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Body Composition

COMPARISON OF A COMMERCIAL WEIGHT LOSS PROGRAM TO A FITNESS CENTER

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ABSTRACT

Ball SD, Bolhofner AT. Comparison of a commercial weight loss program to a fitness center. ***JEP**online* 2008;11(3):1-12. It is not known if commercial weight loss programs are as effective at lowering body weight, altering body fatness and improving the lipoprotein profile as compared to joining a fitness center. PURPOSE: To compare the effectiveness of a commercial weight loss program (Weight Watchers) (WW) to joining a fitness center (FC) for weight loss and body composition. A secondary purpose was to investigate changes in blood chemistry. METHODS**:** Forty-three overweight (BMI = 25) and sedentary women received a 12 week membership to either WW (n=24) or a local fitness center (FC) (n=19). Subjects in WW were instructed to follow the recommendations of the program, which included weekly weigh-ins, counseling sessions, and a point counting system to monitor calories. Subjects assigned to FC were instructed to follow the American College of Sports Medicine guidelines for weight loss. Outcomes included body weight (BW), body fat percentage (%BF) measured via the BOD POD, intraabdominal fat (IAF) and subcutaneous abdominal fat (SAF) measured via computed tomography, total cholesterol (TC), HDL-C with subfractions, and triglycerides. RESULTS**:** BW decreased significantly for WW ($P < 0.001$) but not for FC ($P = 0.055$). %BF did not change significantly for either group. Both groups lost a significant amount of IAF. SAF decreased significantly for WW but not for FC. No changes were observed in the lipoprotein profile. CONCLUSION**:** Although WW subjects lost some body weight and improved abdominal fatness, %BF was not decreased. Overweight women joining a fitness center for the purpose of weight loss or body fat change will likely fail. Neither program was able to alter the lipoprotein profile. Health professionals should consider these results when recommending weight loss programs.

Key Words: Body Composition, Body Fat, Lipoprotein Profile, Exercise.

INTRODUCTION

Obesity has increased dramatically in almost every state, race, age group, and sex over the past twenty years. Close to 65% of the American population is either overweight or obese which is defined as having a BMI of $\geq$ 25 kg/m^2 [1, 2]. Obesity is associated with a number of adverse health consequences. Higher body weight can have a marked increase in morbidity from hypertension, type 2 diabetes, coronary heart disease, stroke, gallbladder disease, osteoarthritis, certain types of cancers, psychological disorders, as well as increase in all cause mortality [3].

The recommendation to treat overweight and obesity is based not only on evidence that relates obesity to increased mortality but also that weight loss reduces risk factors for disease [4]. Weight loss, whether by caloric restriction, exercise, or a combination of both caloric restriction and exercise, has been shown to have various positive effects on the human body: improvement on body composition, abdominal adiposity [5-8], the lipoprotein profile [9], and other metabolic variables resulting in improved health.

Particularly of interest is abdominal adiposity. Subcutaneous abdominal or visceral adiposity has been linked to the lipoprotein profile [10], postprandial lipemia (PPL) [11], insulin sensitivity [12], elevated C-reactive protein [13], and to multiple parameters of the metabolic syndrome [14]. When abdominal adipose tissue, especially visceral, is reduced by diet and/or exercise, the lipoprotein profile is improved [15-18], thus providing support for a link between abdominal adiposity and the lipoprotein profile. Since a poor lipoprotein profile and abdominal obesity are metabolic risk factors and are associated with CHD and diabetes, it is important to study various treatments for decreasing abdominal fat and improving the lipoprotein profile.

It is clear that exercise carries additional metabolic health benefits whether accompanied by weight loss or not [14]. It is also clear that weight loss via diet or exercise can positively influence the lipoprotein profile [7] . Nevertheless, little data is available on the efficacy of commercial weight loss programs such as Weight Watchers (WW) for weight loss, body composition change, and lipoprotein profile improvements. WW is a relatively well-known program that uses a point counting system to monitor caloric intake. Participants have weekly weigh-ins and meetings. Despite being the largest provider of commercial weight loss services in the US [19], very little independent research has investigated the efficacy of this commercial program for weight loss or for improving metabolic markers. Although studies involving WW are available [20-25], a closer look at these studies indicates they were either conducted or funded by WW. More importantly, only one currently published WW study [26] has included a measure of body composition (fat mass vs. fat free mass), a critical omission when evaluating the effectiveness of a weight loss program. Individuals may lose weight, but if that weight is in the form of lean tissue, metabolism decreases [27]. In addition, the published WW studies have no measure of abdominal visceral fat. Research has consistently shown abdominal visceral fat is a much better predictor of cardiovascular disease and other metabolic problems than is total body weight or total body fat percentage [28]. Currently, it is not known if WW participants are losing any significant amounts of abdominal visceral fat.

Most experts agree a combination of exercise and diet therapy is the most effective way to significantly alter body weight, body composition, including abdominal fat, and metabolic variables. For example, the American College of Sports Medicine, a leading agency in the field of exercise science, prescribes moderate caloric restriction in combination with moderate intensity aerobic exercise and resistance training. Although exercise prescription must always be altered to fit the individual, this general formula is widely accepted as a recommended means to alter body weight and body composition. It is not known if WW is as effective at lowering body weight, altering body fatness (especially abdominal fat) and improving the lipoprotein profile as compared to the recommended formula so often used by fitness professionals and fitness centers.

The purpose of the current study is to compare the effectiveness of WW to joining a fitness center (FC) for weight loss and body composition changes after 12 weeks. A secondary purpose is to investigate changes in blood chemistry after 12 weeks. In addition to being the first study comparing WW to FC, this research is unique because it will include valid and reliable measures of body composition and abdominal subcutaneous and visceral fat, key variables missing in the majority of existing studies.

METHODS

Subjects

Fifty-eight overweight and obese adult women completed an informed written consent to participate in accordance with the University IRB guidelines. Forty-three subjects completed the study. To be included in the study, participants had to be overweight (BMI =25.0) and sedentary - defined by participation in less than a total of 60 minutes per week of systematic exercise. Participants also had to be weight stable which was defined as maintenance of body weight within $\leq$ 7% above or below the current body weight for the previous 3 months. Participants were randomly placed into one of two groups: (1) Weight Watchers (WW) or (2) Fitness Center (FC). While a true control group would prove beneficial, there are several reasons it was not essential for this study. First, prior research on weight loss has demonstrated that subjects in a control group will either maintain or gain weight [29]. Second, the FC group was essentially serving as a comparison group to which WW could be compared. Finally, other well respected weight loss researchers have used a similar approach [30].

Procedures

Data was collected for body weight, body composition, abdominal subcutaneous fat, visceral fat, and lipids pre and post 12 weeks. Body weight and body composition were measured additionally at 6 weeks. Dietary and exercise logs were used to help determine compliance.

Participants in WW received a 12 week membership to the Weight Watchers Program. Participants were to follow the dietary and exercise recommendations of the program, which generally included weekly weigh-ins and counseling sessions. A point counting system monitored caloric intake. Participants were required to attend 10 of the 12 weigh-in/counseling sessions.

Participants in the FC group were given a membership to Gold's Gym and followed Gold's "Quick Start" exercise program. Certified trainers outlined the exercise plan and taught the participants how to properly exercise. Specifically, exercise followed the general recommendations of the ACSM guidelines for weight loss [31] and included both aerobic and anaerobic exercise Anaerobic exercise consisted of resistance training using a combination of free weights and pin loaded machines. Participants were required to exercise a minimum of three days per week but encouraged to include additional aerobic exercise daily. The trainer offered only basic nutritional advice. No specific diet (i.e., low carbohydrate, high carbohydrate, high protein, etc.) was to be recommended or encouraged. The number of exercise sessions and types of exercise per session were recorded on the training logs throughout the 12 week program.

Body composition assessed by the BOD POD required the participant to sit quietly in an "egg-shaped" chamber for a 60-second period while their body volume was measured by air displacement. This procedure was repeated two to three times. Thoracic gas volume was measured using a "panting" maneuver mid exhalation. A Computed Tomography (CT) scan was conducted on a

Siemens Somatom Volume Zoom (Forchheim, Germany) and was used for determinations of visceral and subcutaneous adipose tissue modified as described [4].

Blood collections were taken following a 12 hour fast. A lipoprotein profile was determined which included: total cholesterol (TC), HDL cholesterol (HDL-C) and subfractions, and triglycerides (TG) Blood samples were collected via a butterfly needle inserted into an antecubital vein. All blood samples were non-heparinized and collected into 10 ml tubes containing EDTA (anticoagulant and chelating agent). Fasting cholesterol and triglycerides were analyzed in plasma using colorimetric diagnostic kits (Thermo, Arlington, TX). Plasma HDL-C and subfractions were determined using a modified heparin-$MnCl_2$-dextran sulfate method as previously described by our group [32]. HDL_2-C was calculated by subtracting the value for HDL_3-C from the HDL-C value. The intra-assay CVs are 1.0% and 2.0% for HDL-C and HDL_3-C, respectively.

All subjects submitted a 3-day written diet log for two week days and one weekend day which was used to evaluate baseline diet composition. Dietary intake was monitored using written food diaries during the 12 week period. The last three days of the diary were used to evaluate diet composition. Participants were unaware of which days would be selected for analysis. The Food Processor 8.0 computer program analyzed pre- and post-program diets.

Statistical Analyses

Data was analyzed using analyses of variance (ANOVA) using a two-factor ANOVA (group x time) with repeated measures on time (pre vs. post). Significant effects ($p < .05$) from the two-factor ANOVA were followed up with planned comparisons. In addition, the Bonferroni correction was used to prevent artificial inflation of Type I error. Variables that were significantly different between groups at baseline were analyzed using analysis of covariance (ANCOVA).

RESULTS

Subject characteristics are shown in Table 1. Changes in body weight (BW), body mass index (BMI), body fat percentage (BF), fat mass in kg (FM), fat free mass in kg (FFM) are shown in Table 2. At baseline there was a significant difference in BW, BMI, BF, and FM between groups despite random assignment. The WW group lost 5% of their initial BW (4.1 kg) while the FC group lost 2.5% of their initial BW (1.3 kg). ANCOVA revealed this difference was significant between groups (p=0.009). BW and BMI significantly decreased at 6 and 12 weeks for the WW group compared to baseline. No significant changes in BW or BMI were found for the FC group. BF did not significantly change for either group at any time point. FM was significantly lower at week 12 when compared to baseline in the WW group. FFM was significantly lower for both groups at week 12 when compared to baseline.

TABLE 1. Subject Characteristics.

Characteristics	***Baseline Values***
Age	31.7
BodyWeight (kg)	80.2 ± 1.5
Height (cm)	162.9 ± 1.1
BMI	30.2 ± 0.5
Body Fat %	40.4 ± 0.9
SBP (mmHg)	117.7 ± 1.6
DBP (mmHg)	77.8 ± 1.3

Values are means ± SE. N=43.

There was not a significant difference between groups for intra-abdominal fat (IAF) at baseline (Table 3). IAF significantly decreased in both groups at week 12. The amount of difference was not significant between groups (p=0.339). A significant difference was observed at baseline for subcutaneous abdominal fat (SAF) between groups. SAF decreased significantly at week 12 in the WW but not in the FC group.

TABLE 2. Body Composition

Variable	Group	Baseline	Week 6	Week 12
Body Weight (kg)	FC	76.9 ± 2.2	76.2 ± 2.1	75.6 ± 2.1
	WW	$82.7 \pm 1.7^{a*}$	80.0 ± 1.8^{b}	78.6 ± 1.9^{c}
BMI (kg/m^2)	FC	28.6 ± 0.8	28.4 ± 0.8	28.2 ± 0.8
	WW	$31.5 \pm 0.6^{a*}$	30.4 ± 0.6^{b}	29.9 ± 0.7^{c}
Body Fat %	FC	37.6 ± 1.3	38.2 ± 1.4	38.4 ± 1.4
	WW	$42.4 \pm 1.0^{*}$	41.6 ± 1.1	41.3 ± 1.2
Fat Mass (kg)	FC	29.1 ± 1.5	29.3 ± 1.6	29.3 ± ?
	WW	$35.6 \pm 1.5^{a*}$	$34.1 \pm 1.5^{ab*}$	32.9 ± 1.5^{b}
Fat Free Mass (kg)	FC	47.8 ± 1.5^{a}	46.9 ± 1.5^{ab}	46.3 ± 1.4^{b}
	WW	47.2 ± 0.9^{a}	? ? ? ? 0.9^{ab}	45.8 ± 0.9^{b}

Values are means ± SE.
Means with different superscripts are significantly different
*Significantly different than FC.

No significant differences were found between the FC and WW groups at baseline for any dietary variable. The WW group significantly decreased total caloric intake (KCAL), carbohydrate (CHO)(g), protein (PRO)(g), and fat(g) at week 6 and week 12 compared to baseline. No differences were observed between week 6 and week 12 for either group. There were no significant changes in any dietary variable for the FC group. Total cholesterol, HDL_{total}-C, subfractions, and TG results are shown in Table 4. No significant differences were observed for either group for any of these variables. No significant differences were observed between groups at any time point for any of these variables.

DISCUSSION

WW subjects lost body weight and improved abdominal fatness but %BF was not decreased after 12 weeks. FC subjects did not succeed in losing weight or in altering body composition. Neither program was able to alter the lipoprotein profile.

Body Weight

These results support our hypothesis—that WW would lose more BW than FC. ANCOVA revealed that this was a significant difference in the amount of weight lost between groups (p=0.009). The amount of BW loss observed for WW is comparable to previous WW research [23, 26, 33]. Heshka et al. [23] reported that overweight men and women attending WW lost 4.8 ± 5.6 kg at 26 weeks while Dansinger et al. [33] found a loss of 3.0 ± 4.9 kg after 52 weeks. The design of the current study might be viewed as a means of comparing dieting (WW) to exercising (FC) for weight loss and body composition changes. Even though WW promotes exercise, the major component of the program is caloric restriction; and while FC participants were given dietary counseling, the primary component of that program was exercise. Caloric restriction, usually results in more weight loss than exercise alone, especially in short term studies [34]. Despite popular belief, exercise without dietary manipulation, usually results in only modest weight loss even in obese adults [3, 35, 36]. In this regard, current results regarding BW are therefore not surprising. It should be noted that a difference existed at baseline for BW between groups. Despite random assignment, the WW group weighed approximately 5.8 kg more than FC (76.9 ± 2.2 vs 82.7 ± 1.7). This difference is mostly due to the heaviest FC subjects dropping out. It is difficult to surmise how the baseline difference in BW between groups may have affected the results of the study. We recognize this as a study limitation.

TABLE 3. Abdominal Fat

	Group	Baseline	Week 12
Intra-Abdominal Fat	FC	65.2 ± 4.6[a]	58.3 ± 4.3[b]
	WW	79.7 ± 9.1[a]	68.7 ± 7.7[b]
Subcutaneous Fat	FC	360.2 ± 25.1	345.1 ± 24.1
	WW	417.9 ± 23.2[a*]	387.3 ± 18.5[b]

Values are means ± SE.
Means with different superscripts are significantly different.
*Significantly different than FC.

Body Fat Percentage (BF)

Body fat percentage did not significantly change for either group at any time point (Table 2). Only one WW study [26] has included an acceptable lab measure of BF. One additional study by Heshka et al. [23] included bioelectrical impedance analysis (BIA), a field method of body composition assessment, but failed to report findings in %BF change. Although it was hypothesized that WW would lose more weight than FC, we reasoned that FC would have more favorable changes in body composition since exercise has been shown to attenuate the loss of fat free mass (FFM) [37]. Ballor and Poehlman [37] reported that exercise reduces the proportion of FFM lost from 24% to 11% in dieting women. Garrow and Summerbell [36] found similar, but more modest results. Wood et al. [9] compared dieters versus exercisers and found that although both dieters and exercisers lost significant amounts of BW and fat mass (FM), the exercise group maintained FFM while dieters did not. The results demonstrate that although the WW group lost a significant amount of BW by week 12, BF did not improve. WW participants lost 1.4 ± 0.3 kg of FFM or 34% of the total amount of BW lost. Typically for a weight loss of 10 kg achieved by dieting alone, the expected loss is only 2.2 kg of FFM for women or about 22% of total weight lost.

Surprisingly, BF for FC was not decreased by week 12 ($p=0.509$). Typically, structured exercise, despite caloric restriction, results in body composition improvements in overweight subjects [36]. Since caloric intake remained relatively constant (Table 5), the best explanation for the lack of BF change is that the volume of exercise was inadequate to elicit changes. Typically, the higher the volume of exercise the greater change in BW and BF [30, 38]. Even though some FC subjects reported attending all of the required exercise sessions, it is likely they did not follow the program precisely enough. It is likely without direct and continual supervision, some subjects may not have exercised as intensely or for the recommended duration every session. Exercise logs were collected, unfortunately their accuracy is questionable. We recognize this as a study limitation but surmise that the volume of exercise was too low to observe a change in BF. These results imply that overweight women joining a fitness center with the intent of weight loss or BF change will likely fail without additional support such as a personal trainer, workout partner, or life coach. A more structured dietary plan would also be beneficial compared to only crude dietary advice from the personal trainer.

Abdominal Fat

Previous WW research has failed to include any measure of abdominal adiposity other than waist circumference. In this study, both groups lost significant and similar amounts of IAF as measured by CT (FC = 6.8 ± 2.5 cm^2 or 11.6%; WW $=11.0 \pm 3.3$ cm^2 of 13.8%). Dieting alone has been shown to produce greater results in a similar group of women [14]. In the present study the results suggest exercise preferentially reduced IAF in comparison with total fat loss for FC. FC group lost a significant amount of IAF despite not losing a significant amount of BW or total fat. This is consistent with previous research demonstrating the effects of exercise training in the reduction of abdominal adipose tissue, especially intra-abdominal [39]. These results imply that exercise may have a positive influence on the metabolic syndrome despite weight loss or fat loss by reducing IAF.

In support of our hypotheses, IAF and SAF were significantly reduced in the FC group, although significant changes were also found in the WW group. Many studies support the findings of reductions in total abdominal fat and subcutaneous abdominal fat after diet and exercise [40]. When abdominal fat, especially intra-abdominal fat, is reduced by diet and/or exercise, the lipoprotein profile is also improved [15]. We hypothesized that more favorable lipoprotein changes would occur within the FC group rather than WW. Unfortunately, no improvements or significant changes were seen within any lipoprotein variable for either group. Data from the present study contradicts the literature. The lack of change seen in the lipoprotein profile could be due the participants to the already average values at baseline (Table 4).

Total cholesterol, HDL_{total}-C, and HDL subfractions

Surprisingly no significant reduction in TC, HDL-C, or HDL_2-C was observed for either group. It was hypothesized that FC would have favorable changes in the lipoprotein profile. One possible explanation for the current results might be attributable to the exercise threshold. Again we believe FC subjects did not perform enough exercise at a high enough intensity to elicit observable changes in TC, HDL-C, or HDL_2-C. A second explanation might be the lack of weight loss which may be necessary to elicit changes in the lipoprotein profile [41]. In order to help explain these results further, the diet of WW was analyzed. Typically, a low fat diet has been shown to decrease HDL-C [42, 43], as well as HDL_2-C and HDL_3-C [44, 45]. Reductions in HDL-C as a result of a low fat diet can be attenuated by exercise training [46].

TABLE 4. Lipoproteins (mg/dl)

Variable	Group	Baseline	Week 12
Total Cholesterol	FC	220.2 ± 6.5	211.1 ± 7.0
	WW	207.1 ± 5.2	199.7 ± 5.2
HDL_{total}-C	FC	57.5 ± 2.8	56.1 ± 2.6
	WW	52.6 ± 4.9	51.4 ± 1.9
HDL_2-C	FC	35.1 ± 2.8	33.8 ± 2.8
	WW	29.5 ± 1.8	29.3 ± 1.8
HDL_3-C	FC	22.3 ± 1.4	22.2 ± 1.6
	WW	22.0 ± 0.9	22.1 ± 1.1
TG	FC	137.9± 10.6	135.6±11.9
	WW	138.9 ± 6.8	137.7 ± 7.8

Values are means ± SE.
Means with different superscripts are significantly different.

Much research has been done to prove that changes in lipoproteins have occurred during reduced calorie or reduced fat diets without weight loss [44]. Although WW significantly decreased calories and dietary fat, no significant changes in lipoproteins were found in the WW group. A plausible explanation is that although the amount of dietary fat decreased from baseline for WW, these subjects were still consuming fat levels above what is considered low fat. Low fat refers to fat consumption of less than 20% of calories as stated by the US. Dietary Guidelines [47].

Adherence

Fifty percent of people that begin exercise programs end up dropping out within six months [48]. Data also supports that sedentary participants are more likely to adhere to a low intensity or moderate intensity exercise rather than one of high intensity [49]. The FC program included exercise of moderate to vigorous intensity which may have contributed to a high drop out rate. Two times as many subjects (n=10) dropped out from the exercise program compared to WW (n=5). Anecdotally, several FC subjects reported a lack of motivation to stick with the exercise program when BW was not decreasing rapidly. Again, for overweight sedentary women, joining a fitness without additional support will likely result in failure. Although commercial weight loss programs typically also have somewhat high drop out rates [26], the group support associated with WW is no doubt a crucial aspect of the program not found at most fitness centers.

Limitations

There are several study limitations. Although each limitation has been previously acknowledged and discussed they are summarized here for review: (1) There was not a "true" control group; (2) several variables including BW differed at baseline between groups; (3) the short duration of the intervention limits conclusions; and (4) exercise logs were not carefully completed by all subjects. Study limitations should be considered when interpreting and translating the results of research.

CONCLUSIONS

The present study attempted to uncover what transpires in the "real-world" when overweight women attempt to lose weight and improve BF by joining either a fitness center or enrolling in WW. Although WW subjects were able to lose a significant amount of weight and improve abdominal fatness, body composition did not improve after 12 weeks. A loss of FFM might be detrimental to long term weight loss maintenance. Furthermore, the results imply that overweight women joining a fitness center with the intent of weight loss or BF change will likely fail without altering diet. Additional support such as a personal trainer, workout partner, or life coach might also be beneficial. Neither program was successful at significantly altering the lipoprotein profile. The short duration of this study provides a picture of initial changes in body mass, body composition and blood lipids. A study of longer duration is needed. Health professionals should consider these results when recommending weight loss programs.

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REFERENCES

1. Stein C and Colditz G. The epidemic of obesity. ***J Clin Endocrinol Metab*** 2004; 89(6): p2522-2525.
2. Ogden C, Carroll M, Curtin L, McDowell M, Tabak C and Flegal K. Prevalence of overweight and obesity in the United States, 1999-2004. ***Jama*, **2006; 295(13):1549-1555.
3. National Heart, L., and Blood Institute. *Guideline on Overweight and Obesity*. [Electronic textbook] [cited; Available from: www.nhlbi.nih.gov/guidelines/obesity/e_txtbk.
4. Kelley D, Thaete F, Troost F, Huwe T and Goodpaster B. Subdivisions of subcutaneous abdominal adipose tissue and insulin resistance. ***Am J Physiol Endocrinol Metab*** 2000; 278(5): pE941-948.
5. Hainer V, Kunesova M, Stich V, Parizkova J, Zak A, Stukavec V and Hrabak P. Body-fat distribution and serum lipids during the long-term follow-up of obese patients treated initially with a very-low-calorie diet. ***Am J Clin Nutr*** 1992; 56(1 Suppl): 283S-285S.
6. Ross R, DagnonD, Jones P, Smith H, Paddags A, Hudson R and Janssen I. Reduction in obesity and related comorbid conditions after diet-induced weight loss or exercise-induced weight loss in men. A randomized, controlled trial. ***Ann Intern Med*** 2000;133(2):92-103.
7. Williams P, Krauss R, Vranizan K and Wood P. Changes in lipoprotein subfractions during diet-induced and exercise-induced weight loss in moderately overweight men. ***Circulation*** 1990; 81(4):1293-1304.
8. Wirth A and Steinmetz B. Gender differences in changes in subcutaneous and intra-abdominal fat during weight reduction: an ultrasound study. ***Obes Res*** 1998; 6(6):393-399.
9. Wood P, Stefanick M, Dreon D, Frey-Hewitt B, Garay S, Williams P, Superko H, Fortmann S, Albers J, Vranizan K and et al. Changes in plasma lipids and lipoproteins in overweight men during weight loss through dieting as compared with exercise. ***N Engl J Med*** 1988; 319(18): 1173-1179.
10. McCrory M, Gomez T, Bernauer E and Mole P. Evaluation of a new air displacement plethysmograph for measuring human body composition. ***Med Sci Sports Exerc*** 1995; 27(12): p1686-1691.

11. Couillard C, Bergeron N, Pascot A, Almeras N, Bergeron J, Tremblay A, Prud'homme Dand Despres J. Evidence for impaired lipolysis in abdominally obese men: postprandial study of apolipoprotein B-48- and B-100-containing lipoproteins. ***Am J Clin Nutr*** 2002; 76(2):311-318.
12. Duncan G, Perri M, Theriaque D, Hutson A, Eckel R and Stacpoole P. Exercise training, without weight loss, increases insulin sensitivity and postheparin plasma lipase activity in previously sedentary adults. ***Diabetes Care*** 2003; 26(3): 557-562.
13. Lemieux I, Pascot A, Prud'homme D, Almeras N, Bogaty P, Nadeau A, Bergeron J and Despres J. Elevated C-reactive protein: another component of the atherothrombotic profile of abdominal obesity. ***Arterioscler Thromb Vasc Biol*** 2001; 21(6): 961-967.
14. Janssen I, Fortier A, Hudson R and Ross R. Effects of an energy-restrictive diet with or without exercise on abdominal fat, intermuscular fat, and metabolic risk factors in obese women. ***Diabetes Care*** 2002; 25(3):431-438.
15. Despres J, Pouliot M, Moorjani S, Nadeau A, Tremblay A, Lupien P, Theriault G and Bouchard C. Loss of abdominal fat and metabolic response to exercise training in obese women. ***Am J Physiol*** 1991; 261(2 Pt 1):E159-167.
16. Purnell J, Kahn S, Albers J, Nevin D, Brunzell J and Schwartz R. Effect of weight loss with reduction of intra-abdominal fat on lipid metabolism in older men. ***J Clin Endocrinol Metab*** 2000; 85(3): 977-982.
17. Thomas E, Brynes J, et al. Preferential loss of visceral fat following aerobic exercise, measured by magnetic resonance imaging. ***Lipids*** 2000; 35(7): 769-776.
18. Ohkawara K, Tanaka S, Miyachi M, Ishikawa-Takata K and Tabata I. A dose-response relation between aerobic exercise and visceral fat reduction: systematic review of clinical trials. ***Int J Obes (Lond)*** 2007; 31(12):1786-1797.
19. *The US Weight Loss and Diet Control Market.*, Tampa, Fla: Marketdata Enterprises Inc, 2001.
20. McGuire M, Wing R, Klem M, and Hill J. The behavioral characteristics of individuals who lose weight unintentionally. ***Obes Res*** 1999; 7(5):485-490.
21. Klem M, Wing R, McGuire M, Seagle H and Hill J. A descriptive study of individuals successful at long-term maintenance of substantial weight loss. ***Am J Clin Nutr*** 1997; 66(2): 239-246.
22. Rippe J, Price J, Hess S, Kline G, DeMers K, Damitz S, Kreidieh I, and Freedson P. Improved psychological well-being, quality of life, and health practices in moderately overweight women participating in a 12-week structured weight loss program. ***Obes Res*** 1998; 6(3): 208-218.
23. Heshka S, Anderson J, Atkinson R, Greenway F, Hill J, Phinney S, Kolotkin S, Miller-Kovach K, and Pi-Sunyer F. Weight loss with self-help compared with a structured commercial program: a randomized trial. ***Jama*** 2003; 289(14):1792-1798.
24. Lowe M, Miller-Kovach K, and Phelan S.Weight-loss maintenance in overweight individuals one to five years following successful completion of a commercial weight loss program. ***Int J Obes Relat Metab Disord*** 2001; 25(3):325-331.
25. Miller-Kovach K, Hermann M and Winick M. The psychological ramifications of weight management. ***J Womens Health Gend Based Med*** 1999; 8(4): 477-482.
26. Truby H, Baic S, deLooy A, Fox K, Livingstone M, Logan C, Macdonald I, Morgan L, Taylor M, and Millward D. Randomised controlled trial of four commercial weight loss programmes in the UK: initial findings from the BBC "diet trials". ***Bmj*** 2006; 332(7553):1309-1314.
27. Leibel R, Rosenbaum M and Hirsch J. Changes in energy expenditure resulting from altered body weight. ***N Engl J Med*** 1995; 332(10): 621-628.
28. Donahue R and Abbott R. Central obesity and coronary heart disease in men. ***Lancet,*** 1987; 2(8569):1215.
29. Evans E, Saunders M, Spano M, Arngrimsson S, Lewis R and Cureton K. Body-composition changes with diet and exercise in obese women: a comparison of estimates from clinical methods and a 4-component model. ***Am J Clin Nutr*** 1999; 70(1): 5-12.

30. Jakicic J, Marcus B, Gallagher K, Napolitano M and Lang W. Effect of exercise duration and intensity on weight loss in overweight, sedentary women: a randomized trial. ***Jama*** 2003; 290(10):1323-1330.
31. *ACSM's Guidelines for Exercise Testing and Prescription*. 7th ed. 2005, Baltimore, Maryland: Lippincott Williams & Wilkins.
32. Zhang J, Thomas T, and Ball S. Effect of exercise timing on postprandial lipemia and HDL cholesterol subfractions. ***J Appl Physiol*** 1998; 85(4):1516-1522.
33. Dansinger M, Gleason J, Griffith J, Selker H and Schaefer E. Comparison of the Atkins, Ornish, Weight Watchers, and Zone diets for weight loss and heart disease risk reduction: a randomized trial. ***Jama*** 2005; 293(1): 43-53.
34. Ross R, Freeman J and Janssen I. Exercise alone is an effective strategy for reducing obesity and related comorbidities. ***Exerc Sport Sci Rev*** 2000; 28(4):165-170.
35. Miller W, Koceja D and Hamilton E. A meta-analysis of the past 25 years of weight loss research using diet, exercise or diet plus exercise intervention. ***Int J Obes Relat Metab Disord*** 1997; 21(10):941-947.
36. Garrow J and Summerbell C. Meta-analysis: effect of exercise, with or without dieting, on the body composition of overweight subjects. ***Eur J Clin Nutr*** 1995; 49(1):1-10.
37. Ballor D and Poehlman E. Exercise-training enhances fat-free mass preservation during diet-induced weight loss: a meta-analytical finding. ***Int J Obes Relat Metab Disord*** 1994; 18(1): 35-40.
38. Ross R and Janssen I. Physical activity, total and regional obesity: dose-response considerations. ***Med Sci Sports Exerc***, 2001. 33(6 Suppl): p. S521-7; discussion S528-529.
39. Mayo M, Grantham J, and Balasekaran G. Exercise-induced weight loss preferentially reduces abdominal fat. ***Med Sci Sports Exerc*** 2003; 35(2):207-213.
40. Janssen I and Ross R. Effects of sex on the change in visceral, subcutaneous adipose tissue and skeletal muscle in response to weight loss. ***Int J Obes Relat Metab Disord*** 1999; 23(10):1035-1046.
41. Katzel L., Krauss R and Goldberg A. Relations of plasma TG and HDL-C concentrations to body composition and plasma insulin levels are altered in men with small LDL particles. ***Arterioscler Thromb*** 1994; 14(7):1121-1128.
42. Nicklas B, Ferrell R, Bunyard L, Berman D, Dennis K and Goldberg A. Effects of apolipoprotein E genotype on dietary-induced changes in high-density lipoprotein cholesterol in obese postmenopausal women. ***Metabolism*** 2002; 51(7): 853-858.
43. Rock C, Flatt S, Thomson C, Stefanick M, Newman V, et al. Plasma triacylglycerol and HDL cholesterol concentrations confirm self-reported changes in carbohydrate and fat intakes in women in a diet intervention trial. ***J Nutr*** 2004; 134(2): 342-347.
44. Asztalos B, Lefevre M, Wong L, Foster T, Tulley R, Windhauser M, Zhang W, and Roheim P. Differential response to low-fat diet between low and normal HDL-cholesterol subjects. ***J Lipid Res*** 2000; 41(3): 321-328.
45. Berglund L, Oliver E, Fontanez N, Holleran S, Matthews M, Roheim K. Ginsberg R. Ramakrishnan, and Lefevre M. HDL-subpopulation patterns in response to reductions in dietary total and saturated fat intakes in healthy subjects. ***Am J Clin Nutr*** 1999;70(6):992-1000.
46. Volek J, Gomez A, Love D, Weyers A, Hesslink R, Wise J and Kraemer W. Effects of an 8-week weight-loss program on cardiovascular disease risk factors and regional body composition. ***Eur J Clin Nutr*** 2002;56(7):585-592.
47. Department of Health and Human Services (HHS) and the Department of Agriculture (USDA). *Dietary Guidelines for Americans* 2005. [Online]. http://www.health.gov/DietaryGuidelines/dga2005/document/default.htm

48. Sallis J, Hovell M and Hofstetter C. Predictors of adoption and maintenance of vigorous physical activity in men and women. ***Prev Med*** 1992; 21(2):237-251.
49. Dishman R and J Buckworth. Increasing physical activity: a quantitative synthesis. ***Med Sci Sports Exerc*** 1996; 28(6):706-719.