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Regular exercise modulates obesity factors and body composition in sturdy men

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The purpose of this study was to find the change and correlation between obesity factors and body composition according to regular exercise. Thirty-six sturdy men at twenty years old in 'K' university students were participated in this study. The subjects were randomly divided into two groups (n=18 in each group): control group and regular exercise group. Exercise program composed of three programs: warm-up (10 min), work-out (30-60 min), cool-down (10 min), and categorized by five days per week for eight weeks. Aerobic exercise using a treadmill at 60% of heart rate reserve was performed, and weight training was composed of nine different exercises for the large muscles. Before the performing regular exercise, there was no significant difference between control and regular exercise groups. In the present results, 8 weeks regular exercise significantly decreased leptin, weight, fat mass, % fat, waist to hip ratio (WHR), and body mass index (BMI) more than compared to before performing regular exercise, whereas significantly enhanced lean mass more than compared to before performing regular exercise. Furthermore, regular exercise group reduced leptin, weight, fat mass, % fat, WHR, and BMI compared to control group in the post test. In the correlation of obesity-related factors and body composition, tumor necrosis factor-α (TNF-α) showed correlation with weight, lean mass, and fat mass after performing regular exercise. Here in this study, we suggest that regular exercise is a valuable tool for the improvement of health in the sturdy men, because regular exercise suppresses body fat and obesity-related factors.

Keywords: Regular exercise, Leptin, Tumor necrosis factor-α, Interleukin-6, Body composition

INTRODUCTION

Obesity is defined as a state of excess accumulation of adipose in adipocyte, as imbalance of adipose synthesis and degradation phenomena in adipose tissue cells (Kim et al., 2002). In the past, adipose tissue has been synthesized and storage by triglyceride for necessary supplies to other tissues and organs function only in a passive energy reservoir (Ko, 2007). However, to maintain the homeostasis of the energy of body that became known as adipose tissue (Houmard et al., 2000). It has been clearly demonstrated that adipose tissue are able to generate and to secrete several inflammation associated with appetite, such as leptin, tumor necrosis factor-α (TNF-α), and interleukin-6 (IL-6) (Ziccardi et al., 2002).

Leptin, anti-obesity hormone to suppress appetite, is affected by the concentration of adipose tissue cells in adipocyte that elevated leptin concentration in sufficient nutrient intake when high levels of leptin signal is suppress appetite, the brain as opposed to judge from the low level of leptin signal is need to provide adipose (Ahima and Flier, 2000). But excessive nutrient intake and physical inactivity, the accumulation of fat due to the continuous increase of leptin resistance, reduce susceptibility to diet control ability to be lost. Thus, the system has already been an accumulation of many fat, despite makes hunger and overeating will eventually lead to obesity (Enriori et al., 2006). However, leptin is directly proportional to the amount of adipose tissue, reduced by reducing body fat with loss weight (Sartorio et al., 2003; Thomson et al., 2009). Kraemer et al. (2002) reported plasma leptin concentrations declined by 53% after loss weight of 10%. Silha et al. (2003) measured leptin concentrations in reducing body 17 men and obese body 34 men. These results showed that leptin concentra-

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tions were 5.9±0.7 ng/mL in thin body and 26.9±3.9 ng/mL in obese body, meaning of results that leptin concentration has been high level by high level of body mass index (BMI) in obese. Moreover, Masuo et al. (2008) investigated leptin concentration in 129 white person to subjects that normal (BMI < 22.0 ± 1.9 kg/m^2) was 4.48 ± 3.01 ng/mL and over weight (BMI > 30.3 ± 3.5 kg/m^2) was 0.45 ± 5.18 ng/mL. These results that both groups according to body fat and BMI levels of leptin concentration changes can be said, that the amount of adipose tissue and leptin levels can be static correlation (Masuo et al., 2008). In other hands, Noland et al. (2001) reported that no change in leptin with fat loss might be due to training-induced increases in intense training. Fisher et al. (2001) administered a standardized meal to subjects and observed increases in leptin during 41 min of cycling at 50% of the cycling intensity of VO_2max. This was followed by a reduction in leptin concentration during recovery that increased to control values after 2 h. Weltman et al. (2000) reported that 30 min of exercise at, above, and below lactate threshold, an index of accelerated metabolism and exercise intensity, did not alter leptin concentration in young males during exercise or recovery compared with control values. But most previous studies of reported that leptin concentration closely related to body fat that insulin and growth hormone as well as obesity-related inflammatory factors have profound implications (Beck and Offenbacher, 2006; Kapoor et al., 2007) .

In particular, the adipose tissue was promoting the production of pro-inflammatory cytokines related to obesity such as TNF-α and IL-6 that obesity-related inflammatory factors causes anorexia and to regulate the metabolism of fat cells, leptin a function may play an important role (Marfella et al., 2004).

Thus, the presence of significant correlations in leptin, obesity-related inflammatory factors and body fat mass that leptin, and obesity-related inflammatory factors may reduce due to appetite control and weight loss after exercise. However, most previous studies of reported that the correlation between fat and obesity-related factors in the obese group. The backgrounds deficiency and necessary that direct effect of regular exercise relationship between fat and obesity-related factors in sturdy body man rather than being overweight or obese body. Therefore, the purpose of the present study was to find the change and correlation between related obesity factors and body composition according to regular exercise in sturdy body man.

MATERIALS AND METHODS

Subjects and experimental design

Subjects were recruited thirty-six sturdy men at twenty years old in 'K' university students. The consent form for participation was signed and obtained from all participation. They were random divided into two groups, which was regular exercise group (REG, n = 18) and control group (CON, n = 18). The subjects' characteristics before the study are presented in Table 1. By independent t-test, there was no significant difference among the subjects in age, height, weight, % fat and BMI.

Measurement of related obesity factors

Blood sample was obtained from all subjects at 8:00 am after an overnight fast before and after performing regular exercise, which was approximately 10 cc of blood in the forearm veins by clinical pathologist. Leptin was assayed by means of a ^{125}I RIA kit for human leptin (Linco Research Co., St. Charles, USA), TNF-α, and IL-6 was assayed by quantitative sandwich enzyme immunoassay technique.

Measurement of body composition

Body composition was estimated using the data obtained by way of bioeletrical impedance analysis (BIA; In-body 520, Seoul, Korea), which could measure height, weight, lean mass, body fat mass, % fat, waist to hip ratio (WHR) and BMI (Thomson et al., 2009).

Exercise program

Exercise program consisted of warm-up (10 min), work-out (30-60 min), and cool-down (10 min) and the exercise group performed it for 8 weeks. In the work-out, aerobic exercise (6 days/week; Mon-Sat) using a treadmill at 60% of heart rate reserve (HRR) was performed for 30 min and heart rates of exercise were continuously monitored using Polar® heart rate monitors. And then resistance exercise (3 days/week; Mon, Wed, Fri) was composed of nine different exercises for the large muscle in following order: leg press, chest press, lateral pull down, leg extension, leg

Table 1. Physical characteristic of subjects

Groups	Age (yr)	Height (cm)	Weight (kg)	% fat	BMI (kg/m^2)
REG (n = 18)	23.83 ± 1.62	174.67 ± 6.51	76.87 ± 8.00	17.97 ± 3.79	25.25 ± 1.79
CON (n = 18)	23.61 ± 2.03	173.11 ± 4.87	71.95 ± 9.79	20.64 ± 6.79	24.08 ± 3.16

All values are expressed as mean ± standard deviation (SD).
REG, regular exercise group; CON, control group.

Table 2. Exercise program

Items	Exercise	Intensity	Duration
Warm-up	Slow walking/Stretching	Mild discomfort	10 min
Work-out	Walking (Treadmill)	HRR 60%	30 min
	Resistance (arm, trunk, leg)	1-2 wk: 1RM 50%	15 reps/4sets
		3-4 wk: 1RM 60%	12 reps/4sets
		5-6 wk: 1RM 70%	10 reps/4sets
		7-8 wk: 1RM 80%	8 reps/4sets
Cool-down	Stretching	Mild discomfort	10 min

curl, abdomen curl, back extension, biceps curl and triceps curl. Exercise program was according to the principle recommended by ACSM manual (2003; 2006).

The subjects were instructed to follow a normal lifestyle maintaining daily habits and to refrain from alcohol and caffeine. The detail exercise programs are presented in Table 2.

Statistical analysis

Statistical analysis was performed by using the SPSS (ver. 18.0; IBM Co., Armonk, NY, USA). All date were expressed as means ± standard deviation (SD). Initially, the independent t-test was used to determine the significance among subgroups. Two-way ANOVA (2×2) with repeated measures on groups (2 levels) and time (2 levels) were used to determine the significance between subgroups. The correlation coefficient was determined and tested for significance using Pearson's regression (r). When interaction have appeared between subgroups that were used independent t-test and pair t-test. Delta differences (Δ%) between different time points of each group were calculated using the following formula: Δ% = (post-pre)/pre×100. The significance levels of $P<0.05$ were accepted for all comparisons.

RESULTS

Change of obesity-related factors

The difference and change of obesity-related factors after eight weeks in this study are presented in Table 3. *Plasma leptin:* After eight weeks, obesity-related factors was significantly decreased exercise group (from 3.41±1.80 to 2.09±1.08 ng/mL; -38.71%) and control group (from 3.04±1.15 to 2.31±1.33 ng/mL; -24.02%). On this, leptin was significantly difference between times ($P<0.001$), and interactions ($P<0.05$). Independent t-test was no significant and pair t-test was significant difference in both groups ($P<0.001$).

TNF-α: After eight weeks, obesity-related factors was decreased exercise group (from 1.74±0.86 to 1.52±0.68 pg/mL; -12.64%) but, increased control group (from 1.50±0.64 to 1.70±0.68 pg/mL; -13.33%). Here, TNF-α was no significantly difference.

IL-6: After eight weeks, obesity-related factors was decreased exercise group (from 1.32±1.80 to 1.11±0.29 pg/mL; -15.91%) and control group (from 1.05±0.71 to 1.00±0.59 pg/mL; -4.76%). In other words, IL-6 was no significantly difference.

Change of body composition

The difference and change of body composition after eight weeks in this study are presented in Table 3. *Body weight:* After eight weeks, significantly decreased exercise group (from 76.87±8.00 to 74.99±6.92 kg; -2.45%) but, increased control group (from 71.95±9.79 to 72.12±9.23 kg; 0.24%). Namely, weight was significantly difference between times ($P<0.01$), and interactions ($P<0.001$). Independent t-test was no significant and pair t-test was significant difference in REG ($P<0.01$).

Lean body mass: After eight weeks, significantly increased exercise group (from 54.99±10.4 to 55.97±10.92 kg; 1.78%) but, decreased control group (from 49.79±8.41 to 49.29±7.98 kg; -1.00%). Lean mass was significantly difference at interactions ($P<0.01$). Independent t-test was significant difference in post exercise ($P<0.05$) and pair t-test was significant difference in REG ($P<0.01$).

Body fat mass: After eight weeks, significantly decreased exercise group (from 13.82±3.18 to 12.26±2.90 kg; -11.29%) but, increased control group (from 15.31±7.04 to 15.79±7.26 kg; 3.14%). Namely fat mass was significantly difference between times ($P<0.01$), and interactions ($P<0.001$). Independent t-test was no significant and pair t-test was significant difference in REG ($P<0.001$).

% fat: After eight weeks, significantly decreased exercise group (from 17.97±3.79 to 15.97±3.36%; -11.13%) but, increased control group (from 20.64±6.79 to 20.97±7.58%; 1.60%). On this, % fat was significantly difference among groups ($P<0.05$), between times ($P<0.01$), and interactions ($P<0.001$). Independent t-test was significant difference in post exercise ($P<0.05$) and pair t-test was significant difference in REG ($P<0.001$).

Waist to hip ratio (WHR): After eight weeks, significantly decreased in exercise group (from 0.86±0.02 to 0.84±3.360.02%; -2.33%) but, no changed in control group (from 0.86±0.03 to 0.86±0.04%; 0%). In other words, WHR was significantly difference among between times ($P<0.01$), and interactions ($P<0.001$). Independent t-test was significant difference in post exercise ($P<0.05$) and pair t-test was significant difference in REG ($P<0.001$).

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Table 3. Changes of obesity-related factor and body composition after 8 weeks.

Variable	Groups	Pre	Post	Δ%	t-values	F-values in two-way repeated ANOVA		
						Groups	Times	Groups × Times
Leptin (ng/mL)	REG	3.41 ± 1.80	2.09 ± 1.08	-38.71	0.000[f]	0.863	0.000[c]	0.041[a]
	CON	3.04 ± 1.15	2.31 ± 1.33	-24.02	0.000[f]			
	t-values	0.468	0.592					
TNF-α (pg/mL)	REG	1.74 ± 0.86	1.52 ± 0.68	-12.64		0.845	0.964	0.236
	CON	1.50 ± 0.64	1.70 ± 0.68	13.33				
IL-6 (pg/mL)	REG	1.32 ± 1.80	1.11 ± 0.98	-15.91		0.581	0.423	0.632
	CON	1.05 ± 0.71	1.00 ± 0.59	-4.76				
Weight (kg)	REG	76.87 ± 8.00	74.99 ± 6.92	-2.45	0.002[e]	0.179	0.006[b]	0.001[c]
	CON	71.95 ± 9.79	72.12 ± 9.23	0.24	0.526			
	t-values	0.108	0.298					
Lean mass (kg)	REG	54.99 ± 10.46	55.97 ± 10.92	1.78	0.009[e]	0.069	0.363	0.007[b]
	CON	49.79 ± 8.41	49.29 ± 7.98	-1.00	0.209			
	t-values	0.110	0.044[g]					
fat mass (kg)	REG	13.82 ± 3.18	12.26 ± 2.90	-11.29	0.000[f]	0.177	0.010[b]	0.000[c]
	CON	15.31 ± 7.04	15.79 ± 7.26	3.14	0.082			
	t-values	0.421	0.063					
% fat (%)	REG	17.97 ± 3.79	15.97 ± 3.36	-11.13	0.000[f]	0.049[a]	0.002[b]	0.000[c]
	CON	20.64 ± 6.79	20.97 ± 7.58	1.60	0.413			
	t-values	0.154	0.015[g]					
WHR (%)	REG	0.86 ± 0.02	0.84 ± 0.02	-2.33	0.000[f]	1.763	13.307[b]	14.871[c]
	CON	0.86 ± 0.03	0.86 ± 0.04	0.00	0.871			
	t-values	0.806	0.037[g]					
BMI (kg/m^2)	REG	25.25 ± 1.79	24.63 ± 1.24	-2.46	0.000[f]	0.306	0.006[b]	0.001[c]
	CON	24.08 ± 3.16	24.14 ± 2.97	0.25	0.525			
	t-values	0.179	0.518					

All values are expressed as mean ± SD. [a), b), c)]Represent the significant effect in two-way repeated ANOVA P< 0.05, 0.01, and 0.001. [e), f)]Represent the significant effect in paired t-test P< 0.05, 0.01, and 0.001. [g)]Represents the significant effect in independent t-test P< 0.05.
No marking is not significant. REG, regular exercise group; CON, control group; WHR, waist to hip ratio; BMI, body mass index.

Body mass index (BMI): After eight weeks, significantly decreased in exercise group (from 25.25 ± 1.79 to 24.63 ± 1.24 kg/m^2; -2.46%) but, increased in control group (from 24.08 ± 3.16 to 24.14 ± 2.97 kg/m^2; 0.25%). Namely, BMI was significantly difference between times (P < 0.01), and interactions (P < 0.001). Independent t-test was no significant and pair t-test was significant difference in REG (P < 0.001).

Correlation of related obesity factors and body composition

The correlation of obesity-related factors and body composition after eight weeks on regular exercise in this study are presented in Table 4. Eight weeks on regular exercise, TNF-α in obesity-related factors was positively correlated with weight (r = 0.392, P < 0.05), lean mass (r = 0.359, P < 0.05), and fat mass (r = 0.355, P < 0.05).

DISCUSSION

The purpose of this study was to find the change and correlation between related obesity factors and body composition according to regular exercise in 36 sturdy body men. Regular exercise can improve blood lipids and body composition, reduces the risk of chronic diseases such as coronary artery disease, moreover it improve the quality of life (Thompson et al., 2003). However, physical inactivity and excess nutrition increased the amount of adipose tissue, which eventually leads to being overweight or obese, adipose tissue caused of synthesis and secretion of obesity-related factors such as leptin, TNF-α, and IL-6 (Fruhbeck et al., 2001). Leptin serum level correlates with fat stores and reacts according to changes in energy balance (Zurowski et al., 2001).

Obesity-related inflammation such as TNF-α and IL-6 is secreted from serum total cholesterol of adipose tissue and control

Table 4. Correlation of obesity-related factors and body composition after 8 weeks on regular exercise

Variable		Weight (kg)	Lean mass (kg)	Fat mass (kg)	% fat	WHR (%)	BMI (kg/m^2)
Pre exercise	Leptin (ng/mL)	0.312	0.208	0.051	-0.058	-0.050	0.310
	TNF-α (pg/mL)	-0.206	0.329	-0.148	-0.109	-0.169	-0.166
	IL-6 (pg/mL)	-0.042	0.039	-0.147	-0.161	-0.113	0.018
Post exercise	Leptin (ng/mL)	0.327	0.218	-0.014	-0.132	-0.202	-0.306
	TNF-α (pg/mL)	0.392[a]	0.359[a]	0.355[a]	0.221	0.312	0.327
	IL-6 (pg/mL)	0.075	0.099	-0.112	-0.152	-0.158	-0.019

[a]Represent the significant effect in two-way repeated ANOVA $P<0.05$, 0.01, and 0.001.
No marking is not significant. WHR, waist to hip ratio; BMI, body mass index.

the metabolism of fat, positive relationship BMI and body fat (Streetz et al., 2001). Moreover, these obesity-related factors were higher in subcutaneous fat tissue and visceral fat tissue of obese than lean people (Dusserre et al., 2000). But most many previous studies reported that leptin, TNF-α and IL-6 decreased according to fat loss due to regular exercise in obesity body (Canavan et al., 2005; George, 2003). Gmez-Merino et al. (2002) compared regular exercise group and non exercise group that obese subject, which induced an energy deficiency, reduced serum leptin to exercise group. The authors concluded that loss of body fat to the effect of exercise might increase in reduction of the leptin hormone in regular exercise, according to verified improvements. Halle et al. (1999) studied obese males and reported that 1 month of cycling exercise in reduced body weight and leptin concentration. Monzillo et al. (2003) reported that weight reduction in obese individuals on moderate physical activity was associated with a significant decrease in leptin, TNF-α and IL-6.

These studies suggest an important link between obesity-related inflammation (leptin, TNF-α, IL-6) and regular exercise in overweight or obese. However, a little study have subject in sturdy body men. Therefore, the aim of our study was to find the change between obesity-related inflammation and body composition according to regular exercise in sturdy body men, which not being overweight or obese body.

The present study showed that an 8-week regular exercise significantly decreased leptin level in the both control and regular exercise groups, and it reduced in regular exercise group than that of control group. Our findings supports previous studies, Nindl et al. (2002) studied the effects of aerobic training and resistance on leptin in healthy men. The result, between the control and exercise groups were significantly difference and both groups decreased. Moreover, Elias et al. (2000) compared a treadmill exercise to a control that reported a decline in leptin concentrations in healthy males after treadmill exercise. The authors suggested that the decline may be associated with elevated production of non-esterfied fatty acids.

In addition, although no significant, an 8-week regular exercise reduced TNF-α and IL-6 levels compared to before the regular exercise, and in compared to control and exercise groups, an 8-week regular exercise suppressed TNF-α and IL-6 levels than those of control group. These results indicated that regular exercise changed a decrease obesity related hormone of leptin level, and reduced the inflammatory-related factors of TNF-α and IL-6. In generally, leptin and IL-6, due to excessive fat accumulation, is keeps going maintain or increased of adipose tissue to problem sensitivity and resistance of leptin in obese body. But, we thought that the subject of this study, because of sturdy body men were sensitivity and resistance to normal function as appears normal function of appetite suppressant, leptin and IL-6 was decreased in both sturdy body men. Also, we would suggest that effect was reduced as with other previous studies in circadian rhythm, as well as body fat and blood concentration in both groups.

In this study, after eight weeks, weight, fat mass, % fat, WHR as well as BMI was significantly decrease exercise group but increased control group. On the other hand, lean mass was significantly increased exercise group but, decreased control group. Additional date derived from correlation of obesity-related factors and body composition was appear that TNF-α, obesity-related factors, was positively correlated with weight, lean mass, and fat mass in regular exercise. Nicklas et al. (2005) reported that TNF-α release was appeared the higher to affect of adipose mass and elevated in people with a higher fat mass. Kerm et al. (1995) reported that TNF-α has multiple actions in adipose tissue, which include a decrease in weight loss and an increase in lean mass.

The results of this study are appeared by these subjects and the short period of time. Further studies will be needed a statistical analysis method through increased number of subjects, a variety of exercise intensity and duration of exercise, as well as 24 h cycle changes and the physiological mechanisms of blood concentration.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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