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Effects of High Intensity Interval Training (HIIT) and Cinnamon Consumption on Lipid Profile and Serum Resistin in Obese Women

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ABSTRACT

Introduction: Resistin is an important adipokine in obesity-induced inflammation and insulin resistance. This study aimed to investigate changes in lipid profile, body composition, and serum resistin levels in obese women in response to aerobic interval training and cinnamon consumption.

Methods: Twenty-eight obese middle-aged women (age 30.75±3.8 years, BMI ≥ 30-35 kg/m^2) were randomized into four groups (n=7): placebo control, cinnamon supplement, HIIT, and Combined (exercise+supplement). The exercise protocol included 2-minute intervals in a session for 8 weeks, 3 sessions/week, with a 5-minute warm-up and cool-down. Cinnamon groups took three 380 mg capsules daily after meals. Fasting blood samples were collected 24 hours before and 48 hours after the intervention. Paired t-tests and one-way ANOVA were used for within-group and between-group comparisons, respectively (P≤0.05).

Results: Resistin levels significantly differed between the Combined group and the control (P=0.014) and supplement (P=0.004) groups. HIIT (P=0.009) and Combined (P=0.004) groups showed significant resistin decreases compared to baseline. Also, the combined group had significant decreases in weight (P=0.022) and BMI (P=0.021) compared to control. The Combined group had significant decreases in HDL (P=0.001), LDL (P=0.049), and TG (P=0.043) levels compared to baseline.

Conclusion: The study demonstrates that High-Intensity Interval Training (HIIT) combined with cinnamon consumption effectively reduces resistin levels, weight, BMI, and improves lipid profile parameters (including HDL, LDL, and triglycerides) in obese women. These findings suggest that this combined approach may be beneficial for managing obesity-related metabolic issues.

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Introduction

Today, almost all countries face the prevalence of overweight and obesity, with more than 20% of their population affected by this problem (1, 2). To date, no country has succeeded in reducing the prevalence of overweight and obesity (3). In fact, obesity is recognized as a global epidemic that leads to significant mortality. This phenomenon is mainly due to the interaction between genetic and environmental factors, especially a sedentary lifestyle and unhealthy eating habits (4, 5). Obesity is directly or indirectly associated with a wide range of metabolic and non-metabolic disorders, including low-grade chronic inflammation and insulin resistance, which can lead to the development and progression of type 2 diabetes (T2D) (6, 7). Numerous studies have examined the relationship between obesity, inflammation, and insulin resistance. Even the consumption of high-fat diets (HFD) predisposes individuals to obesity, insulin resistance, and low-grade inflammation (8, 9). In fact, low-grade inflammation and insulin resistance are clinical features of obesity, thought to accelerate the onset and progression of T2D (10).

In animal models, it has been shown that obesity alters the functions of secretory adipose tissue, particularly the secretion of adipokines and pro-inflammatory cytokines (7, 11). Among these adipokines, resistin is recognized as a key factor in obesity-induced inflammation and insulin resistance, both centrally and peripherally (12, 13). Resistin exerts its effects by binding to TLR4 and activating pro-inflammatory signaling pathways (12, 14-17). Furthermore, TLR4,

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known as part of the immune system's pattern recognition receptors (PRRs), plays a crucial role in the development of metabolic inflammation and insulin resistance during obesity (18, 19). Numerous clinical and experimental studies have also identified resistin as a key hormone linking insulin resistance to obesity (10). However, the precise mechanisms associated with these disorders are not yet fully understood. Recent reports suggest that inflammation is a key step in the onset of obesity-induced insulin resistance. Given the increasing prevalence of obesity and T2D, which are two major public health concerns worldwide, decoding the mechanisms involved in hypothalamic inflammation is a major challenge in the field of insulin resistance and obesity (10). Overall, evidence from clinical and experimental studies suggests that inflammation plays a significant role in the development of obesity-related problems (20). In particular, the role of adipose tissue as a source of inflammation has increasingly drawn attention to the link between obesity and T2D in recent decades (21). Resistin, as a cytokine, plays a significant role in the metabolism of fats and lipids and has notable effects on lipid profiles in obese individuals. Research indicates that resistin can influence levels of triglycerides, total cholesterol, and LDL (low-density lipoprotein) cholesterol (22). Studies suggest that increased resistin levels may lead to higher triglyceride levels, likely due to enhanced insulin resistance and inflammatory responses associated with obesity (23). Additionally, some research shows a potential link between resistin and elevated total cholesterol and LDL levels. These effects are probably related to increased inflammation and disrupted lipid metabolism (24).

On the other hand, regular physical activity and a proper diet are factors that help prevent inflammation and chronic diseases by reducing fat levels, increasing insulin sensitivity, lowering blood pressure, and improving blood lipid profiles (25). Different types of exercise can reduce serum resistin levels by improving insulin sensitivity and decreasing inflammation (26). Both aerobic and resistance training play effective roles in regulating this hormone, but their impact varies depending on the type, intensity, and duration of exercise (27). High-intensity workouts tend to produce a greater reduction in resistin, while lower-intensity exercises may have less effect (28). Ultimately, exercise modality, intensity, and duration are crucial factors in modulating resistin levels (29). In this regard, it appears that providing regular exercise programs, appropriate nutritional plans, and lifestyle changes can reduce the risk of obesity and cardiovascular diseases (30). One way to prevent inflammation and strengthen the immune system is to consume anti-inflammatory herbal supplements such as cinnamon (31). Cinnamon has been considered as a complementary agent for managing the symptoms of diabetes, metabolic syndrome, and other obesity-related conditions (32). Recently, cinnamon supplements have gained attention due to their positive effects in treating high blood glucose and lipid levels, and other symptoms of metabolic syndrome. The effects of cinnamon on multiple processes affecting metabolic syndrome have been suggested, including enhancing insulin signaling and glucose transport, altering carbohydrate metabolism and glucose absorption, stimulating satiety, delaying gastric emptying, inhibiting the activity of inflammation-related enzymes, and reducing the expression of inflammatory factors (33). Also, the results of human and animal studies suggest that cinnamon has beneficial effects in the prevention and treatment of cardiovascular diseases by reducing oxidative stress and apoptosis, as well as improving blood pressure and lipid parameters (34). In a study, Esfandiarpour et al. (2020) examined the effect of 15 days of cinnamon supplementation on lipid profiles in 24 healthy male in response to a session of aerobic exercise. They observed that aerobic exercise led to a significant increase in HDL and a decrease in LDL, VLDL, TG, and total cholesterol. Also, 15 days of cinnamon supplementation had a significant effect on increasing HDL and decreasing LDL and TG in response to an exercise session (35). In addition, a study investigated the effect of cinnamon extract on resistin levels and insulin sensitivity in male obese rats. The results showed that the consumption of cinnamon extract significantly reduced resistin levels and led to a remarkable improvement in insulin sensitivity (36). Furthermore, Zare and colleagues (2021) examined the effect of cinnamon on serum resistin levels in patients with type 2 diabetes. The findings indicated that a 12-week supplementation of cinnamon resulted in a significant decrease in resistin levels, as well as a reduction in other inflammatory markers (37).

Therefore, conducting this research is of particular significance because, in a society where obesity and metabolic diseases pose major public health challenges, understanding the synergistic effects of interval training and cinnamon consumption can provide more effective strategies for improving lipid profiles and reducing resistin levels. Despite extensive existing research, comprehensive insights into the combined impact of these interventions on metabolic markers in obese women remain limited, with fewer studies focusing on this area. Additionally, combining these methods as natural, non-pharmacological, and cost-effective approaches can enhance health outcomes by not only improving lipid profiles but also reducing insulin resistance and inflammation. Exploring the underlying biological mechanisms involved can further aid in developing targeted strategies for women's health protection. Given the high prevalence of obesity and its associated complications, along with the pro-inflammatory role of resistin and the potential anti-inflammatory and beneficial effects of exercise and herbal medicines on inflammation and lipid indices, this study aims to investigate the effects of interval aerobic training on resistin levels, lipid profile indices, and body composition in obese women.

Materials & Methods

Research Design

This research was an applied and quasi-experimental study with a pre-test and post-test design. The statistical sample included 28 healthy obese women (age 30.75±3.8 years, BMI ≥ 30-35 kg/m^2), selected based on a public call and considering the prerequisite criteria. After recording the subjects' general characteristics and measuring body composition indices (age, height, weight, body mass index, waist-to-hip ratio), the potential benefits and harms of the method were explained to them, and written informed consent and the PAR-Q health questionnaire were completed and obtained. This study was approved by the Ethics Committee of Marvdasht Azad University (IR.IAU.M.REC.1402.096).

Subjects were randomly divided into four groups (7 subjects per group): 1- Placebo control, 2- Supplement (Cinnamon), 3- HIIT, and 4- Combined (Exercise-Supplement). Inclusion criteria included: BMI equal to and above 30-35, physical health (no history of cardiovascular, liver, kidney, or lung diseases, and diabetes, as well as no report of any physical or orthopedic injury that would interfere with the exercises), inactivity (no participation in regular and organized sports activities in the past 6 months), and no restrictions on calorie intake and energy supplements. The exclusion criteria for the study included the following: individuals who did not regularly participate in training sessions or adhere to the prescribed intervention; those with new medical problems or a worsening of existing health issues (such as cardiovascular diseases and diabetes); participants who started new medications that could affect the outcomes; individuals who significantly deviated from the recommended diet; pregnant or breastfeeding women; and those who used other supplements (aside from cinnamon) that might influence the study results.

Table 1. 8-week training protocol

	1 week	2 weeks	3 weeks	4 weeks	5 weeks	6 weeks	7 weeks	8 weeks
%HRR	80	85	90	95	95	95	95	95
#High interval	2	4	6	8	8	8	8	8
#low interval	1	3	5	7	7	7	7	7

%HRR: Heart rate reserve percentage, #High interval: The number of high-intensity intervals, #low interval: The number of low-intensity intervals.

Exercise Protocol and Cinnamon Dosage

The exercise protocol was designed on a treadmill in the form of interval running, with three sessions per week over 8 weeks (table 1) (38). Each session began with a 5-minute warm-up, followed by the main exercise phase, and concluded with a 5-minute cool-down. The intensity of the warm-up, cool-down, and low-intensity intervals was set between 40% to 50% of the subjects' heart rate reserve. To adapt and gradually increase the training load, the number of high-intensity intervals started at two in the first week, increased to four in the second week, six in the third week, and reached eight in the fourth week; this number was maintained throughout the remaining weeks. Each high and low interval lasted 2 minutes, with the intensity of the high intervals gradually increasing from 80% of heart rate reserve in the first week to 95% in the fourth week, then remaining constant until the end of the study. During the intervention, the cinnamon supplement groups took three 380 mg capsules daily—one in the morning, one at noon, and one at night after meals—while the HIIT group received placebo capsules containing wheat flour, administered similarly in terms of dosage and timing (39). The control group subjects did not consume any supplements and did not participate in any exercise during the study.

Blood Sampling

Blood samples were collected from the subjects' brachial vein 24 hours before the start of the exercises and 48 hours after the end of the exercises in a fasting state, and after serum separation, they were stored at -80°C. Serum resistin levels were measured by ELISA (BIOTECH CUSABIO laboratory kit, made in China), and lipid profiles, including triglycerides, cholesterol, HDL, LDL, and VLDL, were measured by colorimetry using Pars Azmoon company kits.

Statistical Analysis

Descriptive statistics were used to calculate mean and standard deviation. After checking the normality of data distribution with the Shapiro-Wilk test and checking the homogeneity of variance between groups with the Levene's test, the paired t-test was used to examine within-group changes (from pre-test to post-test). Also, delta values were calculated from the pre- and post-test data of the groups, and one-way analysis of variance (ANOVA) and Bonferroni post-hoc test were used to examine between-group differences. Data were analyzed using SPSS26 software at a significance level of $P \leq 0.05$.

Results

In this study, four groups were examined: control, cinnamon supplement, HIIT, and combined. The results of one-way ANOVA showed that 8 weeks of HIIT with cinnamon supplementation led to a significant difference in weight ($F_{3,24}=3.834$, $P=0.022$) and body mass index ($F_{3,24}=3.920$, $P=0.021$) between the groups. Furthermore, the results of the Bonferroni test showed that the combined group had a significant decrease in weight (P=0.022) and body mass index (P=0.021) compared to the control group (Table 2). These findings indicate that the combination of exercise with cinnamon supplementation can help reduce weight and improve body mass index.

On the other hand, although no significant difference was observed between the lipid profiles of the groups, the results of the paired t-test (pre- and post-test comparison) showed that HDL (P=0.001), LDL (P=0.049), and TG (P=0.043) in the combined group had a significant decrease compared to before (Table 3).

Also, 8 weeks of HIIT with cinnamon supplementation led to a significant difference in resistin levels between the groups ($F_{3,24}=9.190$, $P=0.000$). The results of the Bonferroni post-hoc test showed that there was a significant difference between the combined group and the control (P=0.014) and supplement (P=0.004) groups (Figure 1). In addition, the results of the paired t-test showed a significant decrease in resistin in the HIIT (P=0.009) and combined (P=0.004) groups compared to before (Figure 1).

Table 2. Demographic and Anthropometric Characteristics of Subjects

Variables	Groups	Pre-test	Post-test	
		Mean ± SD	Mean ± SD	F** - P
Age (years)	Control	31.4 ± 4.8	-	
	Cinnamon	30.8 ± 3.8	-	
	Training	32.1 ± 2.5	-	
	Conna+ training	28.5 ± 3.4	-	
Height (m)	Control	16.2 ± 0.7	-	
	Cinnamon	16.4 ± 0.9	-	
	Training	16.1 ± 0.8	-	
	Conna+ training	16.0 ± 0.7	-	
Weight (kg)	Control	83.8 ± 4.1	83.4 ± 4.11	3.834** - 0.022**
	Cinnamon	85.9 ± 6.2	84.0 ± 7.17	
	Training	85.6 ± 5.4	81.4 ± 5.96	
	Conna+ training	83.2 ± 5.5	77.7 ± 6.74	
BMI (kg/m^2)	Control	31.8 ± 2.3	31.7 ± 2.8	3.920** - 0.021**
	Cinnamon	31.8 ± 1.9	31.1 ± 2.4	
	Training	33.1 ± 2.1	31.3 ± 2.0	
	Conna+ training	32.4 ± 1.9	30.2 ± 3.0	

**Significance of between-group changes using own-way ANOVA

Table 3. HDL, LDL, TG, and TC values separately in different groups

Variables	Groups	Pre-test Mean ± SD	Post-test Mean ± SD	Changes			
				Within-group		Between-group	
				T	P*	F	P**
HDL (mg/dl)	Control	53.60 ± 11.10	57.42 ± 12.91	0.543	0.607	2.291	0.104
	Cinnamon	52.86 ± 14.58	59.87 ± 10.39	1.295	0.243		
	Training	53.60 ± 13.08	72.54 ± 13.88	3.900	0.008*		
	Conna+ training	55.51 ± 11.30	74.91 ± 10.53	5.968	0.001*		
LDL (mg/dl)	Control	166.44 ± 20.63	164.99 ± 14.89	0.153	0.883	0.918	0.447
	Cinnamon	160.48 ± 17.33	142.12 ± 23.99	1.264	0.253		
	Training	160.08 ± 18.73	144.15 ± 26.71	1.038	0.339		
	Conna+ training	162.99 ± 28.29	130.30 ± 25.13	2.460	0.049*		
TG (mg/dl)	Control	223.07 ± 15.69	233.37 ± 41.49	0.596	0.573	1.337	0.286
	Cinnamon	226.70 ± 26.00	209.28 ± 22.13	1.547	0.173		
	Training	237.82 ± 41.92	212.98 ± 26.95	1.150	0.294		
	Conna+ training	227.14 ± 40.36	194.12 ± 17.33	2.563	0.043*		
TC (mg/dl)	Control	209.85 ± 33.92	219.35 ± 29.11	1.027	0.344	1.270	0.307
	Cinnamon	210.62 ± 17.65	206.58 ± 32.99	0.248	0.812		
	Training	216.81 ± 33.49	195.25 ± 25.36	1.214	0.270		
	Conna+ training	235.81 ± 49.01	191.17 ± 27.27	1.814	0.120		

*Significance of within-group changes using paired samples t-test
**Significance of between-group changes using own-way ANOVA

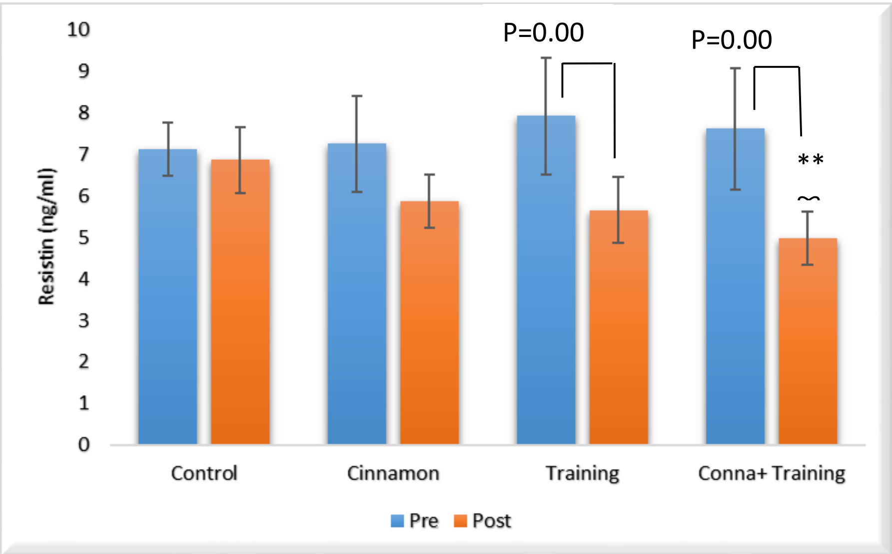

Figure 1. Comparison of intragroup ($F_{3,24}$=9.190, P=0.000) and intergroup (P=0.009, P=0.004) changes to evaluate changes in plasma levels resistin in the study groups
**Significant difference between the Control group and the Conna+Training group (P=0.014).
∞Significant difference between the Cinnamon group and the Conna+Training group (P=0.004).

Discussion & Conclusion

The results of this study showed that the combination of 8 weeks of aerobic interval training and cinnamon supplementation resulted in a significant reduction in weight and body mass index (BMI) in obese women. This finding is consistent with previous studies that have confirmed the synergistic effect of exercise interventions and herbal compounds on weight loss (40). For example, Qin et al. (2020) reported that the combination of aerobic exercise and supplements containing polyphenols, such as cinnamon, facilitates weight loss by increasing fat oxidation and reducing visceral fat stores (41). The possible mechanism of this effect can be attributed to the ability of cinnamon to increase insulin sensitivity and reduce systemic inflammation, both of which play a role in adipose tissue accumulation (42). Regarding the lipid profile, although no significant difference was observed between the groups, the internal reduction in LDL (P=0.049), TG (P=0.043), and the increase in HDL (P=0.001) in the combined group (exercise + cinnamon) indicate the positive effect of this intervention on regulating fat metabolism. These results are consistent with the research of Azimi et al. (2018), which showed that cinnamon improves lipid profiles by inhibiting cholesterol synthesis in the liver through activating AMPK pathways (43). On the other hand, aerobic interval training also accelerates the breakdown of triglycerides by increasing lipoprotein lipase (LPL) activity (44). However, the lack of difference between the groups may be due to the limited sample size or the short duration of the intervention, which has also been raised as a challenge in similar studies (45). In this study, an 8-week cinnamon supplementation did not result in significant changes in lipid profile parameters, including triglycerides, total cholesterol, LDL, and HDL. This lack of effect can be attributed to several factors, such as the insufficient duration for observable changes, individual variability in metabolic response, the dosage or type of cinnamon used, or the mechanisms by which cinnamon influences lipid metabolism—primarily through reducing insulin resistance, activating antioxidant and anti-inflammatory pathways, and modulating key enzymes involved in lipid regulation. However, these effects may require a longer period to manifest or be influenced by baseline health status, dose, form of cinnamon, or demographic factors like age and metabolic condition. Similarly, the exercise protocol in our study did not significantly alter participants' lipid profiles, aligning with some previous research (46) and contradicting others (47). The ineffectiveness of High-Intensity Interval Training (HIIT) in affecting fat profiles among obese individuals can be explained by various reasons: physical limitations or health issues may prevent maintaining sufficient exercise intensity; poor dietary habits and non-adherence to proper nutrition can overshadow exercise benefits; adaptive resistance in obese bodies may hinder metabolic changes; and a lack of variety in training programs can lead to adaptation and diminished improvements over time. These complex factors collectively highlight the challenges in modifying lipid profiles through lifestyle and dietary interventions in obese populations within a short timeframe.

One of the key findings of this study was the significant reduction in serum resistin levels in the combined group compared to the control group (P=0.014) and the supplement group (P=0.004) ($F_{3,24}$=9.190, P=0.000). Resistin is an adipokine associated with insulin resistance and inflammation (48). The reduction in its levels in the combined group is likely due to the simultaneous effect of exercise and cinnamon on inflammatory signaling pathways such as NF-κB (49). Animal studies have shown that cinnamaldehyde (the active compound in cinnamon) suppresses NF-κB activity and reduces the production of pro-inflammatory cytokines by inhibiting IκB-α phosphorylation (50). On the other hand, exercise inhibits resistin secretion from adipocytes by reducing visceral adipose tissue (51). This interaction is likely the reason for the superiority of the combined group in reducing resistin compared to the single-intervention groups.

Also, weight loss and improved body composition in the combined group may have indirectly affected resistin levels. Evidence suggests that a reduction in visceral fat is associated with a decrease in resistin secretion (52). This hypothesis is consistent with the study by Lee et al. (2021), which reported that a 10% reduction in body weight reduces resistin levels by 25% (53). On the other hand, cinnamon may play a direct role in regulating adipokine secretion by improving endothelial function and reducing oxidative stress (54).

Although this study did not show an improvement in lipid profiles between the groups, the internal reduction in LDL and TG in the combined group is significant. These results may indicate the need for longer interventions to observe intergroup changes. For example, in the meta-analysis by Shishehbor et al. (2017), daily consumption of cinnamon for at least 12 weeks was necessary to produce significant changes in total cholesterol and LDL (55). Also, the intensity and type of exercise may affect the results. Studies have shown that high-intensity interval training (HIIT) has a greater effect on lipid metabolism compared to continuous training (56). Overall, the findings of this study support the idea that the combination of exercise and cinnamon supplementation can be used as a non-pharmacological strategy to improve metabolic indices in obese women. However, future research should be designed with a focus on molecular mechanisms, optimal cinnamon dosage, and the long-term impact of this intervention. This study has several strengths, including a randomized design with logical grouping that allows for the comparison of individual and combined effects of exercise and supplementation, and a focus on a specific population of obese women, which makes the results more targeted. Additionally, precise measurement of biochemical parameters, particularly serum resistin and lipid profiles, enhances the reliability of the findings. However, it also has limitations, such as a small sample size with only seven participants per group, which may reduce statistical power, and a relatively short duration of 8 weeks, which might be insufficient to observe significant or long-term changes. The lack of strict control over external factors like diet and physical activity outside the intervention also risks confounding the results. Moreover, using only a specific type of exercise limits understanding of other exercise modalities' effects. Other weaknesses include short follow-up period for assessing long-term effects, and a focus solely on biochemical and physiological parameters without exploring more in-depth physiological mechanisms. Overall, while the study demonstrates valuable insights, increasing sample size, extending the duration, and broadening assessment measures would strengthen the validity and generalizability of the findings.

Conclusion

The 8-week combination of aerobic interval training and cinnamon consumption in obese women led to significant reductions in weight, BMI, and serum resistin levels, suggesting improved fat metabolism. While lipid profile changes were not significant overall, decreases in LDL and triglycerides and an increase in HDL in the combined group indicate positive effects on fat regulation. The decrease in resistin may reflect lowered systemic inflammation. However, the short duration and small sample size highlight the need for longer-term studies to confirm these findings.

Declarations

Author's Contributions

IF designed this study. IF and EM conducted the library search, wrote the manuscript, and drafted and edited the manuscript. All authors have read and approved the final manuscript

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Nil.

Conflicts of Interest

There are no conflicts of interest.

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