Progress in Nutrition 2022; Vol. 24, N. 4: e2022099 DOI: 10.23751/pn.v24i4.11815 © Mattioli 1885

Original article

The effects of dietary intervention with turmeric on lipid profile and anthropometric indices in overweight/obese women with hyperlipidemia: a randomized controlled clinical trial

Ayşegül Atakan, Seray Kabaran, Fatma Hülyam Eren

Department of Nutrition and Dietetics, Faculty of Health Sciences, Eastern Mediterranean University, Famagusta, T.R. North Cyprus, Turkey

Abstract. *Background and Objective:* The objective of this trial was to evaluate the effects of turmeric on blood lipids and body weight loss in overweight/obese women with hyperlipidemia. *Methods and Study Desing:* In this randomized controlled trial, overweight/obese hyperlipidemic women (BMI>25 kg/m^2) were randomly divided into 2 groups as turmeric (n=35; 4 g/d) and control (n=35) groups for 8 weeks. The subjects included in the turmeric and control groups adhered to a medical nutrition therapy. Serum lipid profile and anthropometric data were measured at the beginning and again at the end of the study. *Results:* After 8 weeks of dietary intervention, both turmeric and control groups showed significant decreased in total cholesterol (-55.66 versus -53.06 mg/dl), LDL-C (-35.70 versus -35.91 mg/dl) and TG (-44.34 versus -42.03 mg/dl), respectively ($p<0.01$). Body weight (-5.05 versus -4.91 kg), BMI (-1.88 versus -1.84 kg/m^2), body fat ratio (-4.02 versus -3.30%) and waist circumference (-4.70 versus -3.74 cm) were also significantly decreased after dietary intervention in both groups, respectively ($p<0.001$). No significant difference was found in the reductions of total cholesterol, LDL-C, TG concentrations or in the reductions of body weight, BMI and waist circumference between the turmeric and control groups ($p>0.05$). *Conclusions:* Further randomized controlled trials with longer supplementation durations are needed for a stronger assessment of the lipid-modulating properties of turmeric.

Key words: curcumin, turmeric, lipid profile, anthropometric indices, obesity

Introduction

Curcuma longa, commonly known as turmeric, belongs to the ginger family *(Zingiberaceae)* and has been widely used as a spice in food preparations and also used as a food additive that gives flavor and color, especially in Asian countries (1,2). Turmeric contains highly bioactive non-volatile polyphenols called curcuminoids (curcumin, dimethoxy curcumin, and bisdemethoxycurcumin) which responsible for lipophilic orange-yellow pigment (3,4).

Curcumin is a well-known polyphenolic compound that constitutes 2-5% of turmeric. Also, it is the most active and the major isolated polyphenol from the rhizome of turmeric (3,4). Curcumin has come into prominence for its great number of protective health effects. Studies have demonstrated its various beneficial pharmacological effects including antioxidant, anti-inflammatory, antitumor, antimicrobial, anti-lipidemic, anti-thrombotic, hypotensive, antidiabetic, antirheumatic, hepatoprotective, neuroprotective, and cardioprotective agent (4,5). Thus, turmeric has recently been shown to modulate several diseases, such as cardiovascular disease, diabetes mellitus, obesity, cancer, inflammatory disorders, microbial infections, hepatic disorders, and osteoarthritis (3,6-10).

It was emphasized that turmeric and curcumin/curcuminoids inhibit enzymes (cyclooxygenases, lipoxygenase, xanthine oxidase, nitric oxides) generating reactive oxygen species and inflammatory lipids both at functional and epigenetic mechanisms (11,12). This polyphenolic compound also exerts its beneficial effects by modulating different signaling molecules including transcription factors, cytokines, chemokines, tumor suppressor genes, adhesion molecules, microRNAs (8).

Recent researches on turmeric showed that it has lipid-modifying and anti-atherogenic effects and it may be effective in reducing obesity progression and complications (13-16). There is also evidence for its beneficial hypolipidemic effects in different pathological conditions in humans and various experimental models (17-20). Ingestion of curcumin-containing spices, especially in the high fat and high cholesterol diets, could have a lipid-lowering effect (17).

Previous studies on the effect of turmeric on anthropometric measurements and lipid parameters have shown inconsistent findings. Curcumin at a dose of 93.34 mg added to the diet in women with polycystic ovary syndrome (PCOS) for 8 weeks led to weight and body fat loss but showed no significant differences in lipid parameters compared with the placebo group (21). However, Adab et al. (20) showed that administration of turmeric decreased body weight and improved lipid profile in hyperlipidemic patients with type 2 diabetes in the contrary, a clinical trial on overweight/obese women with systemic inflammation have reported that supplementation with 2.8 g turmeric powder for 4 weeks had no significant changes in body weight and BMI compared with the placebo group (22). The present study was conducted to evaluate the effect of turmeric powder on blood lipids and body weight loss in hyperlipidemic overweight/obese women patients.

Materials and methods

Study design

This is a randomized controlled trial that is approved by the Ethics Committee of Eastern Mediterranean University (approval date: 16.05.2016, approval no: 2016/27-08). The present study was conducted according to guidelines in the Declaration of Helsinki. Written consent was obtained from each participant prior to the study.

Study population

The study population included 25 to 65-year-old overweight or obese hyperlipidemic women patients who were referred to a Nutrition and Diet Clinic in the Northern part of Cyprus. The inclusion criteria were hyperlipidemic women patients with total cholesterol > 200 mg/dl, TG > 150 mg/dl, or LDL-C > 100 mg/dl, body mass index (BMI) between 25.0 and 34.9 kg/m^2, no use of regular medications, no insulin therapy, and no use of antioxidants, multivitamin, or polyphenols supplements for the last 3 months prior to the study. Patients with known diabetes, hypertension, coronary heart disease, renal or liver failure, thyroid disease, severe gastrointestinal disease were excluded. The other exclusion criteria were alcohol or cigarette intake, pregnancy, and lactation.

Sample size calculation

Eligible patients were selected by convenient sampling method. The study protocol is figured in consort diagram of the study (Figure 1). The sample size was calculated considering the blood lipid levels as the main variables in order to have a chance of detecting the differeces, with a power of 80% and a confidence interval of 95%. The calculated sample size was 30 participants in each group. Assuming a 10% non-participation rate, the sample size was estimated to be 35 participants in each group.

Randomization and dietary intervention

Seventy overweight or obese hyperlipidemic women patients were randomly divided into two groups as the dietary intervention with turmeric group (turmeric group) (n = 35) and dietary intervention without turmeric group (control group) (n = 35) according to the permuted block randomization method.

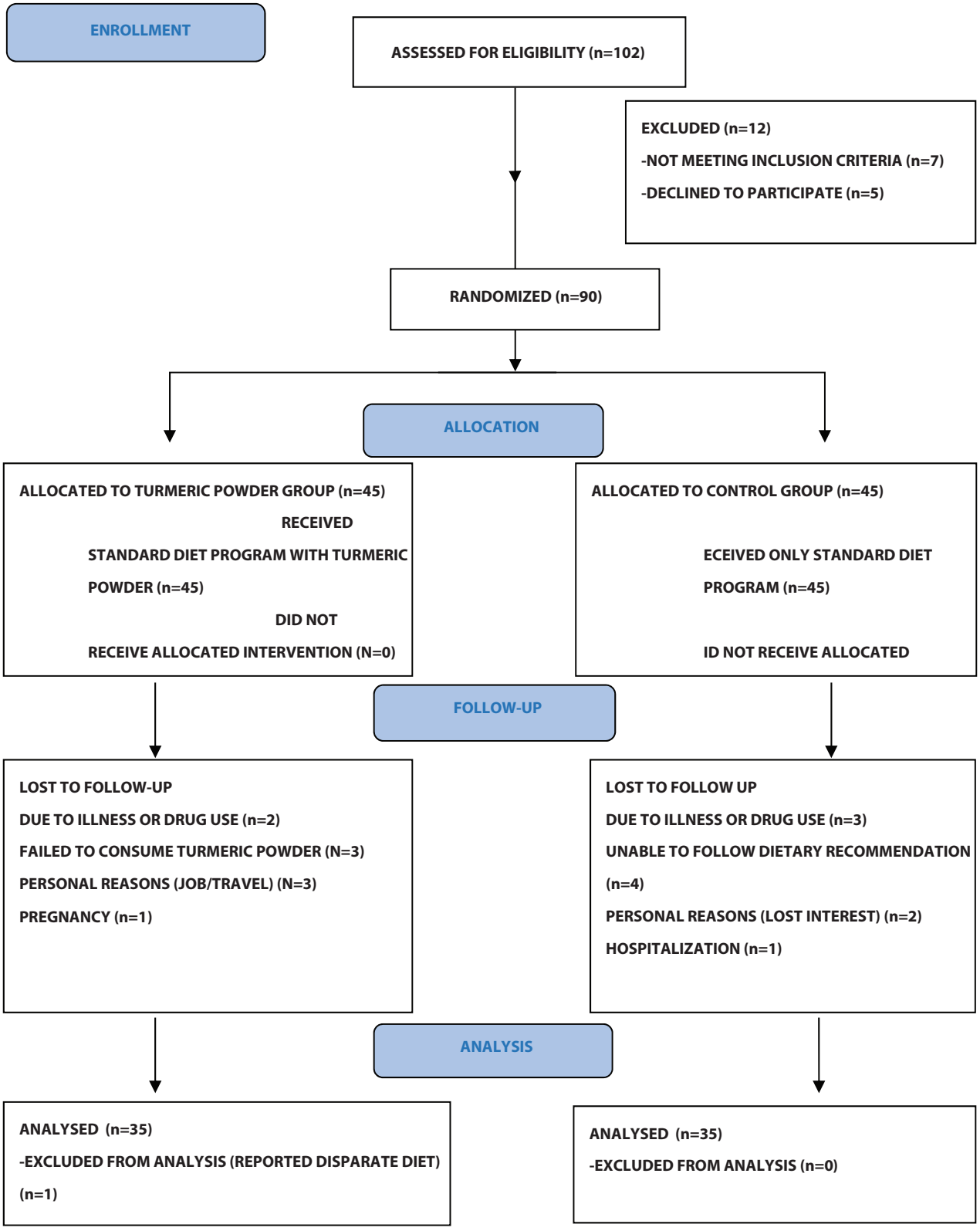

Figure 1: Flow diagram of the study.

Dietary intervention

The subjects included in the turmeric and control groups adhered to a medical nutrition therapy (MNT) for 8 weeks. All obese individuals continued a MNT including all food groups recommended by the World Health Organization (WHO). Weekly 0.5-1 kg body weight loss was targeted in the applied MNT. Accordingly, the energy content of the applied diet was calculated to be 500 kcal/day less than the total energy requirements of the individuals (23). The content of the diet applied was consist of 50-55% carbohydrate, 12-15% protein, and 25-30% fat. Macronutrients, micronutrients, the fiber content of the diet were calculated to be similar between groups, and also both groups take a low cholesterol diet (<300 mg/day) throughout the study. Additionally, the turmeric group was supplemented with 4 g/day of turmeric added to their main meals in powdered form (2 g/day for lunch and 2 g/day for dinner) during 8 weeks. All individuals were monitored regularly by the researcher dietician every week.

Turmeric dose and preparation

Studies on human did not show toxic effects, and curcumin was safe at the dose of 6 g/day orally for 4-7 weeks (1). Based on previous human studies, turmeric consumption in the amount of 1–4 g/day did not show any side effects. In hyperlipidemic subjects, the daily intake of >2 g of turmeric result in a decrease in total blood lipid parameters and body weight (20,24). As a result, we chose the total 4 g/day dose of turmeric added to their main meals (2 g/day for lunch and 2 g/day for dinner).

The powdered form of turmeric was purchased from a local herb store in Cyprus by the researchers. It was given to all subjects in 2 gram cleaned and dried packages and they were asked to consume 2 packages per day with their main meals. Packages were given them weekly, when they come to the dietician for management of MNT and weight control. During this period, information was given about keeping them in a cool, dark, moisture-free, and closed environment. Participants were called on the phone during the intervention to be reminded to receive the supplements, to increase compliance.

Data collection

Dietary intake

At baseline, demographic data and general nutritional habits were obtained with a form. To control the confounding effects of dietary intake, 24-h food consumption records (1 regular day) were collected from all individuals, and data were analyzed by a Dietitian with Nutrition Data Base Software (version 7.2, Mavi Elma Group, Turkey).

Anthropometric measurements

Anthropometric measurements of the subjects were taken at the beginning of the study and were monitored every week throughout the study. Body weight and body composition were measured without shoes and heavy clothing to the nearest 0.1 kg by using Tanita BC418 body composition analyzer. Height measurement was conducted without shoes to the nearest 0.5 cm with a nonelastic tape and in the Frankfort plane position. BMI was calculated by dividing the weight in kilograms by the square of the height in meters. Waist circumference (WC) and hip circumference (HC) were measured to the nearest 0.5 cm by using a nonelastic tape, with the participant in the standing position. WC was measured at the end of normal expiration at the point midway between the lowest rib and the top of the iliac crest while HP was measured at the largest circumference around the buttocks (25). Waist-to-hip ratio (WHR) and calculated as WC/HC.

Biochemical analysis

Blood samples (10 ml) were taken in 12-hr overnight fasting state at the beginning and after 8 weeks of intervention. After separation of serum, blood parameters were measured. The levels of serum glucose, triglycerides (TG), total cholesterol (TC), and high-density lipoprotein (HDL-C) cholesterol were determined using a Dimension Xpand Plus integrated clinical chemistry autoanalyzer (Siemens Healthcare Diagnostics, Deerfield, IL, USA). The serum levels of low-density lipoprotein (LDL-C) cholesterol were calculated using Friedewald's equation.

Statistical analysis

Statistical analyses were performed using the software package of SPSS Statistics for Windows (version 20.0, Statistical Package for the Social Sciences). Variables were tested for normal distribution using the Kolmogorov–Smirnov test. It was determined that the data set followed normal distribution. Thus, parametric hypothesis tests were used in the study. Quantitative variables were compared between groups at baseline and at the end of the study using an independent sample t-test. Quantitative variables before and after treatment within each group were compared using paired sample t-test. All analyses were performed on participants who completed the study duration (35 in turmeric and 35 in the placebo group). All values are reported based on mean ± SD, p value < 0.05 was considered as the statistical significance level.

Results

Daily dietary intakes of the women individuals are presented in Table 1. There were no significant differences in daily total energy, macronutrient and micronutrient intakes between the turmeric and control groups at the beginning of the intervention (p>0.05). Average age was found to be 38.25±11.20 year in control and 35.97±9.29 year in turmeric groups, respectively (p>0.05). Also, comparisons showed no significant differences in age, marital status, and education status

Table 1. Daily dietary intakes of the women individuals at the beginning of the intervention.

Dietary intakes, mean±SD	Control (n=35)	Turmeric (n=35)	t	p
Energy (kcal)	1310.87±200.11	1366.79±243.07	-1.05	0.30
Protein (%)	22.29±5.15	22.66±4.87	-0.31	0.76
Fat (%)	26.69±9.58	27.03±8.84	-0.16	0.88
Carbohydrate (%)	50.71±10.77	50.31±9.83	0.16	0.87
Protein (g)	71.43±20.19	75.25±20.51	-0.79	0.43
Fat (g)	40.15±19.11	41.67±16.06	-0.36	0.72
Carbohydrate (g)	160.21±34.03	166.77±41.62	-0.72	0.47
Fiber (g)	34.15±10.22	33.00±12.70	0.29	0.78
PUFA (g)	8.00±6.12	6.91±4.29	0.72	0.42
MUFA (g)	21.24±9.14	23.12±6.44	0.41	0.55
SFA (g)	10.91±7.13	11.64±5.87	0.35	0.67
Cholesterol (mg)	179.86±113.02	177.46±99.85	0.09	0.93
Zinc (mg)	11.22±3.71	11.56±3.18	-0.41	0.68
Iron (mg)	15.01±10.09	13.68±5.35	0.69	0.49
Potassium (mg)	3202.77±662.22	3292.63±676.07	-0.56	0.58
Calcium (mg)	830.93±219.51	931.76±446.57	-1.20	0.23
Folate (mg)	271.27±66.95	302.93±99.91	-1.56	0.12
Vitamin E (mg)	10.40±5.80	11.28±5.82	-0.63	0.53
Vitamin C (mg)	117.60±64.82	132.77±79.57	-0.87	0.38
Vitamin A (μg)	1004.59±766.22	1151.75±743.11	-0.82	0.42
β-carotene (mg)	25.24±84.79	11.41±37.07	0.88	0.38

PUFA: Polyunsaturated fatty acids, MUFA: Monounsaturated fatty acids, SFA: Saturated fatty acids
Independent Sample t-test was used to calculate the p value

between the two groups at baseline (p>0.05) (Data not shown).

Table 2 shows the effect of turmeric supplementation on anthropometric measurements after 4 and 8 weeks of intervention. Anthropometric measurements have no significant differences between the control and turmeric groups at baseline (p>0.05). Body weight, BMI, waist and hip circumferences, and body fat mass reduced significantly both in the control and turmeric groups at the 4th and 8th weeks of the study (p<0.001). There were no statistically significant differences in all anthropometric measurements between control and turmeric groups at the beginning and the end of the intervention (p>0.05).

Table 3 summarized the effect of turmeric supplementation on biochemical parameters after 8 weeks

Table 2. The effect of turmeric supplementation on anthropometric measurements after 4 and 8 weeks of intervention.

Anthropometric measurements, mean±SD		Control	p_1	Turmeric	p_2	p_3
Body Weight (kg)	W_0	81.00±11.43	W_0-W_4 = 0.00*	84.17±21.07	W_0-W_4 = 0.00*	0.44
	W_4	77.91±11.69	W_0-W_8 = 0.00*	81.27±20.06	W_0-W_8 = 0.00*	0.39
	W_8	76,09±11,73	W_4-W_8 = 0,00*	79,12±19,39	W_4-W_8 = 0,00*	0,43
BMI (kg/m^2)	W_0	31.72±5.24	W_0-W_4 = 0.00*	31.26±5.72	W_0-W_4 = 0.00*	0.73
	W_4	30.37±4.91	W_0-W_8 = 0.00*	30.18±5.50	W_0-W_8 = 0.00*	0.88
	W_8	29.88±5.04	W_4-W_8 = 0.01*	29.38±5.41	W_4-W_8 = 0.00*	0.69
Waist Circumference (cm)	W_0	87.41±14.07	W_0-W_4 = 0.00*	86.83±14.79	W_0-W_4 = 0.00*	0.87
	W_4	85.41±14.41	W_0-W_8 = 0.00*	83.93±13.39	W_0-W_8 = 0.00*	0.66
	W_8	83.67±14.62	W_4-W_8 = 0.00*	82.13±13.51	W_4-W_8 = 0.00*	0.65
Hip Circumference (cm)	W_0	98.83±15.26	W_0-W_4 = 0.00*	95.91±16.98	W_0-W_4 = 0.00*	0.45
	W_4	96.54±14.50	W_0-W_8 = 0.00*	93.37±16.16	W_0-W_8 = 0.00*	0.39
	W_8	95.03±14.43	W_4-W_8 = 0.00*	91.63±15.68	W_4-W_8 = 0.00*	0.35
WHR	W_0	0.86±0.18	W_0-W_4 = 0.50	0.87±0.14	W_0-W_4 = 0.32	0.64
	W_4	0.85±0.17	W_0-W_8 = 0.10	0.87±0.14	W_0-W_8 = 0.57	0.68
	W_8	0.85±0.17	W_4-W_8 = 0.28	0.87±0.14	W_4-W_8 = 0.32	0.56
Lean Body Mass (kg)	W_0	48.38±4.33	W_0-W_4 = 0.00*	49.81±10.66	W_0-W_4 = 0.21	0.47
	W_4	47.66±4.31	W_0-W_8 = 0.01*	49.53±10.93	W_0-W_8 = 0.20	0.35
	W_8	47.72±4.21	W_4-W_8 = 0.82	49.51±10.77	W4-W8 = 0.88	0.36
Body Fat Mass (kg)	W_0	32.63±8.58	W_0-W_4 = 0.00*	34.41±12.75	W_0-W_4 = 0.00*	0.50
	W_4	30.35±8.73	W_0-W_8 = 0.00*	31.93±12.08	W_0-W_8 = 0.00*	0.53
	W_8	28.68±8.95	W_4-W_8 = 0.00*	29.90±11.61	W_4-W_8 = 0.00*	0.62
Body Fat Mass (%)	W_0	39.71±5.52	W_0-W_4 = 0.00*	39.74±5.43	W_0-W_4 = 0.00*	0.98
	W_4	38.19±5.77	W_0-W_8 = 0.00*	37.72±5.81	W_0-W_8 = 0.00*	0.74
	W_8	36.23±5.91	W_4-W_8 = 0.00*	35.72±5.75	W_4-W_8 = 0.00*	0.72
Body Water (%)	W_0	35.43±3.18	W_0-W_4 = 0.00*	36.69±7.35	W_0-W_4 = 0.34	0.35
	W_4	34.80±3.16	W_0-W_8 = 0.66	36.54±7.51	W_0-W_8 = 0.26	0.21
	W_8	35.29±3.58	W_4-W_8 = 0.15	36.41±7.60	W_4-W_8 = 0.49	0.43

W_0: at the beginning of the study. W_4: after 4 weeks of intervention. W_8: after 8 weeks of intervention
WHR: Waist-to-hip ratio. BMI: Body Mass Index.
p_1: differences within control group. p_2: differences within turmeric group. p_3: differences between control and turmeric groups
Paired Sample t-test was used to calculate the p_1 and p_2 values
Independent Sample t-test was used to calculate the p_3 value

Table 3. The effect of turmeric supplementation on biochemical parameters after 8 weeks of intervention.

Biochemical Parameters. mean±SD		Control	p_1	Turmeric	p_2	p_3
Fasting blood glucose (mg/dl)	W_0	160.17±52.12	0.00*	161.40±46.06	0.00*	0.92
	W_8	101.83±17.58		96.17±17.43		0.97
Total cholesterol (mg/dl)	W_0	231.94±33.03	0.00*	231.74±14.07	0.00*	0.16
	W_8	178.89±35.54		176.09±24.91		0.57
HDL (mg/dl)	W_0	87.29±43.79	0.00*	101.57±38.45	0.00*	0.98
	W_8	57.06±23.75		64.83±23.13		0.18
LDL (mg/dl)	W_0	147.26±12.64	0.00*	145.14±17.58	0.00*	0.70
	W_8	111.34±17.44		109.44±14.47		0.17
Triglyceride (mg/dl)	W_0	178.77±28.78	0.00*	178.91±22.95	0.00*	0.62
	W_8	136.74±19.70		134.57±25.32		0.69

W_0: at the beginning of the study. W_8: after 8 weeks of intervention
HDL: High density lipoprotein. LDL: Low density lipoprotein.
p_1: differences within control group. p_2: differences within turmeric group. p_3: differences between control and turmeric groups
Paired Sample t-test was used to calculate the p_1 and p_2 values
Independent Sample t-test was used to calculate the p_3 value

of intervention. After intervention, total cholesterol, HDL-C, LDL-C and TG decreased significantly both in the control and turmeric groups compared with baseline ($p<0.001$). However, there were no statistically significant differences in all biochemical parameters between the two groups at the beginning and the end of the intervention ($p>0.05$).

Table 4 shows that in individuals who received turmeric, more decrease in body weight, BMI, body fat mass, waist and hip circumferences were observed at the end of the study compared with the control group but these differences were not significant ($p>0.05$). Moreover, the mean fasting plasma glucose, total cholesterol and TG levels reduced more in the turmeric group compared with the control group, but these reductions were not statistically significant. Results showed that mean changes of all anthropometric measurements and biochemical parameters were not statistically significant between the two groups after the intervention ($p>0.05$).

Discussion

In the present, study receiving 4 g of turmeric powder (2 g/day for lunch and dinner) for 8 weeks along with individualized dietary management in overweight/obese female subjects with hyperlipidemia showed a significant decrease in body weight, BMI, fat mass, waist circumference and biochemical markers (fasting blood glucose levels, triglycerides, total cholesterol, low-density lipoprotein cholesterol, high-density lipoprotein cholesterol). However, no intergroup statistical differences were documented between the turmeric and control groups. Several clinical trials (20,26-29) on the effect of turmeric powder/extract supplementation on different blood lipid parameters have reported some inconsistent results. A probable explanation for conflicting findings on blood lipids in these studies are likely methodological reasons. In the Sukandar et al.'s study (26) patients were under intensive diet and exercise where the effect of the diet and exercise on serum HDL-C were reported earlier (30). In addition to this in Adab et al.'s study, (20) the patients received blood sugar reducing agents and statins which can clearly change the lipid profile of the subjects. Therefore, compared to our study the anti-hyperlipidemic activity of turmeric that was observed in aforementioned studies can be related to the physical activity and drug use modifications. Given the examples of participants' co-medication, diet and lifestyle changes, it seems that the other differences observed among studies were the result of heterogeneity

Table 4. Comparison of differences in mean changes of anthropometric measurements and biochemical parameters between the control and turmeric groups after 8-weeks intervention.

	Control (n=35)	Turmeric (n=35)	t	p
Anthropometric measurements. mean±SD				
Body weight (kg)	-4.91±2.77	-5.05±3.53	-0.20	0.85
BMI (kg/m^2)	-1.84±1.50	-1.88±1.23	-0.12	0.90
Waist circumference (cm)	-3.74±2.78	-4.70±4.65	-1.04	0.30
Hip circumference (cm)	-3.80±3.82	-4.29±4.17	-0.51	0.61
WHR	-0.01±0.02	-0.00±0.03	0.55	0.58
Lean Body Mass (kg)	-0.66±1.46	-0.30±1.38	1.06	0.29
Body Fat Mass (kg)	-3.95±2.12	-4.51±3.21	-0.86	0.39
Body Fat Mass (%)	-3.30±2.16	-4.02±2.93	-1.16	0.25
Body Water (%)	-0.14±1.89	-0.28±1.46	-0.35	0.72
Biochemical parameters. mean±SD				
Fasting blood glucose (mg/dl)	-58.34±47.77	-65.23±45.54	-0.62	0.54
Total cholesterol (mg/dl)	-53.06±33.92	-55.66±29.90	-0.34	0.73
HDL (mg/dl)	-30.24±39.06	-36.74±34.02	-0.74	0.46
LDL (mg/dl)	-35.91±19.06	-35.70±20.27	0.05	0.96
Triglyceride (mg/dl)	-42.03±32.57	-44.34±26.11	-0.33	0.74

Independent Sample t-test was used to calculate the p value
WHR: Waist-to-hip ratio. BMI: Body Mass Index. HDL: High density lipoprotein. LDL: Low density lipoprotein

such as the differences in metabolic profile of the patients (comorbidities) and stage of disease at enrollment. The difference in subjects' region, age, gender, sample size, trial frequency (duration), dose of turmeric administration and the characteristics of curcuminoid formulations can also be considered as important factors which have inconsistent outcomes among studies (20,31,32).

The study of Iwueke et al. (33) indicated that daily oral turmeric powder (200 mg/kg) treatment for three weeks significantly ($p \leq 0.05$) lowered the serum total cholesterol and triglyceride concentrations of the male albino rats, while those that received 100 mg/kg significantly increased HDL-Cholesterol and reduced LDL-Cholesterol. Several animal studies (34,35) suggested that turmeric, as well as curcumin, has its potential cholesterol lowering effect due to the decreasing cholesterol uptake in the intestines and increasing the conversion of cholesterol to bile acids in the liver. In other words, It was believed that the reason turmeric could possibly improve hyperlipidemia was because it can elevate cholesterol catabolism by suppressing sterol regulatory element binding proteins (SREBPs) and increasing liver cholesterol 7-hydroxylase enzyme activity, and inhibiting the synthesis of cholesterol by suppression of the HMG-CoA reductase enzyme (20,36). Additionally, earlier research studies have revealed that curcumin might affect LDL and HDL cholesterol receptors. Indeed, curcumin has been shown to induce Apo-A1 expression, which mediates the transfer of cholesterol from cells to HDL particles (36,37). On the other hand, curcumin down controls apo100's expression as the LDL's main apo lipoprotein which lead to noticeable reductions in circulation of LDL-C (36).

The present study did not point out how much curcumin was already in each subject's diet because the curcuminoid amount within the turmeric powder was not investigated. Normally turmeric contains 1.5 to 5 per cent curcumin. It is reported that pure turmeric

powder had the highest curcumin concentration, averaging 3.14% by weight (38,39). In addition to this, it was stated that one teaspoon of turmeric contains approximately 250 mg of curcumin (39). Taken together, it can be assumed that in the present study subjects had approximately 125 mg curcumin/d in average for 8 wk. In two randomized control trials daily doses of 500-6000 mg and 1000-4000mg curcumin administration to cognitive decline and healthy individual subjects respectively showed beneficial effect on serum lipid profiles (40,41). In contrast, no lipid-lowering effect was observed in Alwi et al.'s (42) double blind randomized control trial in acute coronary syndrome patients which was ordering a magnitude smaller (45-180 mg/d) dosage levels than the previous studies mentioned, as in accordance with ours.

Singletary (31) stated that in obese individuals, results from 10 studies indicated no consistent effect of curcuminoid treatment on oxidative stress biomarkers, serum levels of cytokines, growth factors, and hormones, or on blood pressure and blood glucose and lipid concentrations, compared with controls. The meta-analysis of 5 RCT studies by (19) did not report the beneficial effect of curcumin in patients with hyperlipidemia. Findings of a recent meta-analysis indicated that in RCTs which found no lipid lowering effect of curcumin, the dosages of curcumin was generally seen as below 500 mg/kg or duration of trial was less than 8 weeks. In other words, it was explained that in RCTs, the lipid lowering effects of curcumin was mostly observed with a dosage of ≥1000 mg and a study duration of ≥8 weeks (43). Another meta-analysis has concluded that both turmeric and curcuminoids can significantly decrease TG, TC, and LDL cholesterol, and increase HDL cholesterol concentration in adults with metabolic diseases, and that the therapeutic effect can be improved by prolonging treatment time to >8 week and elevating the dose to >300 mg/d of curcuminoids (44). In contrast, other RCT on non-alcoholic fatty liver disease patients which took of higher doses of curcumin (1500 mg) and longer treatment duration of 12 weeks did not show the lipid-lowering effect of curcumin (45). There are some limitations that might explain the contradictory findings of the present trial to some of the previous reports. Firstly, these results implied that efficacy of curcumin would be strengthened by increasing the treatment period to ≥8 weeks (44). Probably the reason for insignificant changes compared to the placebo group in the current study was the insufficient time period. Secondly, it would be useful to try higher doses of curcumin with larger clinical trials.

Similarly with regard to the issue in lipid profile, several randomized double blind studies (37,46-48) have shown that curcumin supplementation is effective in reducing fasting glucose levels and insulin resistance while, others (49,50) failed to prove that curcumin produced any significant reducing effect on glycemic indices. Yang et al. (51) showed that the intake of the curcumin extract of 1890 mg/day for 12 weeks was associated with lipid-lowering effect but did not improve weight and glucose homeostasis in the patients with metabolic syndrome.

The mechanism of the curcumin effect on the anthropometric measures is also unclear (37,52). It has been proposed in vivo experiments that curcumin supplementation reduces body weight and body mass index by increasing the underlying metabolic rate, with inhibition of adipocyte differentiation through suppression of the transcription factor peroxisome proliferator-activated receptor-c (52,53). Also, it explained that turmeric can promote lipolysis by down-regulating protein kinase-A pathway (20). Another postulated mechanism, which is found in animal studies is that curcumin can prevent fatty acid synthase enzyme activity (acetyl-CoA carboxylase) and increase fatty acid β-oxidation (20). Therefore, enhanced energy expenditure and fat utilization, together with modulated glucose hemostasis (insulin action) appears to have important role in obesity pathogenesis (reduces fat storage and regulates lipid metabolism) (54).

However, previous meta-analysis on clinical studies (53-55) on the effect of turmeric on anthropometric measurements in humans have shown inconsistent findings. Among adolescent girls (aged 13-18 years), a RCT has shown that supplementation of one curcumin tablet (500 mg) per day, containing either standardized 95% turmeric extract or placebo, and to undergo a weight maintenance or a mild weight loss diet for 10 weeks generated a significant reduction in body mass index, waist circumference and hip circumference in the intervention compared to base line, although no significant difference between the

intervention and placebo groups was observed. The results from this previous study are in line with those of the present study (49). In the Saraf-Bank et al.'s study, (49) the reduction in weight and body mass index in both groups has been attributed to the prescribed diets. Similarly, diet and physical activity can be defined as an important confounding factor for the current study. Therefore, in the present study the body composition improvements in both groups might be explained as a result of lifestyle changes. With regards to issue, we believe that the reduction in blood glucose and blood lipids in both groups could be the reason of the reduction in BMI, waist circumference or percentage of body fat mass, as also reported by previous research (56). In other words, body weight alteration may have affected the lipid profile levels of subjects in both groups (43). Moreover, some recent clinical studies (37,57) and meta-analysis' of randomized control trials (49,52) indicated that curcumin supplementation had the capacity to reduce weight and waist circumference, as seen in studies on subjects with body mass index less than 30 kg/m^2 and studies with durations of more than eight weeks. It seems that with regard to the present study's intervention duration (8 weeks) and participants' average BMI (>30), the findings of our study is consistent from the data obtained from those studies.

This study is designed to evaluate the beneficial effects of turmeric powder in its natural form. To the best of our knowledge, the present study is one of a kind since it examines the effect of turmeric powder as a spice in overweight/obese women with hyperlipidemia. The strength of the study was the high rate of adherence where all subjects reported that they had taken turmeric powder during the study period. According to previous findings, turmeric powder added to food for sensorial means have less advantageous health effects compared to turmeric extract (32). Also, it was stated that in human trials oral curcumin given as raw turmeric powder were found with its poor water solubility, low intestinal absorption, and rapid metabolic degradation, which is bounding its bioavailability (31,37,52). To control the confounding effect of dietary intakes in between groups, participants received similar slight weight loss diets with specific macronutrient distribution in this study. Ultimately, we believe participants consumed limited amount of fat for curcumin absorption. In order to normalize the dietary intake of fats for the bioavailability of curcumin, for future studies, it can be suggested to increase the dietary fat intake. Furthermore it can be recommended to observe the changes in fat intake in detail during the course of the trial on all days as well as in each meal specifically when turmeric is consumed (58).

Additionally, it was stated that, it is not entirely understood whether the whole herb is needed for health action, or if curcuminoids by itself are sufficient (59). It was believed that the new delivery forms/novel formulations of curcuminoids may ameliorate disease indications compared with poorly absorbed raw turmeric or its simple/solvent extracts (31,60,61). It was emphasized that investigating the synergies between turmeric constituents, and whether different preparations may have impact on the gut to increase the absorption is important [59]. Furthermore, well designed randomized control trials are needed to clearly understand turmeric's potential. Standardized preparations would be useful to realize the differences between turmeric powder, curcumin extracts and new formulations on clinical outcomes. Lastly for future research, measuring the serum or urine levels of curcuminoids and/or their metabolites in studies to evaluate the relative bioavailability and efficacy is also suggested (31).

Conclusion

In this randomized controlled clinical trial, dietary supplementation of turmeric had no effect on serum total cholesterol, LDL-C, TG levels and body weight loss in overweight/obese women with hyperlipidemia. However, further well designed randomized controlled trials with longer supplementation durations are needed for a stronger assessment of the lipid-modulating properties of turmeric.

Limitations

There are some limitations that might explain the contradictory findings of the present trial. Firstly, the present study did not point out how much curcumin

was already in each subject's diet because the curcuminoid amount within the turmeric powder was not investigated. Secondly, it was stated that in human trials oral curcumin given as raw turmeric powder were found with its poor water solubility, low intestinal absorption, and rapid metabolic degradation, which is bounding its bioavailability. Also, it would be useful to try higher doses of curcumin with larger clinical trials. Additionally, it was emphisied that efficacy of curcumin would be strengthened by increasing the treatment period to ≥8 weeks.

Acknowledgements: We are grateful to the participants for their willingness to participate in this study.

Conflict of Interest: The authors declare that there is no conflict of interest.

Funding Disclosure: This research did not receive any financial support and any other funding.

References

1. Soleimani V, Sahebkar A, Hosseinzadeh H, Turmeric (Curcuma longa) and its major constituent (curcumin) as nontoxic and safe substances. Phytother Res 2018;32(6): 985-995.
2. Hosseini A, Hosseinzadeh H. Antidotal or protective effects of Curcuma longa (turmeric) and its active ingredient, curcumin, against natural and chemical toxicities: A review. Biomed Pharmacother 2018;99:411-421.
3. Gupta SC, Sung B, Kim JH, Prasad S, Li S, Aggarwal BB. Multitargeting by turmeric, the golden spice: from kitchen to clinic. Mol Nutr Food Res 2013;57(9):1510-1528.
4. Sharifi-Rad J, Rayess YE, Rizk AA, et al. Turmeric and its major compound curcumin on health: Bioactive effects and safety profiles for food, pharmaceutical, biotechnological and medicinal applications. Front Pharmacol 2020;11:01021.
5. Boyanapalli SS, Kong A-NT. "Curcumin, the king of spices": epigenetic regulatory mechanisms in the prevention of cancer, neurological, and inflammatory diseases. Pharmacol Rep 2015;1(2):129-139.
6. Wongcharoen W, Phrommintikul A. The protective role of curcumin in cardiovascular diseases. Int J Cardiol 2009; 133(2):145-151.
7. Pari L, Tewas D, Eckel J. Role of curcumin in health and disease. Arch Insect Biochem Physiol 2008;114(2):127-149.
8. Ghosh S, Banerjee S, Sil PC. The beneficial role of curcumin on inflammation, diabetes and neurodegenerative disease: A recent update. Food Chem Toxicol 2015;83:111-124.
9. Pivari F, Mingione A, Brasacchio C, Soldati L. Curcumin and type 2 diabetes mellitus: prevention and treatment. Nutrients 2019;11(8):1837.
10. Kunnumakkara AB, Sailo BL, Banik K, et al. Chronic diseases, inflammation, and spices: how are they linked? J Transl Med 2018;16(1):1-25.
11. Amalraj A, Pius A, Gopi S, Gopi S. Biological activities of curcuminoids, other biomolecules from turmeric and their derivatives–A review. J Tradit Complement Med 2017; 7(2):205-233.
12. Hassan F-u, Rehman MS-u, Khan MS, et al. Curcumin as an alternative epigenetic modulator: Mechanism of action and potential effects. Front Genet. 2019;10:514
13. Sahebkar A. Dual effect of curcumin in preventing atherosclerosis: the potential role of pro-oxidant–antioxidant mechanisms. Nat Prod Res 2015;29(6):491-492.
14. Campbell MS, Fleenor BS. The emerging role of curcumin for improving vascular dysfunction: A review. Crit Rev Food Sci Nutr 2018; 58(16):2790-2799.
15. Cicero AF, Colletti A, Bajraktari G, et al. Lipid-lowering nutraceuticals in clinical practice: position paper from an International Lipid Expert Panel. Nutr Rev 2017, 75(9):731-767.
16. Ho JN, Jang JY, Yoon HG, et al. Anti□obesity effect of a standardised ethanol extract from Curcuma longa L. fermented with Aspergillus oryzae in ob/ob mice and primary mouse adipocytes. J Sci Food Agric 2012;92(9):1833-1840.
17. Arafa HM. Curcumin attenuates diet-induced hypercholesterolemia in rats. Med Sci Monit 2005;11(7): BR228-BR234.
18. Chuengsamarn S, Rattanamongkolgul S, Luechapudiporn R, Phisalaphong C, Jirawatnotai S. Curcumin extract for prevention of type 2 diabetes. Diabetes Care 2012;35(11): 2121-2127.
19. Sahebkar A. A systematic review and meta-analysis of randomized controlled trials investigating the effects of curcumin on blood lipid levels. Clin Nutr 2014;33(3): 406-414.
20. Adab Z, Eghtesadi S, Vafa MR, et al. Effect of turmeric on glycemic status, lipid profile, hs□CRP, and total antioxidant capacity in hyperlipidemic type 2 diabetes mellitus patients. Phytother Res 2019;33(4):1173-1181.
21. Asan SA, Bas M, Eren B, Karaca E. The effects of curcumin supplementation added to diet on anthropometric and biochemical status in women with polycystic ovary syndrome: A randomized, placebo-controlled trial. Prog Nutr 2020;22(4).
22. Nieman DC, Cialdella-Kam L, Knab AM, Shanely RA. Influence of red pepper spice and turmeric on inflammation and oxidative stress biomarkers in overweight females: a metabolomics approach. Plant Foods Hum Nutr 2012;67(4):415-421.
23. Finkler E, Heymsfield SB, St-Onge M-P. Rate of weight loss can be predicted by patient characteristics and intervention strategies. J Acad Nutr Diet 2012;112(1):75-80.

24. Miquel J, Bernd A, Sempere J, Dıaz-Alperi J, Ramırez A. The curcuma antioxidants: pharmacological effects and prospects for future clinical use. A review. Arch Gerontol Geriatr 2002;34(1):37-46.
25. Pekcan, G. Beslenme Durumunun Saptanması, Diyet El Kitabı, (Yazarlar. Baysal A, Aksoy M, Besler T, Bozkurt N, Keçecioğlu S, Mercanlıgil SM, et al.) Ankara: Hatiboğlu Yayınevi (9. Baskı); 2014. pp.108-119.
26. Sukandar E, Permana H, Adnyana I, et al. Clinical study of turmeric (Curcuma longa L.) and garlic (Allium sativum L.) extracts as antihyperglycemic and antihyperlipidemic agent in type-2 diabetes-dyslipidemia patients. Int J Pharmacol 2010;6(4):456-463.
27. Amin F, Islam N, Anila N, Gilani A. Clinical efficacy of the co-administration of Turmeric and Black seeds (Kalongi) in metabolic syndrome–A double blind randomized controlled trial–TAK-MetS trial. Complement Ther Med 2015;23(2):165-174.
28. Selvi NMK, Sridhar M, Swaminathan R, Sripradha R. Efficacy of turmeric as adjuvant therapy in type 2 diabetic patients. Indian J Clin Biochem 2015;30(2):180-186.
29. Gómez-Téllez A, Sierra-Puente D, Muñoz-Gómez R, et al. Effects of a low-dose spirulina/turmeric supplement on cardiometabolic and antioxidant serum markers of patients with abdominal obesity. Front Nutr 2020;7:65.
30. Ruiz-Ramie JJ, Barber JL, Sarzynski MA. Effects of exercise on HDL functionality. Curr Opin Lipidol 2019;30(1):16.
31. Singletary K. Turmeric: potential health benefits. Nutrition Today 2020; 55(1):45-56.
32. Qin S, Huang L, Gong J, et al. Efficacy and safety of turmeric and curcumin in lowering blood lipid levels in patients with cardiovascular risk factors: a meta-analysis of randomized controlled trials. Nutr J 2017;16(1):1-10.
33. Iwueke A, Madu W, Chukwu E. Turmeric Powder Gavage Improves Lipid Profile of Albino Rats. J Altern Complement Med 2020:42-46.
34. Algridi MA, Azab AE. Amelioration of gentamicin induced dyslipidemia in Guinea Pigs by Curcumin and Rosemary. Guigoz Sci Rev 2017;3(2):6-16.
35. Chanda S, Ramachandra T. Phytochemical and pharmacological importance of turmeric (Curcuma longa): a review. Research and Reviews: A Journal of Pharmacology 2019;9(1):16-23p.
36. Mughal MH. Turmeric polyphenols: A comprehensive review. Integr Food Nutr Metab 2019;6.
37. Dolati S, Namiranian K, Amerian R, Mansouri S, Arshadi S, Azarbayjani MA. The effect of curcumin supplementation and aerobic training on anthropometric indices, serum lipid profiles, c-reactive protein and insulin resistance in overweight women: a randomized, double-blind, placebo-controlled trial. J Obes Metab Syndr 2020;29(1):47.
38. Tayyem RF, Heath DD, Al-Delaimy WK, Rock CL. Curcumin content of turmeric and curry powders. Nutr Cancer 2006;55(2):126-131.
39. Wang MY. Spice up your lipids: the effects of curcumin on lipids in humans. Nutrition Bytes.2012;16(1).
40. Baum L, Cheung SK, Mok VC, et al. Curcumin effects on blood lipid profile in a 6-month human study. Pharmacol Res 2007;56(6):509-514.
41. Pungcharoenkul K, Thongnopnua P. Effect of different curcuminoid supplement dosages on total in vivo antioxidant capacity and cholesterol levels of healthy human subjects. Phytother Res 2011;25(11):1721-1726.
42. Alwi I, Santoso T, Suyono S, et al. The effect of curcumin on lipid level in patients with acute coronary syndrome. Acta Med Indones 2008;40(4):201-210.
43. Saeedi F, Farkhondeh T, Roshanravan B, Amirabadizadeh A, Ashrafizadeh M, Samarghandian S. Curcumin and blood lipid levels: an updated systematic review and meta-analysis of randomised clinical trials. Arch Physiol Biochem 2020:1-10.
44. Yuan F, Dong H, Gong J, et al. A systematic review and meta-analysis of randomized controlled trials on the effects of turmeric and curcuminoids on blood lipids in adults with metabolic diseases. Adv Nutr 2019;10(5):791-802.
45. Saadati S, Hatami B, Yari Z, et al. The effects of curcumin supplementation on liver enzymes, lipid profile, glucose homeostasis, and hepatic steatosis and fibrosis in patients with non-alcoholic fatty liver disease. Eur J Clin Nutr. 2019;73(3):441-449.
46. Jazayeri-Tehrani SA, Rezayat SM, Mansouri S, et al. Nano-curcumin improves glucose indices, lipids, inflammation, and Nesfatin in overweight and obese patients with non-alcoholic fatty liver disease (NAFLD): a double-blind randomized placebo-controlled clinical trial. Nutr Metab (Lond) 2019;16:8.
47. Cicero AF, Sahebkar A, Fogacci F, Bove M, Giovannini M, Borghi C. Effects of phytosomal curcumin on anthropometric parameters, insulin resistance, cortisolemia and non-alcoholic fatty liver disease indices: a double-blind, placebo-controlled clinical trial. Eur J Nutr 2020;59(2):477-483.
48. Sohaei S, Amani R, Tarrahi MJ, Ghasemi-Tehrani H. The effects of curcumin supplementation on glycemic status, lipid profile and hs-CRP levels in overweight/obese women with polycystic ovary syndrome: A randomized, double-blind, placebo-controlled clinical trial. Complement Ther Med 2019;47:102201.
49. Saraf□Bank S, Ahmadi A, Paknahad Z, Maracy M, Nourian M. Effects of curcumin supplementation on markers of inflammation and oxidative stress among healthy overweight and obese girl adolescents: A randomized placebo□controlled clinical trial. Phytother Res 2019;33(8):2015-2022.
50. Hodaei H, Adibian M, Nikpayam O, Hedayati M, Sohrab G. The effect of curcumin supplementation on anthropometric indices, insulin resistance and oxidative stress in patients with type 2 diabetes: a randomized, double-blind clinical trial. Diabetol Metab Syndr 2019;11(1):1-8.
51. Yang YS, Su YF, Yang HW, Lee YH, Chou JI, Ueng KC. Lipid□lowering effects of curcumin in patients with metabolic syndrome: a randomized, double□blind, placebo□controlled trial. Phytother Res 2014;28(12):1770-1777.

52. Mousavi SM, Milajerdi A, Varkaneh HK, Gorjipour MM, Esmaillzadeh A. The effects of curcumin supplementation on body weight, body mass index and waist circumference: a systematic review and dose-response meta-analysis of randomized controlled trials. Crit Rev Food Sci Nutr 2020;60(1):171-180.
53. Akbari M, Lankarani KB, Tabrizi R, et al. The effects of curcumin on weight loss among patients with metabolic syndrome and related disorders: a systematic review and meta-analysis of randomized controlled trials. Front Pharmacol 2019;10:649.
54. Boaz M, Kaufman-Shriqui V, Sherf-Dagan S, Salem H, Navarro DA. Frequently used medicinal herbs and spices in weight management: A review. Funct Food Health Dis 2020;10(7):305-324.
55. Jafarirad S, Mansoori A, Adineh A, Panahi Y, Hadi A, Goodarzi R. Does turmeric/curcumin supplementation change anthropometric indices in patients with non-alcoholic fatty liver disease? A systematic review and meta-analysis of randomized controlled trials. Clin Nutr Res 2019;8(3):196.
56. le Roux CW, Hartvig NV, Haase CL, Nordsborg RB, Olsen AH, Satylganova A. Obesity, cardiovascular risk and healthcare resource utilization in the UK. Eur J Prev Cardiol 2020:2047487320925639.
57. Di Pierro F, Bressan A, Ranaldi D, Rapacioli G, Giacomelli L, Bertuccioli A. Potential role of bioavailable curcumin in weight loss and omental adipose tissue decrease: preliminary data of a randomized, controlled trial in overweight people with metabolic syndrome. Preliminary study. Eur Rev Med Pharmacol Sci 2015;19(21):4195-4202.
58. Mohammadi A, Sahebkar A, Iranshahi M, et al. Effects of supplementation with curcuminoids on dyslipidemia in obese patients: a randomized crossover trial. Phytother Res 2013;27(3):374-379.
59. Rolfe V, Mackonochie M, Mills S, McLennan E. Turmeric/curcumin and health outcomes: a meta-review of systematic reviews. Eur J Integr Med 2020:101252.
60. Panahi Y, Khalili N, Hosseini MS, Abbasinazari M, Sahebkar A. Lipid-modifying effects of adjunctive therapy with curcuminoids–piperine combination in patients with metabolic syndrome: results of a randomized controlled trial. Complement Ther Med 2014;22(5):851-857..
61. Jamwal R. Bioavailable curcumin formulations. A review of pharmacokinetic studies in healthy volunteers. J Integr Med 2018;16(6):367-374.

Correspondence:
Seray Kabaran
Department of Nutrition and Dietetics, Faculty of Health Sciences,
Eastern Mediterranean University,
Famagusta, T.R. North Cyprus via Mersin 10 Turkey
Tel: 0392 630 3929
Fax: 0392 630 3939
E-mail: seray.kabaran@emu.edu.tr