Coenzyme Q10 Supplementation Improves Adipokine Profile In Dyslipidemic Individuals: A Randomized Controlled Trial

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Abstract

Background: Adipokines are peptides secreted mainly by adipose tissue, which have been demonstrated to be vital targets of metabolic diseases. However, the effect of coenzyme Q10 (CoQ10) on adipokines has not been well studied.

Methods: We investigate the effect of CoQ10 intervention on adipokines in dyslipidemic patients. In this randomized, double-blinded, placebo-controlled trial, a number of 101 dyslipidemic individuals were administrated to 120 mg CoQ10 or placebo for 24 weeks. Anthropometric parameters, glucolipid profile, serum total adiponectin, leptin, and resistin were evaluated at baseline, week 12 and week 24.

Results: CoQ10 significantly increased adiponectin at week 12 (380 ng/mL [SE, 101] ng/mL, $p < 0.001$) and had more increment at week 24 (611 ng/mL [SE, 126] ng/mL , $p < 0.001$). The increase of adiponectin was negative associated with decrease in HOMA-IR ($r = -0.465$, $p = 0.001$), TG ($r = -0.297$, $p = 0.047$), and LDL-c ($r = -0.440$, $p = 0.002$) at week 24 only in CoQ10 group. Resistin was reduced by CoQ10 only at week 24 (3.45 ng/mL [SE, 0.69] ng/mL, $p < 0.001$) compared with placebo group. Reduction of resistin was positively correlated with the change in HOMA-IR ($r = 0.343$, $p = 0.021$) and TG ($r = 0.323$, $p = 0.030$) at week 24 in CoQ10 group but not placebo group. Leptin was not influenced by CoQ10 treatment.

Conclusions: Our study shows that CoQ10 ameliorates adipokines dysfunction in dyslipidemia patients in 24 weeks intervention, which suggests the beneficial effect of CoQ10 in modulating adipokine profile and metabolic disorders in dyslipidemic adults.

Trial registration: ClinicalTrials.gov, NCT02407548. Registered on April 3, 2015, https://clinicaltrials.gov/ct2/show/NCT02407548.

Introduction

Dyslipidemia includes the following lipid disorders : increased triglyceride (TG) levels, total cholesterol (TC), low-density lipoprotein cholesterol (LDL-c) and depressed high-density lipoprotein cholesterol (HDL-c). According to nationally data from 2013–2014, among Chinese adults aged 18 years or older, 28.5% had increased TC levels, 26.3% had increased LDL-c, 25.8% had increased TG, and 20.4% had decreased HDL-c level[1]. In developed country such as United States, Japan, and Korea, the incident rate of dyslipidemia is even higher[2–4]. Dyslipidemia is a risk factor of cadiovascular disease and vital component of metabolic syndrome. Sensible management of dyslipidemia can markedly prevent cardiovascular morbidity and mortality. Lifestyle modification, including healthy diets and proper physical activities are recommended to all the dyslipidemia patients. However, many patients require adjuvant therapy to reduce their lipid level[5]. The first-line treatment are statins, which efficiently decrease LDL-c and TC level and risk of atherosclerotic cardiovascular disease by inhibiting cholesterol synthesis. However, the increased risk of developing new-onset diabetes with statin-treatment raised concern of patients with hyperlipidemia, especially those with boderline hyperlipidemia[6]. More safe and effective measures to lower lipid and mitigate metabolic disorders deserve investigation.

Accumulating evidences suggest that adipose tissue is an active endocrine organ. By secreting adipokines, it participates in the crosstalk of organs in various metabolic processes. Adipokines such as adiponectin, leptin and resistin have many different metabolic functions associated with dyslipidemia and hyperglycemia and contribute to cadiovascular disease and metabolic syndrome. Their function included acting directly on the peripheral tissues, influencing their insulin sensitivity, therefore regulating the lipolysis and lipid clearance. Adipokines can also regulate the inflammation pathway, that to mediate the lipid metabolism[7]. Some adipokines such as adiponectin can modulate transcription factor such as peroxisome proliferator- activated receptors (PPARs) that regulate gene expression involved in lipid metabolism in liver, skeletal muscle and adipose tissue[8]. Therefore, dysregulation of adipokines is an indicator of progress of cadiovascular disease and metabolic syndrome. Adipokines have also became pivotal target for treatment of obesity, dyslipidemia and hyperglycemia.

Coenzyme Q10 (CoQ10) is a lipophilic antioxidant, abundant in mammalian organs, such as heart, liver, and kidneys. It forms a crucial part of the electron transport chain in mitochondria which is essential for the production of ATP[9]. CoQ10 level in the tissues and serum significantly decreases during aging[10] and many other pathological processes, such as myocardial disease[11], degenerative disease[12] and diabetes[13]. Effect of supplementation with CoQ10 in various diseases have been studied, but the results are inconsistant. In previous study, we found that CoQ10 can improve serum total antioxidant capacity, lipid profile and insulin resistance in dyslipidemia individuals[14]. However, the effect of CoQ10 on adipokines was still uncertain. Therefore, we conduct further analysis of adipokines on the basis of our previous study, to clarify the effect of CoQ10 intervention on adipokines and further confirm the correlation between adipokine and dyslidemia in human.

Methods

Participants

This study used data from the previous randomized, double-blinded, placebo-controlled trial which examined the effects of CoQ10 supplementation on lipid and glycemic profile in dyslipidemic individuals, and a detailed protocol had been published[14]. Briefly, a number of 101 individuals were recruited from community health service centers in Guangdong province, China. Participants were included if they were aged from 18 to 70 years and 2 or more of the following serum lipid parameters were abnormal: Serum fasting TC ≥ 5.20 mmol/L(200 mg/dL), fasting TG ≥ 1.70 mmol/L (150 mg/dL), fasting LDL-c ≥ 3.12 mmol/L (120 mg/dL), and fasting HDL-c ≤ 0.91 mmol/L (35 mg/dL). The exclusion criteria included serum fasting TC ≥ 8.0 mmol/L (309 mg/dL); fasting TG ≥ 4.5 mmol/L (395 mg/dL); history of cardiovascular disease or atherosclerosis; hyperthyroidism or hypothyroidism; cancer; liver or renal dysfunction; consumption of any medicine or dietary supplement that influences lipid and glucose metabolism, inflammation, and oxidative stress.

Ethics

All protocols in the present study conformed to Helsinki's Declaration and approved by ethics committee of Sun Yat-Sen University. All subjects in this study were provided written informed consent prior to study entry. This trial had been registered at clinicaltrials.gov as NCT02407548.

Randomization And Intervention

As previously described[14], eligible subjects were recruited and randomized to consume softgels of identical appearance with placebo or 120mg CoQ10 (4 softgels per day, each contain 30mg CoQ10, BYHealth Co Ltd, China) for 24 weeks. The softgels were identified by codes printed on the packaging bottles. Participants, investigators, and data analysts were blinded from the grouping information. Randomization was performed by an independent researcher using computer- generated random sequence that matching sex and age in blocks of 4. Participants were requested to maintain their usual diet and exercise habits and visit the study center every 4 weeks. Compliance was assessed by counting the empty pill containers returned by participants at each visit.

Data Collection

Detailed method of data collection have been described in previous published article[14]. Briefly, At baseline, venous blood was collected in the morning after the subjects had fasted for 10 to 12 hours. Then, a structured questionnaire was performed by trained research staffs via face-to-face interview. Information about socio- demographic data, medical history, uses of medications, dietary habits, and physical activities were collected. Blood sample and information collection was repeated at 12 weeks and 24 weeks after intervention.

Biochemical Analyses

After fasting for 10 to 12 hours, blood samples of the subjects were obtained in the morning at the beginning, 12th week, and 24th week of the trial. The blood samples were centrifuged at 3000 × g for 15 minutes before being separated serum and stored at -80°C until used. Biochemical parameters including concentrations of TC, TG, HDL-c, LDL-c, apolipoprotein A-1(ApoA-I), apolipoprotein B (ApoB), blood glucose and insulin were measured with an automatic biochemical analyzer (Roche Group, Switzerland). Index of homeostasis model assessment of insulin resistance (HOMA-IR index) was used to evaluate insulin resistance and calculated as (fasting insulin[mU/L] × fasting blood glucose [mmol/L]) / 22.5.

Fasting serum total adiponectin was measured using commercial ELISA kits (R&D Systems DRP300, USA). The kit can measures total (low, middle, and high molecular weight) human adiponectin in serum. The average intra and inter-assay coefficients of variation for adiponectin were 5.3% and 6.1%, respectively. Fasting serum leptin was measured by Human Leptin Quantikine ELISA Kit (R&D Systems DLP00, USA). The average intra and inter-assay coefficients of variation for leptin were 3.3% and 8.1%,

respectively. Fasting serum resistin was measured with reagents of Human Resistin Quantikine ELISA Kit (R&D Systems DRSN00, USA). The average intra and inter-assay coefficients of variation for resistin were 5.5% and 6.2%, respectively. All ELISA experiments were conducted according to the manufacturer's instructions.

Statistical analysis

The sample size estimation was based on the primary outcome of TG, TC, LDL-c, and HDL-c as reported in the main paper[14]. Briefly, a sample size of 48 per arm was required to detect a 0.3 mmol/L (26.5 mg/dL) decrease in TG between groups at a type I error of 0.05 (two-tailed) and a type II error of 0.20 (power = 80%)[15]. The sample size estimation of TC, LDL-c, and HDL-c were less than 48. Therefore, at least 48 subjects were needed to include in each group. We conducted an intention-to-treat analysis, which included data from all participants who underwent randomization.

SPSS sofeware (Version19.0, IBM, Inc) was used for statistical analysis. Normality was tested by the Kolmogorov–Smirnov test and all adipokines and lipid and glucoregulatory data were found to be normally distributed. Data are shown as mean values (with SD) or mean (with SE) as noted. A 2-tailed $p < 0.05$ was considered statistically significant. Differences of glucolipid profile and adipokines between groups were assessed using independent samples t tests. Paired-samples t test was used to compared change within group. Pearson's correlation coefficients (r) were calculated to evaluate correlations between the changes in adiponkines and glucolipid metabolic variables.

Results

General characteristics of the subjects

By using rapid lipid test with CardioChek PA Analyzer (PTS Diagnostics), we screened 127 qualified participants. After detailed examination, 101 were recruited and randomly assigned to either CoQ10 group (n = 51) or placebo groups (n = 50) at baseline. At week 12, two participants lost to follow-up in CoQ10 group for being absent from the schedule visits (n = 1) and flatulence (n = 1). Two participants in placebo group did not attend the schedule visits and withdrew. At week 24, one participants in CoQ10 group cannot meet the schedule visits and withdrew. Two participants withdrew for not coming the schedule visits (n = 1) and flatulence (n = 1) in placebo group. A total of 94 subjects (93.07% of those assigned) completed the study. But all participants who underwent randomization were included in the analysis. The flow chart presented in Figure 1 shows the allocation and the numbers of dropping out patients for each group.

The mean age of participants included in this study was 50.90 (SD, 9.95 years); 31.7% of them were male; 56.4% were prediabetics (defined as 7.0 > fasting blood glucose ≥ 5.6 mmol/L or 126 > fasting blood glucose ≥ 100.8 mg/dL); 97.0% showed insulin resistance (defined as HOMA-IR index > 1); 64.3% had metabolic syndrome (defined according to National Cholesterol Education Program Adult Treatment

Panel III [2005 American Heart Association] revised edition). At baseline, mean body weight was 64.26 kg (SD, 13.26 kg), BMI was 25.07 kg/m^2 (SD, 3.64 kg/m^2)[14].

CoQ10 effects on the glucolipid profile

Changes of glucolipid parameters are displayed in Table 1. Fasting blood glucose, insulin and HOMA-IR did not differ significantly between the intervention groups at baesline or week 12. At week 24, glucose levels significantly decreased in the CoQ10 group (0.23 mmol/L [SE, 0.09 mmol/L]) related to the placebo group. There were also significant difference in fasting insulin (2.86 mU/L [SE, 1.29 mU/L]) and the HOMA-IR (0.75, [SE, 0.34]) between the intervention groups at week 24.

As for lipid profile, there were no significant differences in all markers between the two groups at week 0 and 12. At week 24, TG (0.33 mmol/L [SE, 0.15 mmol/L]) and LDL-c (0.30 mmol/L [SE, 0.13 mmol/L]) level significantly decreased in CoQ10 group compared to placebo group. ApoA-I / ApoB significantly increased (0.18 mmol/L [SE, 0.04 mmol/L]) in CoQ10 group compared to placebo group.

CoQ10 effects on serum adipokines

Furthermore, in order to investigate the adipokine changes in CoQ10 intervention, we detected three serum adipokines, which were adiponectin, leptin and resistin at baseline and weeks 12 and 24. Concentration of three adipokines were not significantly different between two intervention groups at baseline. In placebo group, adiponectin slightly but significantly decreased at week 12 ($p = 0.031$), but did not significantly changed at week 24 ($p > 0.05$) compared to baseline. However, CoQ10 supplementation significantly increased serum adiponectin at week 12 ($p = 0.004$) and week 24 ($p < 0.001$) compared to baseline. Change of adiponectin between two groups was significant different at week 12 (380 ng/mL [SE, 101 ng/mL]) and this effect maintain by week 24 (611 ng/mL [SE, 126 ng/mL]). Change of resistin concentrations did not differ significantly between the intervention groups at week 12. At week 24, resistin levels significantly decreased in the CoQ10 group (-2.77 ng/mL [SD, 4.23 ng/mL]) relative to placebo group (0.68 ng/mL [SD, 1.91 ng/mL]). Change of leptin levels did not differ significantly between two groups at week 12 or week 24. Changes in serum adipokines are displayed in Table 2.

Correlation of adipokines with markers of glucose and lipid metabolism

Moreover, we performed a correlation analysis to establish the relationship between adipokine profiles change and glucolipid related markers that had been improved in CoQ10 intervention study. Change in adiponectin was negatively correlated with the change in HOMA-IR (r = -0.465, $p = 0.001$), TG (r = -0.297, $p = 0.047$), and LDL-c (r = -0.440, $p = 0.002$) at week 24 in CoQ10 group but not placebo group. There was no correlation between change of adiponectin and ApoA-I / ApoB at week 24 in both groups. Change in resistin concentration was positively correlated with the change in HOMA-IR (r = 0.343, $p = 0.021$) and TG (r = 0.323, $p = 0.030$) at week 24 only in CoQ10 group. There was no correlation between change of resistin and ApoA-I / ApoB and LDL-c at week 24 in both groups. Correlations of adipokines with markers of glucose and lipid metabolism are displayed in Figure 2.

Discussion

In our current study, supplementation with CoQ10 for 24 weeks not only improved serum levels of glucose, insulin, TG, LDL-c and ApoA-I / ApoB, but also increased serum adiponectin and decreased resistin. In CoQ10 group, change in adiponectin and resistin was correlated with the improvement of glucolipid profile.

As a lipophilic antioxidant, CoQ10 regulated lipid and glucose profile in a series of diseases, such as diabetes[16] and metabolic syndrome[17]. Consistently, our study also concluded that in Chinese dyslipidemia patients, long-term CoQ10 supplementation improved their insulin sensitivity and lipid profile. Though less powerful and cost-effective than clinical medication in lipid lowering and hypoglycemic therapy, CoQ10 has benefits on multiple risk factors of cardiovascular disease, including lowering blood pressure[14], blood glucose, lipids and HOMA-IR. Moreover, as a natural endogenous compound, supplementation of CoQ10 cause few side effect. Therefore, CoQ10 is quite a good option for those who have moderate dyslipidemia with borderline hypertension and prediabetes.

Adipokines were closely related to lipid and glucose metabolism. Several trials had explored the relation between adipokines and CoQ10 supplementation in various metabolic diseases with conflicting conclusions[18–21]. To our knowledge, this is the first study to examine the effect of supplementation with CoQ10 on serum adipokines in patients with dyslipidemia. Leptin is secreted by adipose tissue and transported through blood brain barrier to acted on neuroendocrine axes, plays an important role in anorexia and energy expenditure[22]. leptin is a reliable marker of percentage of fat mass[23]. Increased circulating leptin was observed in insulin resistance and T2DM[24] and correlated positively with lipids levels[25]. In previous studies, CoQ10 supplementation significantly reduced leptin levels in individuals with non-alcoholic fatty liver disease[20] and type 2 diabetes[19], which were inconsistent with our study. The conflicting results may come from that the baseline serum level of leptin in the present study (13.17 ng/mL) was much lower than previous two RCTs (26.94 ng/mL in patients with non-alcoholic fatty liver disease and 23.51 ng/mL in patients with type 2 diabetes). Accordingly, participants in our study were much thinner (mean BMI was 25.07 kg/m^2) than those two RCTs (mean BMI was 28.96 kg/m^2 in patients with non-alcoholic fatty liver disease and 28.99 kg/m^2 in patients with type 2 diabetes). Our results also shown that CoQ10 did not cause significant weight loss[14]. Therefore, it was not surprising to observe a less remarkable improvement in leptin in subjects who per se had moderate increased of leptin and BMI. However, we cannot totally rule out the possibility that CoQ10 influence leptin secretion.

Several published RCTs had reported conflicting effect of CoQ10 in adiponectin in various diseases. CoQ10 supplementation at 100 mg/d for 12 weeks increased adiponectin concentration in individuals with non-alcoholic fatty liver disease[20] and mild hypertension[26]. A dose of 200 mg/d CoQ10 supplemented for 8 weeks increased serum adiponectin in individuals with type 2 diabetes[19]. The increase of adiponectin was parallel with the ameliorative effects on lipid peroxidation and glucose control[27]. Results from our present study were coincident with these trials. However, study conducted by Moazen et al found that CoQ10 supplemented at a dose of 100 mg/d in type 2 diabetes for 8 weeks

showed no significant difference in adiponectin when compared to the placebo control[28]. In healthy, nonsmoking, sedentary men, CoQ10 supplementation at 100 mg/d for 8 weeks also suggested no improvement of adiponectin[18]. The limited intervention time (less than 12 weeks) and mild illness condition may account for the negative results of adiponectin responded to CoQ10 supplementation.

Adiponectin was thought as a protective adipokine. Extensive evidence have demonstrated anti-atherosclerotic, anti-diabetic, and anti-inflammatory activities that adiponectin possessed[29]. In contract to leptin, serum adiponectin level was inversely correlated with body fat and obesity[30, 31]. Weight loss due to caloric restriction[32] or insulin sensitivity improvement due to pharmacological treatment [33] would raise adiponectin concentration. The gene expression of adiponectin is tightly controlled by a number of factors. PPAR-γ, which is expressed mainly in adipose tissue, is the major positive regulator of adiponectin gene expression. In contrast, inflammation factors such as tumor necrosis factor-alpha (TNF-α) inhibit adiponectin gene expression[34]. CoQ10 intervention can raise the expression of PPAR-γ in peripheral blood mononuclear cells of subjects with polycystic ovary syndrome[35]. CoQ10 can also partially attenuate the effect of TNF-α on PPAR-γ in HL-1 cardiomyocytes[36]. Then in the present study, we found that CoQ10 could up-regulate adiponectin at the 12th week of intervention, and the effect was more obvious at the 24th week. Remarkable, the increased of adiponectin was related to the improvement of HOMA-IR and lipid profiles. These results further suggested that adiponectin may be an important pathway and target of CoQ10 to improve lipid and glucose metabolic disorders. However, more studies were needed to further confirm them.

Resistin is a signalling molecule that is induced during adipogenesis and secreted mainly by white adipocytes. The concentration of serum resistin increased in genetic and diet-induced obesity. Resistin decreased insulin-stimulated glucose uptake in vitro and impaired glucose tolerance in mice[37]. In human studies, however, resistin is synthesized predominantly by mononuclear cells inside and outside adipose tissues[38, 39]. It can increase the production of the proinflammatory cytokines through the transcription factor NF-κB in mononuclear cells and adipicytes[40, 41]. Plasma resistin levels have been correlated with TNF-α and interleukin-6 (IL-6) in coronary atherosclerosis patients[42]. As we known, chronic inflammation were involved in the pathogenesis of obesity, type 2 diabetes and atherosclerosis. Therefore, resistin has been suggested as an important modulator and predictor of the activity of related diseases.

To our knowledge, this is the first study to investigate the effect of CoQ10 on resistin. Supplementation of CoQ10 for 24 weeks reduced serum resistin. Moreover, change in resistin concentration was positively correlated with the change in HOMA-IR and TG in CoQ10 group, indicating that inflammation signaling pathway modulated by resistin may be involved in the regulation mechanism of CoQ10 on dyslipidemic patients. Interestingly, we did not found significant improvement of high-sensitivity C-reactive protein by CoQ10[14]. Prospective study in atherosclerosis patients showed that resistin was a predictive factor for coronary atherosclerosis in humans, independent of CRP. Other study also suggested that resistin's intracellular signaling pathway was distinct from other common cycotine[41]. Whether the reduction of resistin by CoQ10 was the result from the amelioration of metabolic condition, or suggested a new

mechanism need further investigation. Resisitin has been suggested as a marker of the severity of myocardium ischemic injury[43], the change of resistin by CoQ10 in dyslipidemic patients indicated a decreased risk for them to develop atherosclerosis.

Conclusions

In conclusion, we report that CoQ10 supplementation increase adiponectin and decrease resistin concentrations in dyslipidemic adults, which is correlated with the HOMA-IR and lipid profiles. These data suggest that the improvement of CoQ10 on glucolipid metabolism in dyslipidemic adults was partly by modulating adipokine dysfunction. The mechanism amongst CoQ10, adipokines and metabolic change is needed to figure out by well-designed experiments. Large trials are needed to comfirm our findings in different populations and to determine whether changes in these adipokines by CoQ10 supplementation makes sense to the clinical treatment and prevention of dyslipidemia and related diseases.

Abbreviations

ApoA-I, Apolipoprotein A-1; ApoB, Apolipoprotein B; CoQ10, Coenzyme Q10; HDL-c, High-density lipoprotein cholesterol; HOMA-IR, Homeostasis model assessment of insulin resistance; IL-6, Interleukin-6; LDL-c, Low-density lipoprotein cholesterol; PPARs, Peroxisome proliferator-activated receptors; TC, Total cholesterol; TG, Triglyceride; TNF-α, Tumor necrosis factor-alpha.

Declarations

Ethics approval and consent to participate

All protocols in the present study conformed to Helsinki's Declaration and approved by ethics committee of Sun Yat-Sen University. All subjects in this study were provided written informed consent prior to study entry. This trial had been registered at clinicaltrials.gov as NCT02407548.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/ or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

PZ, and KC conducted the research and wrote the manuscript; HG and XCdesigned the research; TH analyzed the data; XC had primary responsibility for the final content of the manuscript; all the authors read and approved the final manuscript.

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Tables

Table1. Effect of CoQ10 intervention on glucolipid profile

Characteristic	Change in CoQ10 – Change in placebo Mean (SE)		p_1[a]	p_2[b]
	At 12 week	At 24 week		
Glucose, mmol/L	-0.08 (0.11)	-0.23 (0.09)	0.496	0.011
Insulin, mU/L	-1.33 (0.73)	-2.86 (1.29)	0.071	0.030
HOMA-IR	-0.38 (0.23)	-0.75 (0.34)	0.099	0.031
TG [c], mmol/L	-0.07 (0.14)	-0.33(0.15)	0.626	0.032
Cholesterol, mmol/L	-0.19 (0.17)	-0.12 (0.14)	0.271	0.406
HDL-c [d], mmol/L	-0.03 (0.06)	0.02 (0.04)	0.597	0.614
LDL-c [e], mmol/L	-0.17 (0.13)	-0.30 (0.13)	0.181	0.020
ApoA-I [f], g/L	0.02 (0.05)	0.20 (0.04)	0.620	<0.001
ApoB [g], g/L	-0.02 (0.04)	-0.02 (0.03)	0.558	0.464
ApoA-I / ApoB	0.05 (0.06)	0.18 (0.04)	0.428	<0.001

[a] *p* value from comparison between two groups using independent samples t tests at week 12.

[b] *p* value from comparison between two groups using independent samples t tests at week 24.

[c] TG is short for triglyceride

[d] HDL-c is short for high-density lipoprotein cholesterol

[e] LDL-c is short for low-density lipoprotein cholesterol

[f] ApoA-I is short for apolipoprotein A-1

[g] ApoB is short for apolipoprotein B

Table2. Effect of CoQ10 intervention on adipokines [a]

Adipokines	Placebo group (n = 50)	CoQ10 group (n = 51)	p [b]
Adiponectin, ng/mL			
baseline	5779 ± 2008	5794 ± 1782	0.969
12 wk	5650 ± 2018	6046 ± 1807	0.329
24wk	5755 ± 2070	6381 ± 1992	0.147
12-wk change [c]	-129 ± 387	251 ± 552	< 0.001
24-wk change [d]	-23 ± 544	587 ± 644	< 0.001
Leptin, ng/mL			
baseline	12.37 ± 8.38	13.96 ± 8.83	0.386
12 wk	11.67 ± 8.08	14.12 ± 8.76	0.172
24wk	11.94 ± 9.17	14.95 ± 10.33	0.147
12-wk change	-0.70 ± 3.18	0.16 ± 3.46	0.219
24-wk change	-0.43 ± 4.15	0.99 ± 5.07	0.148
Resistin, ng/mL			
baseline	10.04 ± 6.41	11.06 ± 6.50	0.454
12 wk	10.83 ± 7.11	11.33 ± 6.39	0.724
24wk	10.72 ± 6.62	8.29 ± 6.28	0.078
12-wk change	0.79 ± 2.16	0.27 ± 1.32	0.172
24-wk change	0.68 ± 1.91	-2.77 ± 4.23	< 0.001

[a] variables are presented as mean ± SD

[b] *p* value from comparison between two groups using independent samples t tests at baseline, week 12, week 24, 12-wk change and 24-wk change, respectively.

[c] 12-wk change = adipokine value at week 12 - adipokine value at baseline.

[d] 24-wk change = adipokine value at week 24 - adipokine value at baseline.

Figures

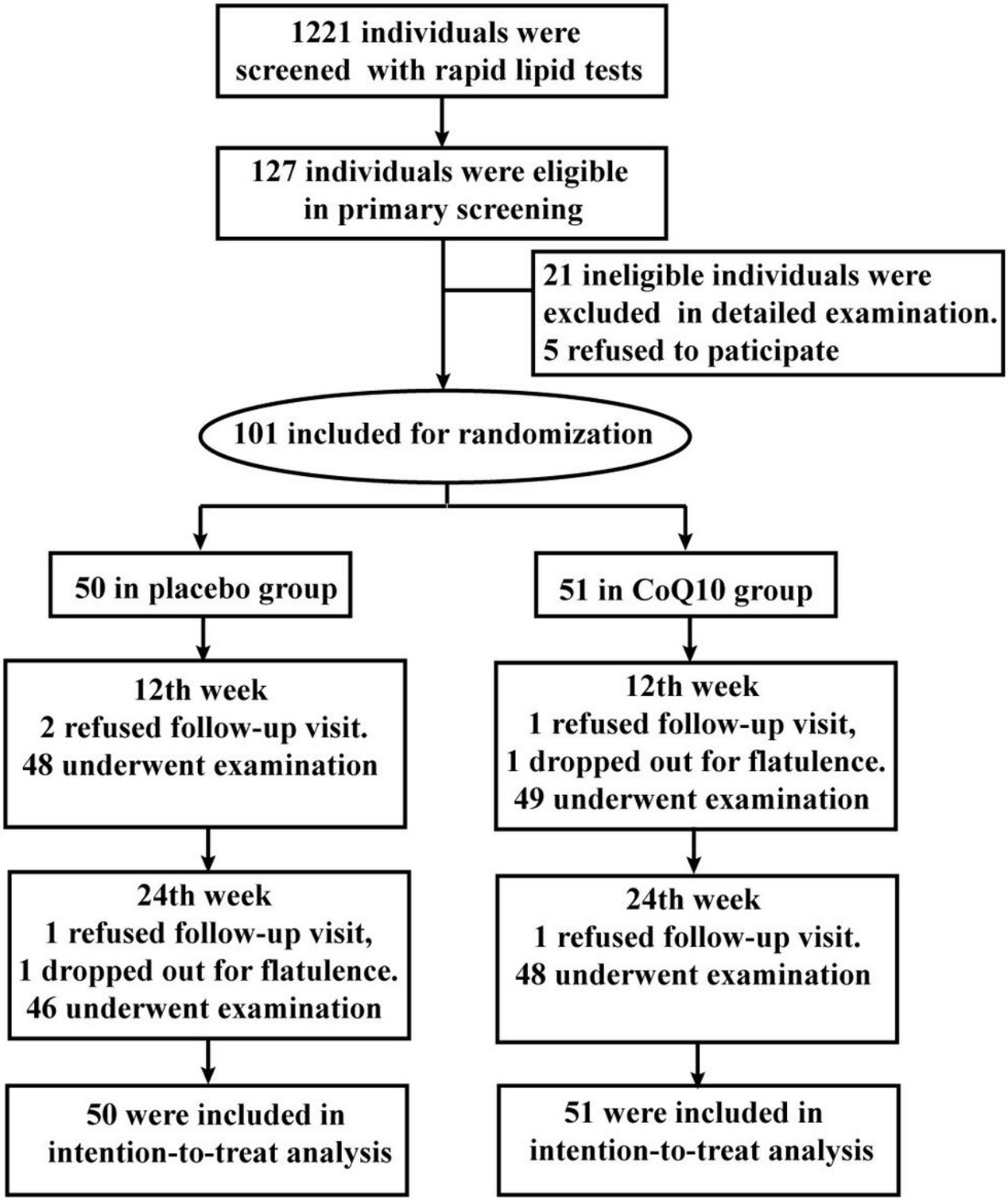

Figure 1

Flow diagram and study design

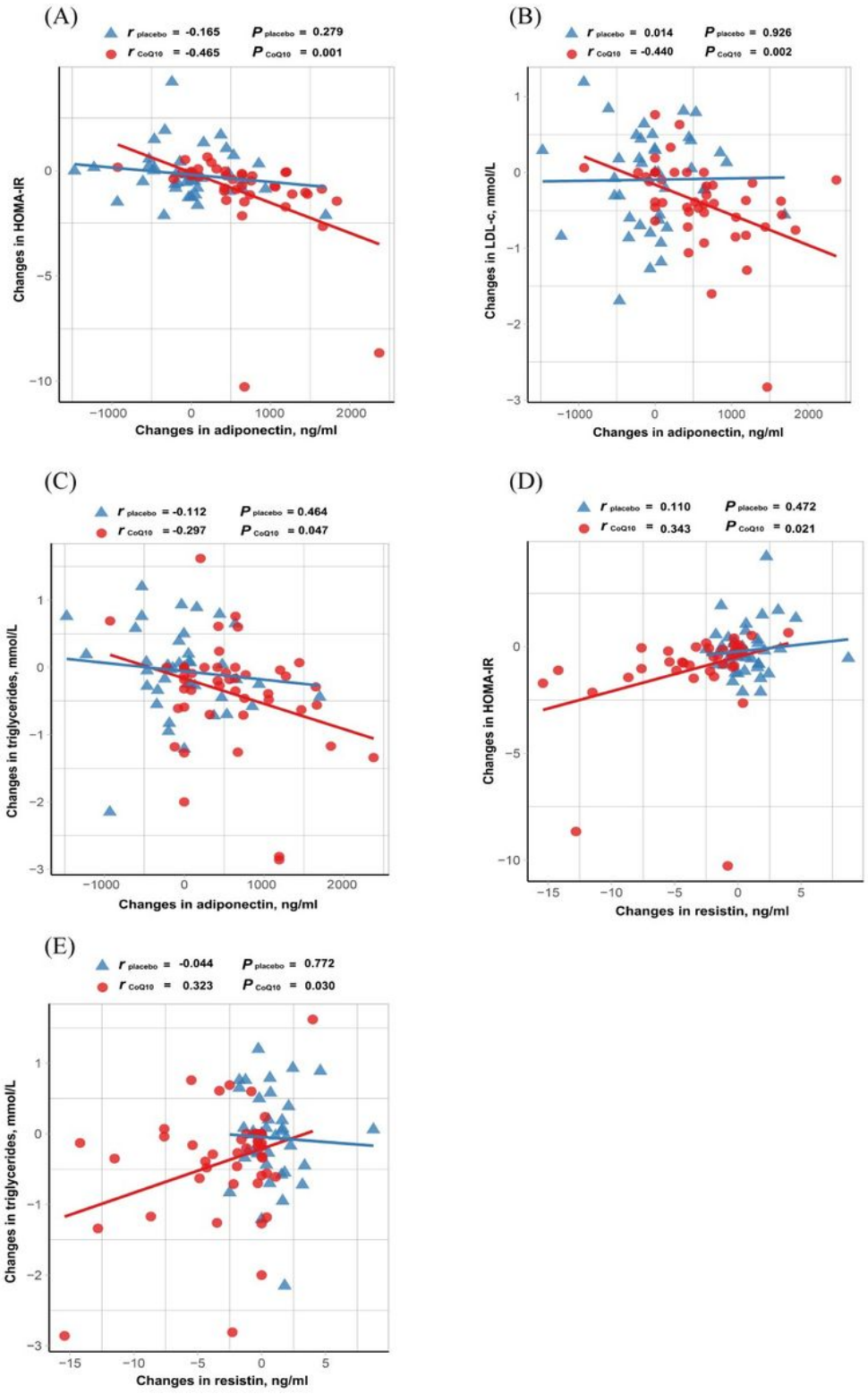

Figure 2

Correlation of adipokines with glucolipid profile Correlation analysis between the 24-week change in serum adiponectin and HOMA-IR index (a), LDL-c (b) and TG (c) in placebo and CoQ10 group, respectively. Correlation analysis between the 24-week change in serum resistin and HOMA-IR index (d) and TG (e) in placebo and CoQ10 group, respectively. (n = 50 in placebo and = 51 in CoQ10 group). The

data were evaluated by pearson correlation coefficient (r). HOMA-IR, homeostasis model assessment of insulin resistance; LDL-c, low-density lipoprotein cholesterol; TG, triglyceride.