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Effect of orlistat alone or in combination with *Garcinia cambogia* on visceral adiposity index in obese patients

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ABSTRACT

Aim: The objective of this study was to estimate the effect of orlistat alone and in combination with *Garcinia cambogia* on visceral adiposity index (VAI) in obese patients. **Patients and Methods:** A total of 99 obese male patients were recruited with aged range between 37 and 46 years. They were randomized into three equal groups, first group treated with orlistat 120 mg/day, second group treated with *G. cambogia* 166 mg/day, and third group treated with orlistat 120 mg/day plus *G. cambogia* 166 mg/day. The duration of the treatments was three consecutive months. Body mass index (BMI), VAI, blood pressure, blood glucose, total lipid profile, atherogenic index, and cardiac risk ratio were recorded at baseline and after 3 months. **Results:** The treatment with *G. cambogia* leads to reduction in VAI $P < 0.05$, whereas orlistat has a beneficial effect on cardiometabolic profiles without a reduction in VAI $P > 0.05$. Combined therapy of *G. cambogia* plus orlistat showed the more significant effect in reduction of VAI $P < 0.05$, cardiometabolic profiles and anthropometric measures $P < 0.01$ compared to pretreatment period. **Conclusion:** Combination of *G. cambogia* with orlistat lead to more significant effect than orlistat alone in amelioration of cardiometabolic profile and VAI in obese patients.

KEY WORDS: *Garcinia cambogia*, obesity, orlistat

INTRODUCTION

Obesity is a body fat excess as a result of positive energy balance or it is an excess of body fat mass that linked with frequent metabolic disorders such as ischemic heart diseases, dyslipidemia, type 2 diabetes mellitus, and hypertension [1,2].

Thus, the principal that been measures taken to manage the obesity like exercise and dietary restriction are often insufficient alone, so anti-obesity pharmacotherapy is needed as an adjuvant in the management of obesity [3].

Most of anti-obesity agents acting centrally leading to appetite suppression and reduction in food intake such as fenfluramine, sibutramine, and amphetamine which causes serious sympathetic activation and cardiovascular adverse effects that limit and restrict their uses chiefly in patients with cardiovascular disease [4]. Therefore, peripherally acting agents effects such as orlistat and *Garcinia cambogia* are recommended.

Orlistat is a potent and specific 47-91% of gastric lipase, 51-82% of pancreatic lipase) without any action on amylase, phospholipase and trypsin, this lead to inhibition of triglyceride (TG) hydrolysis, absorption of fatty acids, and monoglycerides from enterocytes consequently; the ingested fat absorption is diminished by about 36% [5].

Multicenter randomized trials on the efficacy of orlistat in weight reduction showed a favorable weight reduction and improvement in obesity profiles such as a reduction in insulin resistance, anthropometric measure, and improvement in lipid profiles in diabetic obese patients [6].

Orlistat was approved by Food and Drug Administration on 1999 as anti-obesity agent for long-term therapy; it is not absorbed so it's not produced any systemic manifestation, thus, it causes local gastrointestinal disorders which include reduction of fat soluble vitamin absorption (vitamin A, D, E, K), oily spot, flatulence, and increases frequency of defecations and rarely it may cause a severe hepatic damage [7].

On the other hand, *G. cambogia* contains an active constituent called hydroxycitric acid (HCA) that plays an important role in weight reduction, which is a competitive inhibitor of citrate-lyase enzyme that catalyze extra-mitochondrial citrate into acetyl coenzyme A and oxaloacetate causing a significant reduction of acetyl coenzyme A pools that limiting the availability of substrate for lipogenesis through activation of glycogenesis [8]. A study has been revealed that HCA inhibits *de novo* fatty acid and cholesterol biosynthesis leading to significant reduction of subcutaneous and visceral fat accumulations subsequently; long-term therapy with *G. cambogia* leading to significant weight reduction [9].

Regarding the cardiometabolic risk profile in obesity, visceral adiposity index (VAI) has been recognized as a clinical marker for adipose tissue dysfunction before it expands into an evident metabolic syndrome. VAI is highly associated with cardiovascular complications and insulin resistance [10], while body mass index (BMI) is incorrectly considered as a reasonable predictor for body fat percentage regardless of gender because of BMI is not always linked with cardiovascular mortalities [11]. Moreover, waist circumference (WC) has been regarded as an applicable index in the evaluation of adipose tissue distribution that is highly linked to visceral and abdominal obesity, but cannot distinguish between subcutaneous and visceral adipose tissue in the abdominal area [12].

Therefore, the objective of this study was evaluating the effect of orlistat alone or with *G. cambogia* on VAI in obese patients.

PATIENTS AND METHODS

This randomized, population-based controlled study was done and carried out at Department of Clinical Pharmacology, College of Medicine, Al-Mustansiriya University, from June to September 2015, Baghdad-Iraq. The study was approved according to the guide of the Declaration of Helsinki and by the Institutional Review Board and Ethical Committee in College of Medicine. The procedures of the study were completely explained to all patients, and all patients provided a written consent before the contribution in this study according to the ethical resolution 33AT/2015.

Study Design

In this study, 99 obese male patients were recruited; age range was 37-46 years. The patients were selected according to the European Society of Cardiology [13]. Appropriate patients, identified from a direct interview and according to the routine investigations while, obese patients with diabetes mellitus, renal failure, liver disorders, severe cardiovascular disorders, cerebrovascular disorders and severe anemia were excluded from this study. Obese patients were randomized into three equal groups, first group treated with orlistat 120 mg/day (xenical capsule, Roch), second group treated with *G. cambogia* 166 mg/day (Garcinia capsule, himalaya), and third group treated with both orlistat and *G. cambogia*. The duration of treatments was three consecutive months. The baseline data were recorded, then after the end of the duration of therapy; the biochemical and anthropometric measures were estimated. The patients were allocated to receive *G. cambogia* and orlistat in addition to their current treatment like antihypertensive agents. All medications were supplied free of charge. The patients were asked to avoid treatment with mineral and vitamins during the study. In addition, the patients have been advised for standard diet and avoidance of sedentary lifestyle.

Assessment of Anthropometric and Cardio-Metabolic Measures

BMI = body weight (kg)/height (m^2) [14].

VAI is calculated according the specific formula which depends on WC, TG, and high-density lipoprotein (HDL) in mmol/L [15].

$$\text{VAI} = \left(\frac{1.31}{\text{HDL}}\right) \times \left(\frac{\text{TG}}{1.03}\right) \times \left(\frac{\text{WC}}{39.68 + \left(1.88 \times \text{BMI}\right)}\right)$$

Assessment of Lipid Profile

TG, total cholesterol (TC), and HDL were assessed by specific ELISA kits; from this profile, we can measure the followings: Atherogenic index (AI) = log (TG/HDL), when TG and HDL measured in mmol/l., atherogenic coefficient (AC) = (TC-HDL)/HDL, low density lipoprotein (LDL) = (TC)-(HDL)-(TG)/5, very LDL (VLDL) = TG/5, and cardiac risk ratio (CRR) = TC/HDL [16].

Moreover, blood pressure measurements and other routine investigations such as fasting and random blood glucose were performed.

Statistical Analysis

Statistical estimation of data was done through using the statistical package for social sciences software version 21.0 (SPSS). Data were expressed as mean ± standard error. Continuous variables were compared via analysis of variance (ANOVA), which also evaluated the significance between groups. Paired *t*-test was used to compare results before and after administration of treatments, *P* value for all statistical analysis regarded significant when it was <0.05.

RESULTS

A total number of 99 obese male patients were enrolled in this study, of these 89 patients completed the study, 30 (26.7%) was allocated in orlistat group, 30 (26.7%) was allocated in *G. cambogia* and 29 (25.81%) was allocated in combined orlistat plus *G. cambogia* group.

A total number of 10 patients did not complete the study due to drug side effects, non-compliance and other reasons. At the end the duration of treatment, the study withdrawal rate was three (0.99%) [Figure 1].
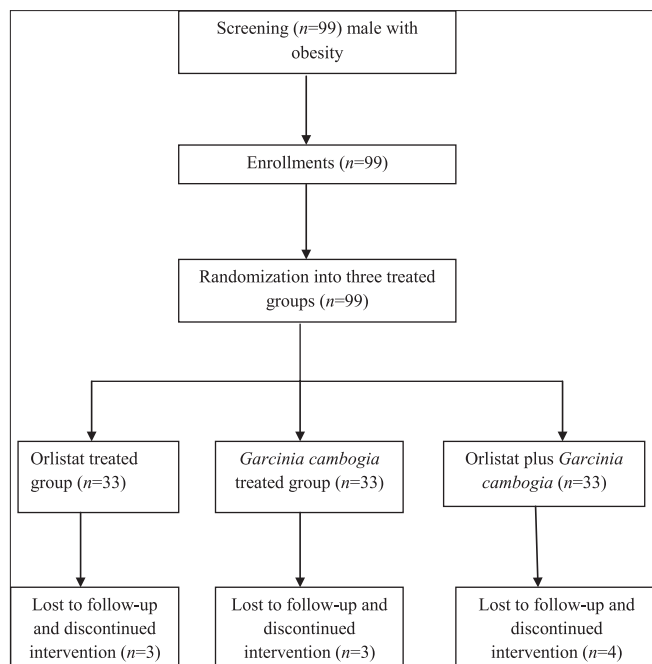
Figure 1: Flow chart of the present study

Most of the enrolled patients were hypertensive with dyslipidemia and other concomitant diseases that were currently treated with antihypertensive, antiplatelet, and hypolipidemic agents. The patient characteristics of the present study are shown in Table 1.

Orlistat produced significant reduction in body weight $P < 0.01$ and WC $P < 0.05$ compared to baseline parameters. Moreover, orlistat produced significant blood pressure lowering effect ($P < 0.01$). Regarding the effects of orlistat on lipid profile effect, it produced significant reductions in TC level $P < 0.0001$, VLDL $P < 0.0001$, LDL $P = 0.006$, AI $P = 0.0395$, AC $P = 0.040$, and CRR $P = 0.023$. The descriptive effects of orlistat showed in Table 2.

G. cambogia treatment led to significant body weight reduction ($P < 0.05$) and more significant reduction in WC ($P < 0.01$) compared with baseline data. *G. cambogia* therapy led to significant reduction in VAI $P = 0.0051$. Furthermore, *G. cambogia* produced a more significant effect on blood pressure, TC, and LDL ($P < 0.01$). Furthermore, AI ($P = 0.039$), AC ($P = 0.0381$), and CRR ($P = 0.0032$) are decreased significantly [Table 3].

Our study also revealed that combination of *G. cambogia* and orlistat showed a significant reduction in cardiometabolic indices; body weight and BMI ($P < 0.01$ and 0.05), respectively. Moreover, the combined effect demonstrated significant reductions in WC $P < 0.0001$, VAI $P = 0.023$, significant reduction in all lipid profile without significant elevation in HDL cholesterol ($P > 0.05$). Furthermore, combination treatment lowered blood pressure significantly ($P < 0.01$), [Table 4].

Table 1: Characteristics of the study

Variables	Orlistat	*G. cambogia*	*G. cambogia* plus Orlistat
Number	33 (33.33)	33 (33.33)	33 (33.33)
Age (years)	41.22±4.64	42.48±7.03	39.73±5.83
Gender (male)	33 (33.33)	33 (33.33)	33 (33.33)
Body weight (kg)	104.75±3.94	103.65±3.44	102.33±2.24
Associated disease			
Dyslipidemia	29 (29.29)	30 (30.30)	27 (27.27)
Hypertension	22 (22.22)	24 (24.24)	25 (25.25)
Asthma	2 (2.02)	3 (3.03)	4 (4.04)
Current therapy			
Statins	27 (27.27)	30 (30.03)	25 (25.05)
Aspirin	22 (22.02)	29 (29.02)	21 (21.02)
Clopidogrel	11 (11.01)	8 (8.08)	9 (9.09)
Montelukast	2 (2.02)	3 (3.03)	4 (4.04)
Theophylline	2 (2.02)	3 (3.03)	4 (4.04)
Gemfibrozil	15 (15.01)	14 (14.01)	5 (5.05)
Omega-3 fatty acid	18 (18.01)	16 (16.01)	20 (20.62)
ACEI	20 (20.02)	20 (20.02)	19 (19.01)
B-blockers	2 (2.02)	4 (4.04)	6 (6.06)

Data are presented as number, % and mean±SE; ACEI: Angiotensin-converting enzyme inhibitors. *G. cambogia: Garcinia cambogia*

Table 2: Effects of orlistat on cardiometabolic indices in obese patients

Variables	Before (n=33)	After (n=30)	P
body weight (kg)	104.75±3.95	90.55±1.87	0.002**
Height (cm)	165.35±3.47	165.31±3.97	0.99
BMI (kg/m²)	38.92±3.28	36.50±3.57	0.61
WC (cm)	101.11±3.46	91.76±2.11	0.0239*
HC (cm)	116.55±5.14	110.88±6.99	0.512
VAI	4.05±0.64	3.32±0.21	0.28
SBP (mmHg)	158.73±1.34	143.12±1.09	<0.0001**
DBP (mmHg)	90.76±1.39	80.67±1.22	<0.0001**
Pulse P (mmHg)	67.96±0.05	62.45±0.13	<0.0001**
Mean BP (mmHg)	124.75±1.37	111.89±1.11	<0.0001**
HDL (mg/dL)	41.29±3.21	44.99±3.94	0.46
VLDL (mg/dL)	67.41±3.3	64.138±2.1	<0.0001**
LDL (mg/dL)	138.28±11.7	91.6±11.71	0.006**
TC (mg/dL)	246.98±5.20	200.77±4.83	<0.0001**
TG (mg/dl)	337.05±16.52	320.69±12.76	0.432
AI	0.552±0.02	0.493±0.022	0.0395*
AC	4.84±0.62	3.46±0.22	0.040*
CRR	5.98±0.61	4.46±0.22	0.023*
PPG (mg/dL)	138.77±4.62	139.95±5.62	0.87
FBG (mg/dL)	90.39±2.69	89.39±3.55	0.82

Data are expressed as mean±SE, *$P<0.05$, **$P<0.01$, BMI: Body mass index, WC: Waist circumference, HC: Hip circumference, VAI: Visceral adiposity index, BP: Blood pressure, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, HDL: High density lipoprotein, VLDL: Very low density lipoprotein, LDL: Low density lipoprotein, TC: Total cholesterol, TG: Triglyceride, AI: Atherogenic index, AC: Atherogenic coefficient, CRR: Cardiac risk ratio, PPG: Postprandial glucose, FBG: Fasting blood glucose

One-way ANOVA test analysis, demonstrated significant differences in most cardiometabolic indices among orlistat, *G. cambogia* and orlistat plus *G. cambogia* except on height, LDL, HDL, CRR, fasting and postprandial blood glucose when $P > 0.05$, [Table 5].

Table 3: Effects of *G. cambogia* on cardiometabolic indices in obese patients

Variables	Before (*n*=33)	After (*n*=30)	*P*
body weight (kg)	103.65±3.45	91.31±3.99	0.021*
Height (cm)	165.35±2.18	165.31±4.97	0.99
BMI (kg/m²)	37.91±2.29	33.41±1.61	0.110
WC (cm)	102.12±3.26	90.56±1.11	0.0016**
HC (cm)	115.44±5.14	109.28±3.97	0.343
VAI	4.17±0.64	2.24±0.11	0.0051**
SBP (mmHg)	151.72±3.34	133.12±2.09	<0.0001**
DBP (mmHg)	92.55±2.39	82.11±1.12	0.0002**
Pulse P (mmHg)	59.17±1.04	51.01±0.97	<0.0001**
Mean BP (mmHg)	122.13±2.86	107.61±1.60	<0.0001**
HDL (mg/dl)	42.33±3.21	43.99±2.94	0.69
VLDL (mg/dl)	69.41±3.3	64.24±2.28	0.199
LDL (mg/dL)	139.20±6.21	94.16±3.22	<0.0001**
TC (mg/dL)	250.92±5.22	202.34±4.83	<0.0001**
TG (mg/dL)	347.05±6.52	321.22±5.39	0.0031**
AI	0.554±0.01	0.503±0.022	0.039*
AC	4.92±0.61	3.59±0.12	0.0381*
CRR	5.92±0.41	4.59±0.11	0.0032**
PPG (mg/dL)	132.77±4.62	135.17±3.83	0.68
FBG (mg/dL)	91.93±2.99	93.31±2.39	0.71

Data are expressed as mean±SE, *P<0.05, **P<0.01, BMI: Body mass index, WC: Waist circumference, HC: Hip circumference, VAI: Visceral adiposity index, BP: Blood pressure, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, HDL: High density lipoprotein, VLDL: Very low density lipoprotein, LDL: Low density lipoprotein, TC: Total cholesterol, TG: triglyceride, AI: Atherogenic index, AC: Atherogenic coefficient, CRR: Cardiac risk ratio, PPG: Postprandial glucose, FBG: Fasting blood glucose. *G. cambogia: Garcinia cambogia*

Table 4: Combined effect of *G. cambogia* plus orlistat on cardiometabolic indices in obese patients

Variables	Before (*n*=33)	After (*n*=29)	*P*
body weight (kg)	102.33±2.25	83.22±3.56	<0.0001**
Height (cm)	165.35±3.97	165.31±3.88	0.98
BMI (kg/m²)	37.43±1.42	30.45±2.36	0.013*
WC (cm)	103.17±3.63	84.16±1.54	<0.0001**
HC (cm)	114.11±5.18	102.17±3.11	0.041
VAI	3.01±0.22	2.17±0.17	0.023*
SBP (mmHg)	152.93±3.28	133.10±2.03	<0.0001**
DBP (mmHg)	92.29±2.38	80.13±1.18	<0.0001**
Pulse P (mmHg)	60.64±0.9	52.97±1.69	0.0002**
Mean BP (mmHg)	122.61±2.83	106.61±1.60	<0.0001**
HDL (mg/dL)	43.42±3.87	49.11±2.14	0.20
VLDL (mg/dL)	70.05±3.50	44.38±2.06	<0.0001**
LDL (mg/dL)	140.6±9.5	93.8±5.31	<0.0001**
TC (mg/dL)	254.12±5.83	187.31±2.53	<0.0001**
TG (mg/dL)	350.15±17.52	221.92±10.30	<0.0001**
AI	0.547±0.02	0.295±0.022	<0.0001**
AC	4.85±0.61	2.81±0.11	0.0022**
CRR	5.85±0.11	3.81±0.01	<0.0001**
PPG (mg/dL)	131.62±4.11	131.17±3.49	0.933
FBG (mg/dL)	91.19±2.39	91.10±2.10	0.977

Data are expressed as mean±SE, *P<0.05, **P<0.01, BMI: Body mass index, WC: Waist circumference, HC: Hip circumference, VAI: Visceral adiposity index, BP: Blood pressure, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, HDL: High density lipoprotein, VLDL: Very low density lipoprotein, LDL: Low density lipoprotein, TC: Total cholesterol, TG: Triglyceride, AI: Atherogenic index, AC: Atherogenic coefficient, CRR: Cardiac risk ratio, PPG: Postprandial glucose, FBG: Fasting blood glucose. *G. cambogia: Garcinia cambogia*

The compliance to the treatment was good, but some drug adverse effects were reported during the duration of the study among treated groups; fatty spot was the most reported side effect 7.92% in orlistat group which was decreased to the 0.99% in combined *G. cambogia* plus orlistat group, [Table 6].

DISCUSSION

This study revealed a new modality in the treatment of obesity through combination of drug and herbal medicine. Orlistat therapy in the current study produced a significant reduction in BMI, TC, WC without significant effects on VAI compared to baseline values. These findings corresponded with other studies which demonstrated that orlistat therapy produced a significant body weight reductions in obese patients with additional amelioration on lipid profile, anthropometric measures, inflammatory markers (tumor necrosis factor α [TNF-α] and interleukin 6 [IL-6]), and cardiometabolic risk factors [17,18].

Orlistat leads to dose-dependent inhibition of intestinal fat absorption through suppression of intestinal lipase activity [19] which *per se* explains the improvement in TC levels, VLDL, LDL AI, AC, and CRR.

TG serum levels were not decreased during orlistat therapy in the present study since; TGs hydrolyzed before inhibition of intestinal lipase by orlistat [20] or due to small sample size that may affects the statistical results, patients non-compliance or small dose that may not affect high TG levels while; a reduction in serum cholesterol levels in orlistat-treated group may be through inhibition of 3-hydroxy-3-methylglutaryl coenzyme A reductase, decreasing in cholesterol intestinal absorption through decreasing of bilirubin blood concentration (via augmentations of bilirubin turnover and fecal excretion). Orlistat also decreases postprandial free fatty acid levels leading to the reduction in TG and cholesterol biosynthesis with a significant increment in insulin sensitivity since; free fatty acids interfere with insulin action [21]. Unfortunately, insulin resistance was not measured in the present study.

Furthermore, orlistat in the present study led to significant reduction in systolic and diastolic blood pressure, since treatment with orlistat in obese hypertensive patients, leads to the improvement in endothelial functions and significant vasodilatation that causing significant reductions in blood pressur [22].

As well, the presence of vascular endothelial dysfunction in obesity favor the development of cardiovascular disorders due to the ability of adipocytes for synthesis and secretion of adipocytokines - such as TNF-α, IL-6, and resistin - which play a potential role in induction of low-grade inflammatory changes at vascular endothelium causing obesity-induced vascular dysfunction [23]. Therefore, administration of orlistat leads to direct effect via reduction in adipocytes-induced inflammatory markers and indirect effect through augmentation of postprandial glucagon like peptide-1 that inhibits adipose tissue inflammatory mediators [24]. Moreover, orlistat produced significant homeostatic effects through reduction in plasma fibrinogen and P-selectin levels in obese patient [25]. All of these findings indicating a vascular protective effect of orlistat,

Table 5: Variations of post-treatment effects among orlistat, *G. cambogia* **and orlistat plus** *G. cambogia* **(intergroup comparisons)**

Variables	Orlistat	*G. cambogia*	Combined	ANOVA	
				F	P
body weight	90.55±1.87	91.31±3.99	83.22±3.56**¶¶	9.62	0.0139ˣ
Height (cm)	165.31±3.97	165.31±4.97	165.31±3.88	0.000	1.00ˣ
BMI (kg/m²)	36.50±3.57	33.41±1.61	30.45±2.36**¶	5.40	0.046ˣ
WC (cm)	91.76±2.11	90.56±1.11	84.16±1.54**¶¶	25.04	0.001ˣˣ
HC (cm)	110.88±6.99	109.28±3.97	102.17±3.11**¶¶	3.58	0.095
VAI	3.32±0.21	2.24±0.11	2.17±0.17*	726	0.0005ˣˣ
SBP (mmHg)	143.12±1.09	133.12±2.09	133.10±2.03*	33.4	0.001ˣˣ
DBP (mmHg)	80.67±1.22	82.11±1.12	80.13±1.18¶	3.14	0.11
Pulse P (mmHg)	62.45±0.13	51.01±0.97	52.97±1.69**	336.4	0.0005ˣˣ
Mean BP (mmHg)	111.89±1.11	107.61±1.60	106.61±1.60*	23.59	0.001ˣˣ
HDL (mg/dL)	44.99±3.94	43.99±2.94	49.11±2.14*¶	3.89	0.08
VLDL (mg/dL)	64.138±2.1	64.24±2.28	44.38±2.06**¶¶	102.07	0.0005ˣˣ
LDL (mg/dL)	91.6±11.71	94.16±3.22	93.8±5.31	0.130	0.88
TC (mg/dL)	200.77±4.83	202.34±4.83	187.31±2.53**¶¶	17.06	0.003ˣˣ
TG (mg/dL)	320.69±12.76	321.22±5.39	221.92±10.30**¶¶	33.51	0.001ˣˣ
AI	0.493±0.022	0.503±0.022	0.295±0.022	416	0.0005ˣˣ
AC	3.46±0.22	3.59±0.12	2.81±0.12	1999.6	0.0005ˣˣ
CRR	4.46±0.22	4.59±0.11	3.81±1.11*	4.27	0.07
PPG (mg/dL)	139.95±5.62	135.17±3.83	131.17±3.49**¶	4.04	0.07
FBG (mg/dL)	89.39±3.55	93.31±2.39	91.10±2.10**	1.23	0.34

Data are expressed as mean±SE, *$P<0.05$, **$P<0.01$ combined versus orlistat group, ¶$P<0.05$, ¶¶$P<0.01$ combined versus *G. cambogia* group, ˣ$P<0.05$, ˣˣ$P<0.01$ regarding *post-hoc* ANOVA test. BMI: Body mass index, WC: Waist circumference, HC: Hip circumference, VAI: Visceral adiposity index, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, HDL: High density lipoprotein, VLDL: Very low density lipoprotein, LDL: Low density lipoprotein, TC: Total cholesterol, TG: Triglyceride, AI: Atherogenic index, AC: Athrogenic coefficient, CRR: Cardiac risk ratio, PPG: Postprandial glucose, FBG: Fasting blood glucose. *G. cambogia: Garcinia cambogia*

Table 6: Side effects of treatment during the study

Side effects	*G. cambogia*	Orlistat	*G. cambogia*+Orlistat
Abdominal pain	4 (1.32)	12 (3.96)	3 (0.99)**
Fatty spots	0	24 (7.92)	6 (1.98)**¶
Flatulence	2 (0.66)	12 (3.96)	3 (0.99)**
Diarrhea	3 (0.99)	9 (2.97)	4 (1.32)*
Constipation	5 (1.65)	1 (0.33)	3 (0.99)**
Headache	13 (4.29)	2 (0.66)	2 (0.66)**¶
Heartburn	9 (2.97)	5 (1.65)	4 (1.32)*¶

Data are expressed as % and numbers. **$P<0.01$;*$P<0.05$ combined versus orlistat group. ¶$P<0.05$ combined versus *G. cambogia*. *G. cambogia: Garcinia cambogia*

which *per se* explaining the blood pressure lowering effect in the current study. Unluckily, these biomarkers and endothelial function were not measured in the present study.

Therefore, in spite of weight reduction effects of orlistat on body weight it failed in the reduction of VAI, this finding is incompatible with findings of Smith *et al.* study that revealed a significant reduction in visceral adiposity following orlistat therapy [26].

Regarding the effect of *G. cambogia* on obesity indices, it reduced body weight, BMI, WC and VAI; these findings correspond with a study that showed a significant reduction in anthropometric indices with *G. cambogia* treatment [27] but other studies reported non-significant differences between *G. cambogia* and placebo during 12th weeks of treatment on anthropometric indices [28].

Furthermore, this study revealed a significant reduction in TC, total TG, AI, AC, CRR, and blood pressure lowering effect

significantly due to the treatment with *G. cambogia* that led to a reduction in the visceral and subcutaneous fat accumulations regardless of gender effect [29]. This potential effect of *G. cambogia* was due to the effects of the active ingredient, HCA that inhibits lipogenesis and reduction in LDL levels that causing amelioration in vascular and visceral functions [30]. These observations may explain the significant reduction in VAI in the present study.

Several animal and human studies reported that treatment of obesity with *G. cambogia* led to significant body weight loss compared with placebo, but these studies were conducted on small groups and for short duration <12th weeks [31] while in the present study the duration of therapy reached the duration of 3 months with minimal adverse effects.

In addition to the peripheral effect, *G. cambogia* has a central appetite suppressant effect through upregulation of serotonin neurotransmission [32]. Therefore, Semwal *et al.* study pointed out that *G. cambogia* acts in the dual pathway through central and peripheral suppressant effects causing a more significant reduction in visceral adiposity compared to orlistat alone [33].

Furthermore, effects of combined treatment with *G. cambogia* plus orlistat on obesity indices demonstrated a significant reduction in most of the obesity and cardiometabolic risk scores mainly on hip circumference and VAI.

VAI is a mathematical model that depends on BMI, WC, HDL and TG serum levels, VAI is gender dependent that reflect fat distribution, it linked with cardiometabolic risk scores and visceral adiposity-induced complications such as hypertension and diabetes mellitus [34]. Thus, combined therapy of

G. cambogia plus orlistat led to a more significant reduction in VAI which pointed out to the potential additive effect of *G. cambogia* plus orlistat on weight reduction in obesity and obesity-induced complications.

Phytochemical analysis of *G. cambogia* detected polyphenolic flavonoids that inhibit pancreatic lipase activity which may explain the additive effect of *G. cambogia* with orlistat on weight reduction in obese patients [35]. Moreover, HCA isomer (2s, 3r) block pancreatic amylase and intestinal α-glucosidase leading to a reduction in the carbohydrate metabolism and absorption with significant reduction in blood glucose in diabetic patients [36]; this effect was not observed in our study since; all of the enrolled patients were non-diabetic. Consequently, *G. cambogia* potentiates the effect of orlistat in obese patients.

Regarding the reported side effects in the present study, combined treatment significantly showed less adverse effects compared to either *G. cambogia* or orlistat since, both drugs are well tolerated and *G. cambogia* induces feeling of satiety that decreases food intake and gastrointestinal disturbances [37,38].

CONCLUSION

Combinations of *G. cambogia* and orlistat have a more favorable effect than orlistat alone on cardiometabolic profile and VAI in obese patients.

LIMITATIONS OF THE STUDY

This study had many limitations. First, the total daily calorie intake was not determined and collected. Second, lifestyle and exercise were not documented. Finally, 3 months duration of treatment may be short for estimation the long-term effects of *G. cambogia* and orlistat.

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