Effect of a Weight Loss Program on Body Composition and Metabolic Syndrome Markers in Obese Weight Cyclers

Samuel Oetoro[1], Lukman H. Makmun[2], Widjaja Lukito[1], Andi Wijaya[3]

[1] Department of Nutrition, Faculty of Medicine, Universitas Indonesia, Jakarta, Indonesia.
[2] Department of Internal Medicine, Faculty of Medicine, Universitas Indonesia - Cipto Mangunkusumo Hospital, Jakarta, Indonesia.
[3] Post Graduate Program in Clinical Biochemistry, Universitas Hasanuddin, Makassar, Indonesia.

Correspondence mail:
Samuel Oetoro. Department of Nutrition, Faculty of Medicine, Universitas Indonesia. Jl. Mangga 15 blok U no. 1 Kepa Duri Kebon Jeruk, Jakarta 11510, Indonesia. email: dr_samoetoro@yahoo.com.

ABSTRAK

Tujuan: *untuk menilai pengaruh program penurunan berat badan (BB) terhadap massa lemak (ML), rating lemak viseral, dan parameter sindrom metabolik pada penyandang obesitas dengan weight cycling (WC).* ***Metode:*** *penelitian ini merupakan rancangan penelitian uji klinis terbuka selama 8 minggu yang dilakukan di Balai Kota DKI Jakarta. Subyek penelitian diambil secara konsekutif dan selanjutnya diklasifikasikan menjadi kelompok WC dan first encounter obesity (FEO). Kedua kelompok diberikan program penurunan BB yang terdiri dari pengurangan asupan energi sebesar 1000 kkal dan olahraga intensitas ringan - sedang tiga kali seminggu selama 45 menit. Pengukuran komposisi tubuh (ML, rating lemak viseral), dan petanda sindrom metabolik (lingkar pinggang/LP dan kadar trigliserida.TG) dilakukan pada awal penelitian, minggu ke 4 dan pada akhir penelitian.* ***Hasil:*** *sebanyak 72 subyek berhasil menyelesaikan penelitian (34 orang pada kelompok WC dan 38 orang pada kelompok FEO). Pada akhir penelitian, ML, rating lemak viseral, dan LP menurun pada kedua kelompok di mana penurunannya lebih kecil pada kelompok WC dibandingkan kelompok FEO; namun tidak berbeda bermakna (p >0,05). Kadar TG menurun pada kelompok FEO sedangkan pada kelompok WC didapatkan peningkatan kadar TG namun tidak berbeda bermakna (p=0,055).* ***Kesimpulan:*** *program penurunan BB dapat mempengaruhi komposisi tubuh dan petanda sindroma metabolik pada penyandang obesitas, namun responnya tampak lebih buruk pada penyandang obesitas dengan WC.*

Kata kunci: *progam penurunan berat badan, weight cycling, massa lemak, rating lemak viseral, sindrom metabolik.*

ABSTRACT

Aim: *to evaluate the effect of weight loss program on fat mass, visceral fat rating and metabolic syndrome markers in obese subjects with weight cycling.* ***Methods:*** *this was an 8-week open trial. The subjects were recruited consecutively from Balai Kota DKI Jaya. Subjects were classified into two groups according to the fluctuation of weight gain (weight cycling/WC and first encounter obesity/FEO group). Both groups were assigned to receive weight loss program consisted with following goals: a 1000 kcal energy intake reduction and 45 minutes mild-to-moderate intensity physical activity three times a week. Body composition (fat mass, visceral fat rating), and metabolic syndrome markers (waist circumference and triglyceride levels) were measured at baseline, week 4 and at the end of study.* ***Results:*** *seventy two subjects completed the study (34 subjects in WC group and 38 subjects in FEO group). Following weight loss program, a decrease in fat mass, visceral fat rating, and waist circumference was lower in WC group compared with FEO group but it was not statistically*

significant (p>0.05). Triglyceride levels were decreased in the FEO group while it was increased in WC group. However the difference was not significant (p=0.055). ***Conclusion:*** *weight loss program may contribute to changes in body composition and metabolic syndrome markers in obese subjects, which the response appears to be worse in weight cyclers.*

Key words: *weight loss program, weight cycling, fat mass, visceral fat rating, metabolic syndrome.*

INTRODUCTION

Obesity continuously becomes a public health problem with increasing prevalence every year. According to "*Riset Kesehatan Dasar"* (Riskerdas), prevalence of obesity in Indonesia increased significantly from 23.8% to 39.2% in women and 13.9% to 19.7% in men by year 2013.[1,2]

Weight changes is strongly correlated with changes in body composition.[3] Body composition changes in obesity is characterized by an increase in fat mass and decrease in fat-free mass. Review by Sun et al[4] stated that adipocyte cell number is relatively constant by early adulthood so that any alterations of fat mass during adulthood are merely caused by adipocyte hypertrophy. The enlargement of adipocyte volume that is not accompanied by adequate angiogenesis can lead to cell hypoxia, adipocyte cell death, enhanced chemokine secretion, and dysregulation in fatty acid fluxes.[5] These conditions will initiate inflammatory mediator secretion and moreover will induce systemic oxidative stress, which contributes to the development of the metabolic syndrome.[6]

Dietary program coupled with physical activity are considered the first-line strategy to manage obesity.[7] The majority of individuals who lost weight could not maintain the reduced weight for a period of time. There are often repeated cycles of weight loss followed by weight regain, form a pattern known as weight cycling (WC) or "yo-yo". Some experts have asserted that WC may increase the risk of developing metabolic syndrome and cardiovascular disease because of fat accumulation, central obesity, insulin resistance, and hypertension promoted by WC.[8,9] Study by Zhang et al.[10] reported a positive association between metabolic syndrome components and weight fluctuation that started from young adulthood. Until now, there is no conclusion whether weight cyclers will have more fat mass, visceral fat rating, and worse metabolic syndrome markers compared with obese individuals who never follow weight loss program (first encounter obesity/FEO).

We have not found published study has evaluated the effect of weight loss program in weight cycling population. Based on the background above, we conduct a pilot study to evaluate the effect of weight loss program (diet and exercise) on fat mass, visceral fat rating, and metabolic syndrome markers in obese subjects with weight cycling.

METHODS

Subjects

Subjects were recruited from Balai Kota DKI Jaya (Jakarta City Hall). Potential subjects were initially screened by medical record review and those who appeared to be eligible were approached for consent. A written consent form was signed by all subjects prior to data collection.

Men and women aged 20-50 years old, had a body mass index (BMI) of between 30-35 kg/m2, and with waist circumference >90 cm for man and >80 cm for woman, were included. The subjects were divided into two groups; WC and FEO group. Subjects who ever lost weight ≥4.5 kg and regained weight at least three times in 4 years were included in former group; while those who never experienced weight loss were included in later group. Exclusion criteria were defined as fasting blood glucose ≥126 mg/dL (7.0 mmol/L); blood pressure ≥140/90 mmHg; current treatment with anti-diabetes, anti-hypertension, anti-cholesterol, and anti-inflammatory medications; history of gastrointestinal resection and hormonal diseases; smoking; pregnancy and lactation. Those who were in weight loss program, using dietary fat

absorption inhibitor and anti-appetite drugs were also excluded. This study was approved by the Committee of Medical Research Ethics, Faculty of Medicine, University of Indonesia.

Study Design and Intervention

This study was an 8-week open clinical trial. The subjects were assigned to receive a weight loss program consisting of the following goals: a 1,000 kcal reduction of total energy based on resting energy expenditure (REE) using WHO guideline and physical activity level of each subject.

Subjects attended 45-minute mild-to-moderate intensity exercise twice a week supervised by investigators at Balai Kota DKI Jaya and exercised for their remaining sessions once a week at home. Facility-based exercises included treadmill walking or stationary bicycling; while home exercise was a 45-minute brisk walking.

Study Measures and Data Collection

At the beginning, demographic information and a brief history of dietary and physical activity were recorded. There was 2-week wash out period prior to study. Subjects were seen at three scheduled visits (baseline or week 0, week 4 and 8) during the study. Height was recorded using microtoise after removal of the subject's shoes. Subjects also received diet consultation, menu, program journal, and exercise scheduled at Balai Kota sports center. Each subject was explained how to take note about dietary and exercise activity on journal. During each visit, the following assessments were performed: weight, waist circumference, fat mass, visceral fat rating, and triglyceride level.

Body weight, fat mass, and visceral mass rating were measured using 8 electrode method of Bio-Electrical Impedance Analysis (BIA) (MC-180 MA Tanita, Tokyo, Japan). Waist circumference was taken with subject in a standing position at level of the last rib and hip using measuring tape (Roche). Serum triglyceride was measured using spectrophotometry (Cobas c501, Roche).

Adherence to the intervention during the study was assessed via multiple approaches including phone call once a week, short message service (SMS) messaging twice a week, and one-to-one session with the investigator once a week.

Statistical Analysis

A sample of 196 subjects were needed in order to provide 90% power (with $p<0.05$) and possible 10% drop out. Kolmogorov-Smirnov test was used to test data distribution. If p value >0.05, normality was established and presented as mean ± standard deviation, otherwise data were presented as median (minimum-maximum). Paired t-test was used to compare within group values of weight, waist circumference, fat mass, visceral mass rating, and triglyceride levels if data distribution was normal; otherwise the data was compared using Wilcoxon test. Values between WC and FEO groups were compared using independent t-test if the data was normally distributed; otherwise values were compared using Mann-Whitney test. Correlation between variables that were normally distributed was analyzed using Pearson test; otherwise Rank-Spearman test was used. All analyses were carried out using statistical package for social sciences (SPSS) version 11.5 software and $p<0.05$ was considered statistically significant.

RESULTS

Of the initial 160 subjects who enrolled in the study, only 88 met the study criteria which consisted of 43 subjects in WC group and 45 in FEO group. Fifteen subjects withdrew prior to the study and one subject could not complete the program. Thus, the study was completed by 72 subjects (n=34 subjects for the WC group and n=38 subjects for the FEO group). Because of limited sports equipment and staff, the study was held in three different period study: group I (n=25 subjects), group II (n=24 subjects), and group III (n=39 subjects). (**Figure 1**)

About 48.7% subjects in FEO group were men compared with WC group (23.5%) and the difference was statistically significant (p=0.026). All subjects in FEO group were significantly experienced obesity longer than WC group. All body composition variables between groups were not differ significantly except for fat mass (p=0.008). Visceral fat rating between both groups was not significantly different. However 18 subjects in WC group (52.9%) and 27 subjects

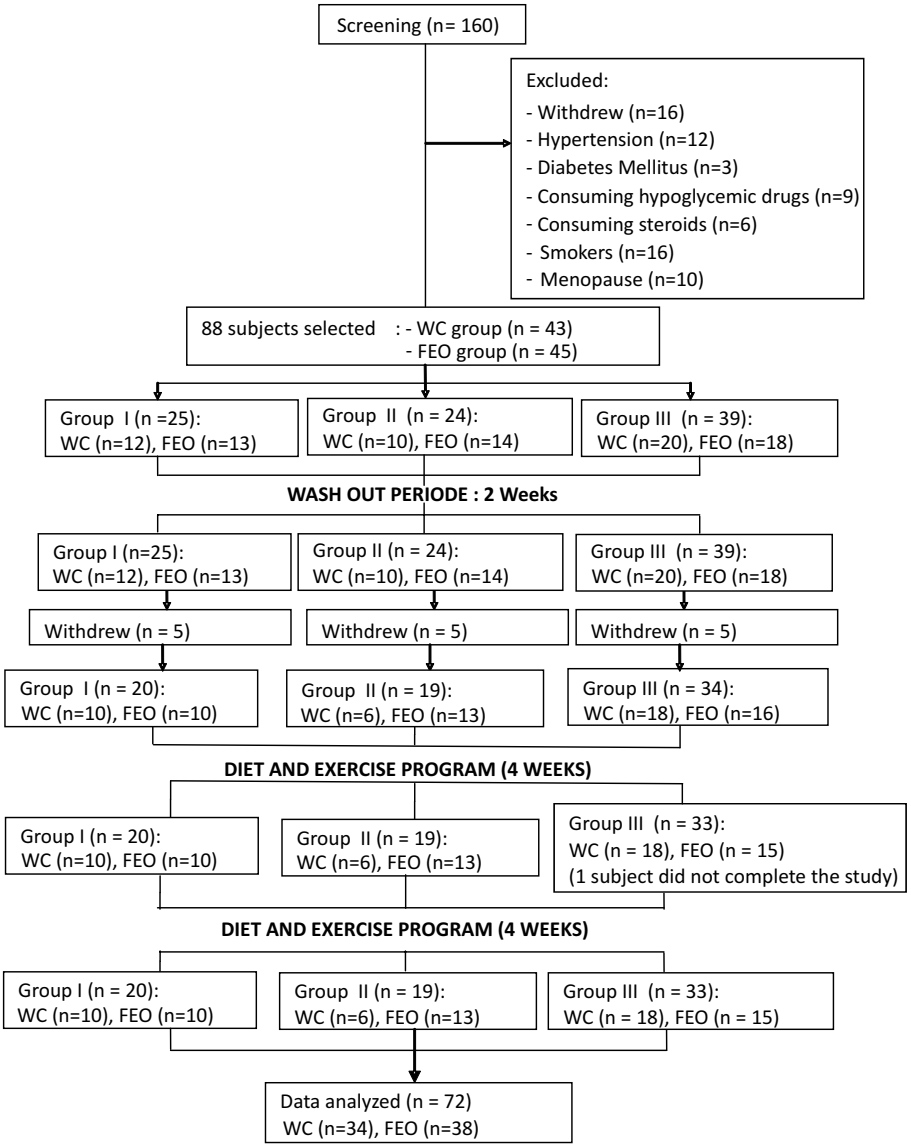

Figure 1. Flow diagram of the study

in FEO group (69.2%) had visceral fat rating above normal (≥13). The difference between groups was not significant. (p=0.153).

Waist circumference and triglyceride level were two parameters used as metabolic syndrome markers in this study. Baseline triglyceride levels in FEO group were significantly higher than WC group (p=0.039).

Following 8-week weight loss program, changes of visceral fat rating are shown in **Table 2**. There were no significant differences between groups.

Table 3 shows the changes of body weight and fat mass between groups during the study were not significantly different.

The decrease of waist circumference was smaller in WC group than FEO group. The highest changes during study were seen in both groups at the first four week. Triglyceride levels in WC group were elevated, while in FEO group triglyceride levels were reduced after 8-week program (4.12±54.11 vs 19.02±45.59 mg/dL); however, the difference was not significant (p=0.055).

Baseline triglyceride levels of five subjects in WC groups (14.7%) and 12 subjects (30.8%) in FEO group were above 150 mg/dL. At the end of the study, triglyceride levels of eight subjects in WC group (23.5%) and eight subjects in FEO group (21.1%) increased. The changes of waist

Table 1. Baseline characteristics of study population

Variables	Weight cycling (n = 34)	First encounter obesity (n = 39)	p
Age (y)	38.00 (25.00-49.00)	40,00 (25.00-50.00)	0.859K
Gender			
- Male	8 (23.5%)	19 (48.7%)	
- Female	26 (76.5%)	20 (51.3%)	0.026*C
Family history of obesity			
- Yes	28 (81.3%)	30 (76.9%)	
- No	6 (17.6%)	9 (23.1%)	0.567C
Length of obesity (year)			
- Male	5.12 ± 2.69	11.68 ± 4.61	<0.001T*
- Female	6.58 ± 2.33	12.25 ± 6.73	0.002T*
Food intake			
Energy (kcal)	2343.76 ± 609.56	2568.19 ± 821.55	0.186T
- Carbohydrate (g)	244.57 ± 89.13	266.05 (107.00-570.00)	0.089M
- Protein (g)	90.27 (61.00-178.55)	104.84 ± 35.12	0.274M
- Fat (g)	109.41 ± 38.64	114.16 ± 45.48	0.632T
Dietary composition in percentage			
- Carbohydrate (%)	43.00 ± 7.00	44.00 ± 8.00	0.738T
- Protein (%)	16.00 ± 3.00	16.00 ± 3.00	0.965T
- Fat (%)	40.00 ± 7.00	39.00 ± 8.00	0.819T
Physical activity (n)			
- Mild	10 (29.4%)	14(35.9%)	
- Moderate	22 (64.7%)	21 (53.8%)	
- High	2 (5.9%)	4 (10.3%)	0.601*C
Body composition			
- Body weight (kg)	82.99 ± 9,78	82.25 ± 9,65	0.745T
- Height (m)	1.57 (1.46-1.76)	1.59 (1.44-1.78)	0.634M
- Body mass index (kg/m^2)	31.85 (30.00-35.30)	31.20 (30.00-35.00)	0.306M
- Fat mass (kg)	35.51 ± 6.51	31.19 ± 6.93	0.008T*
- Visceral fat rating	13.00 (9.00-19.00)	14,00 (8,00-19,00)	0.218M
Metabolic syndrome markers			
- Waist circumference (cm)	101.16 ± 6.74	103.09 ± 6.76	0.226T
- Triglyceride (mg/dL)	96.00 (43.00-305.00)	133.00 (50.00-342.00)	0.039M*

Cchi-square, T independent t test, M Mann Whitney, *significant (p < 0.05)

circumference and triglyceride levels are shown in **Table 4**.

The correlation of all variables is shown in **Table 5**. Body weight, fat mass, and visceral fat rating in both groups were moderately correlated with waist circumference. Meanwhile, only the changes of body weight in WC group and fat mass in FEO group correlated with triglyceride levels with r=0.365, p=0.034 and r=0.351, p=0.031 respectively.

DISCUSSION

Baseline characteristics included age, family history of obesity, dietary intake, and physical activity of the subjects were comparable. There were more men in the FEO group and this might cause bias. Gender could interfere with body composition, this is shown by the difference of body composition between men and women at the same age.[11] Oxidative stress is greater in men than women and it can affect body response to weight loss program. Smith et al.[12] showed

Table 2. Changes of visceral fat rating during the program

Visceral fat rating	Weight cycling (n = 34)	First Encounter Obesity (n = 38)	p
W0	13.00 (9.00-19.00)	14.00 (8.00-19.00)	0.169[M]
W4	12,03 ± 2,43	12.42 ± 2.81	0.528[T]
W8	11.00 (7.00-18.00)	12.50 (7.00-17.00)	0.208[M]
- Δ W4-W0	-1.00 (-3.00–1.00)	-1.00 (-4.00–0.00)	0.269[M]
- Δ W8-W4	-1.00 (-2.00–1.00)	0.00 (-2.00–2.00)	0.571[M]
- Δ W8-W0	-1.50 (-4.00–1.00)	-2.00 (-4.00–0.00)	0.560[M]

[T] independent t test, [M] Mann Whitney, *significant (p <0.05), W0: baseline, W4: week 4, W8: week 8, Δ: changes

that the response of muscle protein synthesis after endurance exercise was different between men and women. An animal study by Valle et al.[13] showed the energy balance response to the caloric restriction and muscle protein synthesis response to exercise differ according to gender. Macronutrient proportions in both group showed high proportion of fat which may contribute to the pathogenesis of obesity. Fatty acids trigger peroxisome proliferator-activated receptors delta (PPAR δ) and gamma (PPAR γ) receptor, which may induce adipogenesis and fat deposition in adipose tissue.[14]

Table 3. Changes of body weight and fat mass during the study

Variables	Weight cycling (n = 34)	First Encounter Obesity (n = 38)	p
BW (kg)			
M0	82.99 ± 9.78	82.47 ± 9.68	0.817[T]
M4	79.41 ± 9.36	78.21 ± 8.97	0.579[T]
M8	78.08 ± 9.69	76.75 ± 8.73	0.546[T]
- Δ M4-M0	-3.58 ± 2.18	-4.25 ± 2.11	0.189[T]
- Δ M8-M4	-1.34 ± 1.55	-1.46 ± 1.74	0.764[T]
- Δ M8-M0	-4.92 ± 3.20	-5.71 ± 3.10	0.292[T]
Fat mass (kg)			
M0	35.51 ± 6,51	31.19 ± 7.02	0.008[T*]
M4	32.69 ± 6.19	28.37 ± 6.76	0.006[T*]
M8	31.71 ± 6.36	27.31 ± 6.41	0.005[T*]
- Δ M4-M0	-2.82 ± 2.02	-2.81 ± 1.74	0.986[T]
- Δ M8-M4	-0.98 ± 1.39	-1.07 ± 1.54	0.797[T]
- Δ M8-M0	-3.80 ± 2.84	-3.88 ± 2.33	0.895[T]

[T] independent t test, * significant (p <0.05), BW: body weight, W0: baseline, W4: week 4, W8: week 8, Δ: changes

Subjects in WC group had higher fat mass and the result was similar with other references that suggested WC was correlated with adipogenesis and hyperplasia of adipose by alteration of fat metabolism.[15] One of the possibilities that WC may promote fat deposition in adipose tissue is that WC induces the fluctuation of lipogenic enzyme, cholesterol, triglyceride, glucose, insulin and glucagon levels by the alterations

Table 4. Changes of metabolic syndrome markers during the study

Variables	Weight cycling (n=34)	First encounter obesity (n=38)	p
Waist circumference (cm)			
W0	101.16 ± 6.75	103.27 ± 6.76	0.190[T]
W4	97.61 ± 7.48	99.17 ± 6.39	0.350[T]
W8	95.34 ± 7.07	96.31 ± 6.25	0.543[T]
- Δ W4-W0	-3.55 ± 3.42	-4.10 ± 2.87	0.459[T]
- Δ W8-W4	-1.50 (-8.00–1.80)	-2.25 (-7.50–3.00)	0.158[M]
- Δ W8-W0	-5.82 ± 4.38	-6.97 ± 3.59	0.233[T]
Triglyceride (mg/dL)			
W0	96.00 (43.00–305.00)	134.50 (50.00–342.00)	0.030[M*]
W4	88.00 (47.00–311.00)	96.50 (45.00–377.00)	0.524[M]
W8	99.00 (44.00–428.00)	103.00 (54.00–310.00)	0.502[M]
- Δ W4-W0	-0.50 (-118.00–95.00)	-23,00 (-119.00–199.00)	0.024[M*]
- Δ W8-W4	4.50 (-88.00–200.00)	5.50 (-111.00–84.00)	0.982[M]
- Δ W8-W0	4.12 ± 54.11	-19.02 ± 45.59	0.055[T]

[T] independent t test, [M] Mann Whitney, *significant (p <0.05), W0: baseline, W4: week 4, W8: week 8, Δ: changes

Table 5. Correlation the changes of body weight, body composition (fat mass and visceral fat rating) and metabolic syndrome markers in WC and FEO groups

Variables	Metabolic syndrome markers			
	Δ waist circumference		Δ triglyceride levels	
	r	p	r	p
WC group				
- Δ BW	0.404	<0,001^{P*}	0.365	0,034^{P*}
- Δ FM	0.445	0.008^{P*}	0.314	0.071^{P}
- Δ visceral fat rating	0.321	<0,001^{P*}	0.225	0.201^{P}
FEO group				
- Δ BW	0.546	<0.001^{P*}	0.235	0.155^{S}
- Δ FM	0.555	<0.001^{P*}	0.351	0.031^{S*}
- Δ visceral fat rating	0.603	<0.001^{P*}	0.281	0.088^{S}

^{P} Pearson test, ^{S} Rank-Spearman test,* significant ($p<0.05$), BW: body weight, FM: fat mass, r: coefficient of correlation

of metabolism and genetic expression. Another possibility is that fat deposition correlates with leptin level and lipogenic enzyme stimulation in white adipose matter. Caloric restriction followed by exaggerate feeding could promote an increase in adipose tissue which respond to changes of energy supply by the release of leptin and adiponectin. The increase of lipogenic activity and leptin level could contribute to weight gain in WC.[16]

Following weight loss program consisting of energy-reduction diet and exercise, there were loss of body weight loss and fat mass in both groups. There were various studies that demonstrated the loss of body weight and fat mass after diet and/or exercise intervention. Kempen et al.[17] demonstrated that addition of exercise to 4-week energy-restricted diet in obese women has advantages to the changes in body composition including body weight and fat mass. Study by Geliebter et al.[18] showed that in diet plus aerobic training group, mean body weight and fat mass reduced 9.2 ± 4.5% and 7.2 ± 3.0% respectively although the difference did not differ significantly compared with diet plus strength training and diet alone groups.

The present study showed at the first four weeks, the loss of fat mass was higher than second four weeks study in both groups. At the end of study, the loss of fat mass in WC group was lower than FEO group and the difference was not significant. This result demonstrated the response of subjects in FEO group to the program was better than WC group. Similarly, Yoo et al.[19] demonstrated that a decrease in body weight and fat mass was greater in non-WC group compared with WC group after 12 weeks of the weight control program; however, the difference was not significant. It is conceivable that diet and exercise have fewer advantages in weight cyclers. It is suggested that weight cyclers have a lower basal metabolic rate which makes it difficult to control long term stable body weight. Therefore, weight cyclers tend to experience weight regain.

Visceral fat rating may reflect the amount of abdominal visceral fat. This study showed mean visceral fat rating in both groups did not differ significantly. However, most of subjects in FEO group (69.2%) and WC group (52.9%) had visceral fat rating above normal (>13). It is suggested that there were more men in FEO group which abdominal fat in men is larger than women.[20]

There are many criteria proposed to describe metabolic syndrome, but Despre et al.[21] proposed hypertriglyceridemic waist (hypertriglyceridemia and high waist circumference) as a simple criteria for early screening to identify metabolic syndrome. Baseline waist circumference of all subjects was larger than normal values. Fat accumulation in obesity, especially visceral fat, has been known correlated with metabolic syndrome.[22] A study of Lemieux et al.[23] showed a positive association between waist circumference and apolipoprotein B level, it is suggested due to accumulation of visceral adipose tissue. The study also showed in men, fasting insulin levels increased consistently with waist circumference.

Baseline triglyceride levels in FEO group were higher than WC group. It might correlate with waist circumference which was higher in FEO group. Waist circumference is well recognized to predispose intraperitoneal fat and abdominal or intraperitoneal fat is predisposing factor for hypertriglyceridemia. The mechanism for this relationship is that intraperitoneal fat releases fatty acids directly into the splanchnic circulation. These fatty acids may add a lipid load

on the liver thus this extra load should translate into higher triglyceride levels.[24]

Sex difference may also influence triglyceride levels via the action of estrogen hormone. Estrogen has role in suppress lipoprotein lipase enzyme activity in plasma and adipose tissue. Estrogen also has an inhibitory effect on fat deposition, especially visceral fat via unclear mechanism.[25] In this study, there were more women in WC group which might correlated with lower triglyceride levels in WC group.

No subjects has normal waist circumference until the end of study. However, there was a higher decrease in waist circumference in FEO group than WC group which it was significantly different. A decrease in waist circumference might have correlation with weight loss. Analysis in this study showed moderate correlation between body weight and waist circumference in both groups. The correlation of body weight changes with waist circumference after 1-year follow up was also shown in study by Miyatake et al.[26] A decrease in body weight of 3 kg corresponded to a decrease in waist circumference of 3.45 cm in men and 2.83 cm in women. Other study by Egger et al.[27] showed 0.75 kg weight loss equals as 1 cm reduction of waist circumference.

Weight loss program in this study did not contribute significant effect in triglyceride levels. However, FEO group had better response to the program which the triglyceride levels significantly decreased after 4-week program although no significant difference at the end of study between groups. An animal study of Barbosa-da-Silva et al.[28] demonstrated WC caused dysregulated lipid metabolism which mild reduction of fat mass is not able to recover the high levels of adipokines in serum and adipose tissue.

Weight cycling theoretically may influence blood lipid but in this study, baseline triglyceride levels in FEO group was higher than WC group. It was suggested that subjects in FEO group experienced obesity longer than subjects in WC group. The changes of body composition following the program may promote better response in FEO groups, which triglyceride levels decreased, although the decrease was not significant compared with WC group. It was also shown that the changes of body weight and composition in this study only had weak correlation with triglyceride levels in both groups. Grundy SM et al.[24] demonstrated that intra peritoneal fat correlated with triglyceride levels. Meanwhile, Ribeiro-Filho et al.[29] shown there was a weak correlation between triglyceride levels and waist circumference.

Both markers of metabolic syndrome are well recognized to have correlation with visceral fat. In this study, there was a decrease in visceral fat rating in both groups. At baseline, 18 subjects (52.9%) in WC group had visceral fat rating above normal value and it decreased to only 13 subjects (38.4%) at week 4; and 11 subjects (32.4%) at the end of study. Meanwhile in FEO group, at baseline 27 subjects (69,2%) had visceral fat rating above and it decreased into 20 subjects (52.6%) at week 4; and 19 subjects (50%) at the end of study. It may suggest the decrease may related with a decrease in waist circumference. Statistical analysis showed that visceral fat rating was moderately correlated with waist circumference in FEO group ($r=0.603$, $p<0.001$), while the correlation in WC group was weaker ($r=0.321$, $p<0.001$). There were various results regarding the correlation between visceral fat and waist circumference. Prado et al.[30] showed a moderate correlation between waist circumference and visceral fat measured by ultrasound examination ($r=0.615$, $p<0.001$). In that study, visceral fat thickness also showed the best correlation with metabolic syndrome components. Similar result was also shown in study by Ribeiro-Filho et al.[29] waist circumference was moderate and strong correlated with visceral fat measured by computed tomography (CT) and ultrasound respectively. A marked correlation between visceral fat and triglyceride levels could not be established in the present study.

The current study was the first clinical trial in Indonesia to assess the effect of a weight loss program in WC on changes of body composition and parameters of metabolic syndrome, while the control group was those who never experienced weight cycling (or FEO). There were several limitations including no randomization and blinding but the same intervention was applied to two groups with different characteristics. Also,

the original sample size could not be achieved due to limited time of the study.

CONCLUSION

The weight loss program may contribute to changes in body composition and markers of metabolic syndrome in obese subjects. The response appears to be worse in weight cyclers comparing with FEO. Further studies are required to confirm these findings and the exact mechanisms responsible for these results.

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