a significant decrease in triglycerides in patients with non-alcoholic fatty liver disease. The reason for the discrepancy is the difference in the consumed doses and statistical samples.

The test results showed a significant reduction in triglyceride levels among obese teenage girls after eight weeks of aerobic exercise in the experimental group. We found that consumption of cinnamon with aerobic exercise showed a decrease in triglyceride levels. The researchers propose that the main mechanism behind reducing the plasma concentration of triglyceride, total cholesterol and low-density lipoprotein after exercise is the increase of the lipoprotein lipase enzyme and the decrease of the hepatic liver triglyceride lipase

enzyme. Lipoprotein lipase enzyme plays a pivotal role in regulating the metabolism of triglycerides and lipoproteins, which are often found in fat tissue and skeletal muscle. Engaging in aerobic activities amplifies muscle engagement and subsequently augments the demand for free fatty acids as an energy substrate. This prompts the replacement of triglyceride and phospholipid reserves over glycogen reserves for energy production, thereby boosting the lipoprotein lipase enzyme activity. As a result of this operation, cholesterol removal increases, followed by a decrease in triglycerides and total cholesterol, and low-density lipoprotein, which is the main factor in cholesterol transport, becomes denser and larger, and its plasma level will decrease (22).

The results of the present study showed that cinnamon alone had no effect on high-density lipoprotein in overweight adolescents. This result is consistent with the findings of Some studies (28) which found that various doses of cinnamon intake in people with type 2 diabetes had no effect on high-density lipoprotein. Some other studies found that a 12-week cinnamon consumption in people with type 2 diabetes (26) did not lead to a significant difference in high-density lipoprotein between the placebo and cinnamon consumption groups. However, this is in contrast to the findings of Kim et al.'s research (29) who found that cinnamon extract increases high-density lipoprotein in an animal model with type 2 diabetes. The reason for the discrepancy can be the use of animal samples. On the other hand, aerobic exercise alone was effective in increasing high-density lipoprotein, which is consistent with the results of Kozechian et al (30) who observed significant changes in high-density lipoprotein in adolescents undergoing 12 weeks of aerobic training starting from the sixth week. Conversely, this contradicts Asad's research (31) which showed that eight weeks of regular exercise does not cause significant changes in high-density lipoprotein among obese men, Haqiqi et al (32) reported no change in high-density lipoprotein between the two control and experimental groups. Also, the combined consumption of cinnamon and aerobic exercise showed a significant change in high-density lipoprotein, which is consistent with the results of Rashidelmir et al (21) who found that 4 weeks of aerobic exercise with cinnamon consumption increases the amount of high-density lipoprotein.

Based on our results, the consumption of cinnamon alone did not affect the low-density lipoprotein of overweight people, which is in line with the findings of Dondra (26) who observed no significant distinction in LDL levels between the placebo and cinnamon consumption groups after 12 weeks of cinnamon intake in individuals with type 2 diabetes,

Chen et al (27) who found that cinnamon extract had no effect on low-density lipoprotein in the low- and high-dose cinnamon groups, and consistent with and contrary to the findings of Khan et al (28) who observed a decrease in low-density lipoprotein in people with type 2 diabetes in groups with different doses of cinnamon. On the other hand, aerobic exercise alone was not effective in reducing low-density lipoprotein, which is consistent with the research of Haqiqi et al. (32) which showed no change in low-density lipoprotein between the two control and experimental groups, Kazemi et al (20) which found insignificant changes in low-density lipoprotein levels, contrary to the Asad's research (32) which showed that eight weeks of regular exercise causes a significant decrease in low-density lipoprotein in obese men, and Abid Natanzi et al (22) whose results of the intra-group test showed that eight weeks of aerobic training significantly decreased the amount of low-density lipoprotein in the experimental group, but the consumption of cinnamon with aerobic exercise showed a significant change in low-density lipoprotein which is consistent with the results of Rashidelmir et al.'s research (21) who found that 4 weeks of aerobic exercise combined with cinnamon consumption reduces the amount of low-density lipoprotein.

Although the results of the present study do not support a decrease in blood lipid levels solely due to cinnamon usage in overweight and obese participants, the significant reduction of blood lipid response after using cinnamon along with HIIT among overweight and fat participants aligns with previous observations. Therefore, it is vital to conduct further clinical trials with a combined acute and chronic design to understand whether the acute effect of post-meal cinnamon consumption can predict its long-term health implications. Moreover, the findings of this research also showed that HIIT along with using cinnamon probably causes a significant reduction in the risk indicators of cardiovascular diseases among overweight high school girls.

Given the observed effectiveness of concurrent cinnamon along with HIIT on the body composition indices of obese people, it is suggested to incorporate herbal remedies, particularly cinnamon, as part of weight management strategies in conjunction with regular physical activities. Also, considering that the simultaneous use of cinnamon along with HIIT was effective on blood fats including cholesterol, triglycerides, high-density lipoprotein and low-density lipoprotein of obese people, it is advisable for those with high blood fat to consider this combination to aid in reducing fat levels. Dissemination of the research

findings to weight loss centers, healthcare facilities, and health centers is recommended to facilitate its practical implementation and benefits for a wider population.

To further enhance the understanding and applicability of the findings, several recommendations for future research are proposed. Firstly, conducting a study with meticulous control over subjects' nutrition could offer insights into the isolated effects of cinnamon and exercise. Exploring the impact of a higher dose of cinnamon in a similar study might reveal dose-dependent relationships. Additionally, extending the research to different subject groups, age ranges, or varying body mass indexes could provide a more comprehensive perspective on the intervention's effectiveness. Comparative studies involving different interventions, such as incorporating diverse sports exercises alongside cinnamon consumption, could yield valuable comparative data. Investigating the outcomes of the intervention under different exercise intensities and meticulous variable control would contribute to a deeper understanding of the mechanisms at play. Lastly, a high-intensity study conducted within a single session, evaluating acute exercise effects, could complement the current research by elucidating immediate responses.

Conclusion

This pilot study has several limitations that should be acknowledged. The primary limitation is the small sample size, which may impact the generalizability of the findings. Future research should aim for larger subject groups with consistent characteristics, such as age and physical fitness levels, particularly among overweight and obese individuals. Another limitation pertains to potential biases that could affect the research outcomes. While the current study's results do not provide strong support for the blood lipid-lowering effects of cinnamon in overweight and obese participants, the noteworthy reduction in blood lipid response observed when cinnamon is combined with HIIT aligns with previous observations. Hence, it remains crucial to undertake further clinical trials adopting both acute and chronic designs to discern whether cinnamon's acute postprandial impact can indeed forecast its long-term health implications. These measures will help refine our understanding of the relationship between cinnamon consumption, exercise, and lipid profiles.

It is also concluded that after eight weeks of intervention, a significant decrease in weight and body mass index of the HIIT group with cinnamon was observed compared to the cinnamon alone group. Also, the group that underwent both HIIT and cinnamon intervention

exhibited a considerable reduction in blood lipid levels, including cholesterol, triglycerides, and low-density lipoprotein, along with a notable increase in high-density lipoprotein levels post-intervention. Collectively, the outcomes of this study strongly suggest that the combination of HIIT and cinnamon consumption potentially leads to a significant reduction in cardiovascular disease risk indicators among overweight high school girls.

Declaration

Competing interests

There is no competing interest to disclose.

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