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The effects of a diet-exercise program on blood lipids, blood pressure, and diabetes indices in relation to body fat and body fat distribution

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THE EFFECTS OF A DIET-EXERCISE PROGRAM ON BLOOD LIPIDS, BLOOD PRESSURE, AND DIABETES INDICES IN RELATION TO BODY FAT AND BODY FAT DISTRIBUTION

by

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Approved by

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APPROVAL PAGE

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DEDICATION

I want to dedicate this work to my beloved daughter Rocio del Carmen Lugo. For all the times you have make me laugh, for your singing, your cute drawings, for all your jokes and for reminding me that life is always much more than what we sometimes think it is.

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SANCHEZ-LUGO, LIZETTE, Ph. D. The Effects of a Diet-Exercise Program on Blood Lipids, Blood Pressure, and Diabetes Indices in Relation to Body Fat and Body Fat Distribution. (1992) Directed by Dr. Terry L. Bazzarre. 268 pp.

The purpose of this dissertation research was to evaluate the relationship of obesity measured as the sum of skinfolds (SSF) and body mass index (BMI) and body fat distribution measured as waist-hip ratio (WHR) to risk factors for cardiovascular heart disease (CHD), hypertension, and diabetes, and to evaluate the effects of a 12-week diet-exercise program on fasting insulin, glucose, glycohemoglobin (Hb A_1), systolic (SBP) and diastolic blood pressure (DBP), total cholesterol (TC), high density lipoprotein cholesterol (HDL-C), high density lipoprotein cholesterol subfraction 2 (HDL_2-C), subfraction 3 (HDL_3-C), diet, body weight (BW), body fat (%BF), waist (WC) and hip circumference (HC) cardiovascular fitness and stress.

Fifty-five subjects (20 males and 35 females) were evaluated for the cross-sectional component of this research, and 36 subjects (15 males and 21 females) were evaluated for the longitudinal study. The exercise program consisted of "fast" walking sessions 3 times/week. Lifestyle workshops on topics such as nutrition, stress management, and the benefits of physical activity and a healthy diet were conducted weekly.

Statistical analysis conducted included Pearson's correlation coefficients, multiple regression analysis, and analysis of covariance. The paired-difference t-test was used

to estimate differences between weeks 0 and 12 for each variable.

TC was the only dependent variable positively associated with WHR independent of age and SSF. Insulin, glucose, SBP, and DBP were positively associated with SSF independent of age and WHR. Hb A_1 was positively associated with SSF independent of age and WHR in females. HDL_2-C and HDL_3-C were negatively associated with SSF independent of age and WHR in females and males, respectively. Increases in WHR tertiles were not associated with increases in any of the diabetes or hypertension risk factors, TC, or with decreases in HDL-C, HDL_2-C, or HDL_3-C in females. HDL_3-C levels decreased with increments in WHR in males.

At week 12, BW, SSF, BMI, %BF, WC, and HC decreased significantly while WHR did not. Fasting insulin, glucose, Hb A_1, SBP, and TC were reduced significantly while HDL-C, HDL_2-C, and HDL_3-C were not altered. Cardiovascular fitness improved significantly while stress levels decreased. Fat and calorie intake decreased significantly in males. Decreased SSF was correlated with decreased insulin and DBP in males and with increased HDL_2-C in females. Decreased WHR was correlated with decreased TC in males while decreased BW was correlated with decreased TC in females. Overall, the most important findings of this dissertation were that TC was positively associated with body fat distribution independent of general obesity.

CHAPTER I

INTRODUCTION

Obesity is a major public health problem in developed countries (Larsson, Svardsudd, Welin, Wilhelmsen, Bjorntorp, and Tibblin, 1984; Van Gaal, Vansant, and Leeuw, 1989). The prevalence of obesity ranges from 25% to 50% or more in adults. Excess body fat or obesity is a risk factor associated with increased susceptibility to a variety of disorders and a higher mortality rate (Bray, 1985). However, a considerable period of observation is required before the associations between obesity and disease can be seen (Bjorntorp, 1985).

Several studies (Van Gaal et al., 1989; Lundgren, Bengtsson, Blohme, Lapidus, and Sjostrom, 1989; Ohlson et al., 1985) suggest that fat distribution, especially the android (abdominal) pattern, is a risk factor for cardiovascular heart disease (CHD), non insulin dependent diabetes mellitus (NIDDM), systolic blood pressure (SBP), and diastolic blood pressure (DBP). The effect of fat distribution on these conditions seems to be independent of the effect of obesity. Utilizing the waist/hip circumference ratio (WHR), as a measurement of abdominal obesity, Larsson et al. (1984) found that a relative excess of abdominal

tissue increased the risk of myocardial infarction or death. Appendix A includes a diagram explaining the relationships between abdominal obesity, diabetes, hypertension, and coronary heart disease risk factors.

Purpose of the Study

The overall purpose of this dissertation research was to examine the effects of a 12-week multidisciplinary nutrition education, physical fitness, and lifestyle management program (RESHAPE), on the dependent variables fasting insulin, glucose, hemoglobin A_1 (Hb A_1), total cholesterol (TC), high density lipoprotein cholesterol (HDL-C), high density lipoprotein cholesterol subfraction 2 (HDL_2-C), high density lipoprotein cholesterol subfraction 3 (HDL_3-C), SBP, and DBP according to measurements of body fat (sum of four skinfolds), and body mass index (BMI) and measurements of body fat distribution (measured as the WHR).

Overall Goals and Objectives:

The overall purpose of this dissertation research was to evaluate the relationship of obesity to risk factors for CHD, hypertension, and diabetes. The particular focus of this research was to determine if body fat distribution (android obesity vs. gynoid obesity) was more highly correlated to each of these groups of chronic disease risk

factors than an estimate of overall measure of obesity such as sum of skinfolds (SSF) or the BMI.

The specific objectives of this research were directed at the measurement of diet, body fat, cardiovascular fitness, and stress as well as selected risk factors for CHD, hypertension, and diabetes in a group of overweight/obese males and females. The selected nutrient variables of interest were: energy intake (kcal), fat, protein, and carbohydrate (total grams per day), cholesterol, dietary fiber, sodium, potassium, calcium, zinc, and copper. Measures of body fat included body weight, the Quetelet or Body Mass Index ($BMI=wt/ht^2$), sum of four skinfolds (SSF=triceps, biceps, subscapular, and suprailiac), estimated % body fat (%BF), and the WHR. Cardiovascular fitness was measured by the amount of time required to walk one mile. Measures of stress included the Current Self-Appraisal Questionnaire (CSA) developed by Bazzarre (unpublished) and the State-Trait Anxiety Inventory (STAI) developed by Spielberger, Gorsuch, and Lushene (1970).

The relative risk of developing CHD was based on the measurement of TC, HDL-C, and the HDL_2 and HDL_3 cholesterol subfractions (i.e., HDL_2-C and HDL_3-C, respectively). The relative risk of developing hypertension was based on the measurement of both SBP and DBP. The relative risk of

developing diabetes was based on measuring fasting glucose, insulin, and Hb A_1.

Other objectives of this research were based on an evaluation of the effect of an intervention, the RESHAPE Program, on the selected chronic disease risk factors. The goal of the RESHAPE program is to reduce obesity/adiposity through effective lifestyle management programs, and simultaneously to reduce one's risk factors for these chronic diseases. Thus, a cross-sectional study as well as a longitudinal/intervention study were developed in order to test specific hypotheses that would demonstrate whether abdominal or android obesity (i.e., a high WHR) was more highly correlated to the regulation of the selected chronic disease risk factors than general obesity.

Specific Hypotheses:

Because gender and age have consistently been shown to account for a considerable amount of variation in the prevalence of chronic diseases, and in dietary intake, obesity (including body fat distribution) and cardiovascular fitness, all of the hypotheses have been tested separately for both males and females. The hypotheses have been grouped according to the two study designs used in this dissertation research: the cross-sectional study which is represented by data collected at week 0 (baseline); and the intervention study which included data collected at both

weeks 0 and 12 of the RESHAPE program. Since these hypotheses were developed a priori, statistical tests were considered significant at the $p \leq 0.05$ level even though a large number of hypotheses were tested and even though the sample size was predetermined by the limitations of the RESHAPE Program to be relatively small. Changes in social variables such as the Current Self Appraisal and the State-Trait Anxiety Inventory were considered significant if the p-value was lower than 0.10 (Skipper, Guenther, & Nass, 1967).

Cross-sectional study research hypotheses:

For the first hypothesis, the Pearson product moment correlation coefficient test was used to assess the correlations between the dependent variables and the WHR, SSF, and BMI.

Hypotheses 1: There are positive correlations between the WHR, SSF, and BMI and:

a. diabetes risk factors: fasting insulin, glucose, and Hb A_1;

b. hypertension risk factors: SBP and DBP;

c. CHD risk factors: TC; and,

d. negative correlations with selected CHD risk factors: HDL-C, HDL_2-C, and HDL_3-C.

Multiple regression analysis was used to evaluate the associations between the dependent variables and the SSF (hypothesis 2), or the WHR (hypothesis 3). When the

association between the dependent variables and SSF were assessed, age and WHR were included in the model to adjust for any confounding effect. Age and SSF were controlled for, when the associations between the dependent variables and WHR were evaluated.

Hypotheses 2: After controlling for the effects of the variables age and WHR, the regression coefficient for SSF is greater than zero for:

a. diabetes risk factors: fasting insulin, glucose and Hb A_1;

b. hypertension risk factors: SBP and DBP;

c. CHD risk factors: TC; and,

d. less than zero for CHD risk factors: HDL-C, HDL_2-C, and HDL_3-C.

Hypotheses 3: After controlling for the effects of age and SSF, the regression coefficient for WHR is greater than zero for:

a. diabetes risk factors: fasting insulin, glucose, and Hb A_1;

b. hypertension risk factors: SBP and DBP;

c. CHD risk factors: TC; and,

d. less than zero for CHD risk factors: HDL-C, HDL_2-C, and HDL_3-C.

For hypotheses 4, the relationships between the dependent variables and the categorical WHR variable were

evaluated using Analysis of Covariance. Age and SSF were used as covariates.

Hypotheses 4: After adjusting for SSF and age, an increase in WHR tertile from low to medium to high is associated with:

a. an increase in the estimated means of the following diabetes risk factor variables: fasting insulin, glucose, and Hb A_1;

b. an increase in the estimated means of the following hypertension risk factors: SBP and DBP;

c. an increase in the estimated mean of TC as a CHD risk factor; and,

d. a decrease in the estimated means of the following CHD risk factors: HDL-C, HDL_2-C, and HDL_3-C.

Intervention study research hypothesis:

For the longitudinal component of this dissertation research, a paired-difference t-test was used to test hypotheses 5 through 9. Hypothesis 5 assessed the changes in the levels of the dependent variables (fasting insulin, glucose, Hb A_1, SBP, DBP, TC, HDL-C, HDL_2-C, and HDL_3-C) after the 12-week exercise-nutrition program. Hypotheses 6 through 9 assessed changes after the 12-week intervention program for the following independent variables: body weight, BMI, SSF, %BF, waist circumference, hip circumference, WHR, calories, fat, dietary fiber, and

cholesterol intake, time to walk a mile, as well as the current self appraisal and the STAI as indices of stress.

Hypotheses 5: At the end of the 12-week RESHAPE Program, the following dependent variables will decrease:

a. diabetes risk factors: fasting insulin, glucose, and Hb A_1;

b. hypertension risk factors: SBP and DBP;

c. CHD risk factors: TC; and,

d. the CHD risk factors: HDL-C, HDL_2-C, and HDL_3-C will increase.

Hypotheses 6: At the end of the 12-week RESHAPE Program, measures of obesity such as body weight, BMI, SSF, %BF, waist circumference, hip circumference, and WHR will decrease.

Hypotheses 7: Participants in the RESHAPE Program will have higher CSA scale scores and lower STAI scale scores at the end of the 12-week program.

Hypotheses 8: Participants in the RESHAPE Program will have a lower calorie, fat, and cholesterol intake, and a higher dietary fiber intake.

Hypothesis 9: The cardiovascular fitness of the participants in the RESHAPE Program will improve at the end of the 12-week as measured by a decrease in the time taken to walk a mile.

Hypotheses 10 through 12 assessed the associations between changes in SSF, WHR, and body weight with changes in

each of the dependent variables. The Pearson product moment correlation coefficient was used to test these hypotheses.

Hypotheses 10: Favorable reductions in SSF are positively correlated with changes in:

a. diabetes risk factors: fasting insulin, glucose, and Hb A_1;

b. hypertension risk factors: SBP and DBP;

c. CHD risk factors: TC;

d. and negatively correlated with changes in CHD risk factors: HDL-C, HDL_2-C, and HDL_3-C.

Hypotheses 11: Favorable reductions in WHR are positively correlated with changes in:

a. diabetes risk factors: fasting insulin, glucose, and Hb A_1;

b. hypertension risk factors: SBP and DBP;

c. CHD risk factors: TC;

d. and negatively correlated with changes in CHD risk factors: HDL-C, HDL_2-C, and HDL_3-C.

Hypotheses 12: Favorable reductions in body weight are positively correlated with changes in:

a. diabetes risk factors: fasting insulin, glucose, and Hb A_1;

b. hypertension risk factors: SBP and DBP;

c. CHD risk factors: TC;

d. and negatively correlated with changes in CHD risk factors: HDL-C, HDL_2-C, and HDL_3-C.

Definitions:

Sum of Skinfolds (SSF): The sum of tricep, bicep, subscapular, and suprailiac skinfolds. SSF is an estimate of total subcutaneous body fat.

Body mass index (BMI): weight/height^2. BMI is an estimate of percent body fat (%BF). However, it may reflect both lean and fat tissue.

Waist to hip ratio (WHR): WHR is an indirect measure of the relative amount of visceral or intra-abdominal adipose tissue. Abdominal obesity (AO) or android pattern is characterized by a high WHR and is more common in males than females. Gluteo-femoral obesity (GFO) or gynoid pattern is characterized by a low WHR and is usually observed in females. Increased body fat deposition is generally associated with increased AO in males and increased GFO in females; however, increased abdominal fat distribution can increase with increased body fat in females. The difference between male and female fat distribution patterns is governed by hormonal influences. Android obesity either in males or females is associated with an increased risk of developing NIDDM, hypertension, and CHD. Gynoid obesity does not appear to be associated with these metabolic complications.

List of Acronyms:

AI	atherogenic index (TC/HDL-C)
AO	abdominal obesity
%BF	percent body fat
BMI	body mass index or Quetelet Index (weight/height^2)
CHD	cardiovascular heart disease
BW	body weight
CSA	current self appraisal
CT	computed tomography
DAF	deep abdominal fat
DBP	diastolic blood pressure
FFA	free fatty acids
FT	free testosterone
GFO	gluteofemoral obesity
HB A_1	glycosylated hemoglobin
HDL-C	high density lipoprotein cholesterol
HL	hepatic lipase
HSL	hormone sensitive lipase
LBM	lean body mass
LPL	lipoprotein lipase
NIDDM	non-insulin dependent diabetes mellitus
OGTT	oral glucose tolerance test
SBP	systolic blood pressure
SF	skinfold
SSF	sum of four skinfolds (tricep, bicep, subscapular, and suprailiac)

SHBG	sex hormone binding globulin
STAI	State-Trait Anxiety Inventory
STR	subscapular/tricep skinfold ratio
TC	total cholesterol
TG	triglycerides
VLCD	very low calorie diet
VLDL	very low density lipoprotein
WHR	waist to hip circumference ratio

CHAPTER II

REVIEW OF THE LITERATURE

The purpose of this chapter was to review and analyze research on the relationships of body fat and body fat distribution to each of the following dependent variables: fasting insulin, glucose, HbA_1, SBP, DBP, TC, HDL-C, HDL_2-C, and HDL_3-C. The effects of exercise on body fat and each of the chronic disease risk factors are also included in this review of the literature.

Introduction:

Fat distribution differs according to gender (Van Gaal et al. 1989). Fat tends to be either predominantly in the abdominal region or in the upper trunk in males. In females, fat is more commonly distributed in the gluteal-femoral regions.

The major clinical findings regarding the effects on health of the central type of fat distribution which also apply to the grossly obese include: elevated glucose intolerance, non insulin dependent diabetes mellitus (NIDDM), hyperinsulinemia (Hartz, Rupley, Kalkhoff, & Rimm, 1983; Larsson et al. 1984); high blood pressure (Modan et al., 1985; Van Gaal et al., 1989); increased occurrence of strokes and heart diseases (Modan et al., 1985); increased

total cholesterol and low HDL-C levels (Larsson et al., 1984; Van Gaal et al., 1989); and, increased HbA_1 levels (Van Gaal et al., 1989).

Using the WHR as a measurement of abdominal obesity, Larsson et al. (1984) found that a relative excess of abdominal tissue increased the risk of myocardial infarction or death. Kissebah et al. (1982) noted that hyperinsulinemia is characteristic of subjects with upper segment body mass distribution. Kissebah et al. (1982) subsequently proposed that upper trunk obesity be used as a diagnostic marker for glucose intolerance, fasting hyperinsulinemia, and fasting hypertriglyceridemia. Hartz et al. (1983) noted a sharp increase in the prevalence of diabetes as the WHR increased in 15,532 females. After controlling for the effect of general obesity, they found that the relative risk of diabetes in females with upper body obesity was 3.17 times ($p<0.001$) higher than for females with lower body obesity.

Measurements of body fat and body fat distribution

Anthropometric measurements can be useful tools for evaluating the health of individuals in clinical diagnostic situations, as well as in populations as part of public health screenings. According to Hass and Flegal (1981), anthropometry is based on the concept that appropriate measurements reflect morphological changes that occur in response to functionally significant physiological changes.

Nutrition science relies heavily on anthropometric techniques as a first-order indicator for detection and treatment of some nutritional problems, especially those involving energy and protein (e.g. obesity and malnutrition).

The development of indirect methods of determining human body composition began during the 1940's (Lukaski, 1987). Most body composition methods are based on the two-compartment model (a fat one and a fat-free one). Unfortunately, this model does not account for the differential effects of water, protein-muscle tissue, and skeletal-bone tissue.

Densitometry

Densitometry is used to estimate body fat by determining body density which is measured by comparing the weight of a body in air to the weight of the body in water (hydrostatic weighing). The chemical composition of the fat-free body is assumed to be relatively constant with a density of 1.100 g/cc at 37°C. The density of fat is 0.900 g/cc at 37°C. (Behnke, et al., 1942 cited in Lukaski, 1987). Residual lung volume and the volume of gas in the gastrointestinal tract affect body density. Therefore, the residual lung volume is measured based on the determination of vital capacity. The volume of gas in the gastrointestinal tract is estimated as 100 ml for adults. Other assumptions in using the densitometric approach

include: the concept that the chemical composition of the fat-free body is relatively constant; and, the concept that hydration status and the proportion of bone mineral to muscle in the fat free body are constant (Lukaski, 1987).

The application of this formula used for adults and for children may result in artificially elevated values since differences in hydration and bone density are not accounted for. According to Lohman (1981), body densities of the fat-free body and lean body mass change from population to population depending on age, racial background, gender, and one's level of physical activity.

Skinfold Thicknesses

The measurement of skinfold (SF) thickness has basically two assumptions (Lukaski, 1987): the concept that the thickness of subcutaneous adipose tissue reflects a constant proportion of total body fat; and, the concept that the sites selected for measurement represent the average thickness of subcutaneous adipose tissue.

The anatomic locations of the five most commonly measured SF sites are: triceps, subscapular, suprailiac, abdomen, and thigh. There are basically two ways to use SF (McArdle, F. I. Katch, & V. L. Katch, 1986). The first method is based on using the sum of the values for different SF as an indication of the relative degree of fatness among individuals which can be used to reflect changes in fatness after an intervention program. The second method is based

on using the SF in conjunction with mathematical equations designed to predict body density or percent body fat. These equations are population specific, and predict fatness fairly accurately in samples of subjects similar in age, gender, state of training, and fatness to those from which the equations were derived (Lohnman, 1981). According to Hass and Flegal (1981), there is more error in measuring SF in females than in males which reflects greater variability in the amount of adipose tissue at any site in females compared to males. Skin elasticity, different subcutaneous tissue mobility, different compression times, and individual skills also influence the results.

Various ratios of SF thickness measurements have been used to assess body fat distribution and its relationship to disease. Haffner, Stern, Hazuda, Pugh, and Patterson (1987) found that the subscapular:triceps skinfold ratio (STR) was associated with NIDDM in females. In a prospective study, Haffner, Stern, Mitchell, Hazuda, and Patterson (1990) found that BMI, the STR, fasting insulin, and glucose concentration were all predictors of the incidence of diabetes in a group of Mexican Americans.

Body Mass Index

Body mass index (BMI) or Quetelet index (QI), is the body weight in kilograms divided by the height squared in meters, weight/(height)^2. The BMI is more highly correlated with body fat than with other indices of height and weight

(National Research Council [NRC], 1989). According to the NRC, definition of obesity can be based on either SF measurements or BMI as follow: a BMI above 30 kg/m^2, a tricep plus subscapular SF above 45mm in males and 65mm in females, or %BF more than 25% of body weight in males or 30% in females. Roche, Siervogel, Chumlea, and Webb (1981) found a positive correlation between BMI and %BF of 0.77 for males and 0.76 for females ($p<0.01$).

Circumferences

Fat distribution can also be determined by waist to hip circumference ratios (WHR), or waist to thigh circumference ratios (NRC, 1989). Waist or the narrowest region between bottom of the rib cage and superior iliac spine, abdomen at the level of the umbilicus, pelvis at pubic symphysis, thigh, and arm have been used most widely. The use by different investigators of various anatomic landmarks for measuring hip and waist circumferences accounts for some of the differences in reported measurements (Leibel, Edens, and Fried, 1989). Obesity located in the abdominal areas (android obesity) is the subgroup of obesity with complications endangering health and life. The simplest method for measuring this form of obesity is to record the waist circumference and to divide it by the hip circumference in order to compensate for variation in frame size.

According to Bjorntorp (1985) the WHR is at least as effective as other measurements of abdominal obesity such as skinfolds, ultrasound, or fat cell size. Ashwell et al. (1985) cited in Leibel (1989) found a significant correlation ($r=0.61$, $p<0.001$) between WHR and intra-abdominal:subcutaneous fat ratio measured by computed tomography (CT). Therefore, the WHR appears to be a useful indirect measure of the relative amount of visceral adipose tissue, and this ratio in turn correlates well with many morbidities associated with obesity (Leibel et al., 1989).

Houmard et al. (1991) found that the predictive strength of WHR on non-obese, middle to older aged males varies depending upon the measurement method used. They found that the WHR obtained from circumference measures at the level of umbilicus/maximal hip, level of umbilicus/level of greater trochanter, and minimal waist/maximal hip achieved the strongest relationships with indices of carbohydrate and lipid metabolism, body composition, and fitness level. The WHR measured at the level of the umbilicus/level of superior iliac spine was intermediate in terms of the strength of the associations. The WHR measured at the level of 1/3 of the distance between the xiphoid process and umbilicus/level of 4 cm below the superior iliac spine was not related to any metabolic or physiological variable. Ostlund, Staten, Kohrt, Schultz, and Malley (1990) found that WHR measured at the minimal waist/maximal

hip was more useful than the WHR measured at the level of the umbilicus/maximal hip in predicting the HDL_2-C levels. Peiris et al. (1987) cited in Kissebah and Peiris (1989) found that WHR correlated highly with the intra-abdominal visceral fat mass even after controlling for the effects of age and degree of overweight. The simplicity of this method is an advantage for epidemiologic studies.

Ultrasound and Radiography

Muscle, bone, and fat cross-sectional areas can be assessed using ultrasound and radiographic analysis (McArdle et al., 1986). In the ultrasound method, the distance between the skin and the fat-muscle layer, and the distance between the fat-muscle layer and the bone are measured indicating thickness of fat and muscle at different sites. Lukaski (1987) reported a correlation of 0.80 ($p<0.05$) between ultrasonic measurements and skinfold thickness.

Computed Tomography

The computed tomography (CT) allows for radiographic images of different body sections giving information on total tissue-fat area and intra-abdominal fat area. Using CT, Sjostrom (1988) found that the 4th or 5th lumbar vertebra separates males and females according adipose tissue distribution estimating the amount of visceral fat and the relative distribution of fat between the intra-abdominal and extra-abdominal compartments. He found that

adult males have 53% of their fat in the upper body, while females have 46% of their fat in the upper body.

Limitations

There are several scientific, theoretical as well as practical limitations associated with the procedures available for the determination of body fat.

1. It is questionable whether any of the formulas represent sufficiently accurate predictions to be useful in practical applications (Hass et al., 1981).

2. The generalized density values for lean and fat tissues of 1.10 and 0.90 g/cc, respectively, are average values for young and middle age adults. The assumptions that these values are constant, may not be entirely valid.

3. The use of these formulas to estimate body fat in children and aging adults is questionable. For example, the density of the skeleton is probably in continual change during the growth period as well as during bone demineralization with aging. These facts would make the actual density of the lean tissue of young children and the elderly lower than the assumed values. As a result, an overestimation of relative body fat would occur with densitometry for children and the elderly (Durnin and Womersley, 1974). The variability in the protein:mineral ratio could lead to a variation in percent body fat of 2.1% (0.005 g/cc) in healthy subjects (Lukaski, 1987).

4. The measurement of body density by hydrostatic weighing requires complex laboratory equipment and very cooperative subjects. The technique is also more time consuming than the measurements of body density by SF measurements. The subjects cooperation is necessary for the under-water weighing technique, and it is unsuitable for most young children and elderly people. On the other hand, the use of SF as a measure of subcutaneous fat thickness is widespread because the technique is relatively easy, inexpensive and requires little equipment. SF measurements are suitable for nutrition surveillance and clinical evaluation (Himes, Roche & Webb, 1980).

5. Lohman (1981) has pointed out that changes in the thickness of the subcutaneous fat from the elbow toward the shoulder are fairly large. If the point of application of the caliper is displaced by 2.5cm proximal, distal, medial, or lateral to the midpoint, the SF thickness changes on the average 2 to 3 mm. In addition, there are differences in skin compressibility that may become greater in older people (Durnin et al., 1974). In individuals with flabby, easily compressible tissue, the measurement presents a problem for obtaining valid measurements of SF thickness.

6. The precision of a SF thickness measurement is dependent upon the skill of the person taking the measurements and upon the site measured. A precision within

5% could be attained easily by a trained individual (Lukaski, 1987).

7. The accuracy of these measures is limited by the variability of the composition and density of the fat-free compartment in different individuals.

8. There is little information on the distribution of fat in the body of the population at large. Therefore, the validity of using equations to predict body composition is restricted to populations from whom these equations were derived (Durnin & Womersley, 1974).

9. Ultrasound and CT may be more accurate methods for predicting body fat, but generally they are not suitable for epidemiological studies due to the cost of these procedures (Lukaski, 1987). The cost and general availability of modern CT scanners prohibit the routine use of this instrumentation for body composition assessment. Another difficulty is the need for uniform and constant pressure applied by the probe to the scan site. Changes in pressure by probe application can affect the distribution of adipose tissue and bias the ultrasonic estimation of adipose thickness. Validation studies are needed using large populations of people with different amount of body fat.

10. Even when the WHR provides a useful estimation of the proportion of abdominal or upper body fat, it does not distinguish between accumulations of deep abdominal fat and subcutaneous abdominal fat.

Relationship between Insulin, Glucose intolerance, and Non Insulin Dependent Diabetes Mellitus (NIDDM) with obesity measured by BMI and SK, and adipose tissue distribution measured as the WHR.

The second National Health and Nutrition Examination Survey (NHANES II) found that 26% of Americans adults, or about 34 million people aged 20 to 75 years, are overweight. The survey used a BMI of 27.8 kg/m2 or greater for males and 27.3 or greater for females to define overweight (NRC, 1990). The NHANES II survey showed that for overweight adults aged 20 to 75 years, the relative risk of diabetes is 2.9 times that for non-overweight people of comparable ages. Among overweight Americans aged 20 to 45 years, the relative risk for diabetes is 3.8 times that for non-overweight Americans in the same age group. Among overweight Americans aged 45 to 75 years, the relative risk for diabetes is almost twice that for non-overweight people in the same age group (Van Itallie, 1985).

Lonnroth (1988) established that obesity is often associated with insulin resistance and type II diabetes (non insulin dependent diabetes mellitus [NIDDM]). Hyperinsulinemia accompanies obesity as a marker of the insulin resistance, and fasting plasma insulin levels correlated with the degree of obesity. Bagdade, Bierman, and Port (1967) found that fasting insulin levels of obese subjects (36uU $\pm$ 17.6) were significantly higher ($p<0.001$)

than in nonobese subjects (15uU $\pm$ 4.8). Subjects with 25% of ideal body weight (IBW) according the Metropolitan Life Insurance Table were classified as obese, while subjects who were within 15% of IBW were classified as non obese.

Recent studies indicate that the association between obesity and diabetes is highly influenced by the regional location of body fat, and that the abdominal (android pattern, central fat distribution, apple shape, male habitus) but not the gluteal (gynoid pattern, peripheral fat distribution, pear shape, female habitus) obesity is correlated with insulin resistance and glucose intolerance (Despres, Nadeau et al., 1989; Freedman & Rimm, 1989; Haffner et al., 1987; Hartz et al., 1983; Landin, Krotkiewski & Smith, 1989).

Vague (1956) found that abdominal fat distribution correlates with various metabolic aberrations related with NIDDM suggesting that obese subjects with an abdominal fat distribution are more prone than others to develop insulin resistance. In studies where selected obese subjects have been investigated (Haffner et al., 1987; Lundgren et al., 1989; and, Ohlson et al., 1985), body fat measured as BMI or WHR represents two independent factors correlating with glucose intolerance. Several studies suggest that the risk contributions of WHR and BMI to NIDDM might be mediated via separate mechanisms. Hyperinsulinemia and insulin resistance are important factors for NIDDM (Bjorntorp,

1988b). Various investigators have found that BMI correlates positively with insulin secretion and, that WHR, when it is high, is associated with insulin resistance with a decreased hepatic clearance of insulin which contribute to the hyperinsulinemia characteristic of obesity (Holm & Krotkiewski, 1988). The increased insulin resistance might be due to increased insulin secretion by secondary down-regulation of the insulin receptor (Bjorntorp, 1990; Kissebah and Peiris, 1989). There seems to be a consensus that NIDDM develops when there is a decrease in the effectiveness of the insulin produced. The association between obesity and NIDDM is probably due to insulin resistance in obesity. The tissues responsible for the impaired insulin response are those where insulin action is quantitatively important for glucose homeostasis including liver, muscles, and adipose tissue (Hunt & Groff, 1990). Some cellular events that account for the insulin resistance in obesity have been studied. The possibilities that could explain these events are: elevated counterregulatory hormones and/or target tissues defects. Two anti-insulin hormones that may play a role are cortisol and androgens.

Glucocorticoids in the presence of insulin markedly increase lipoprotein lipase (LPL) activity <u>in vitro</u> in human adipose tissue (Cigolini & Smith, 1979, cited by Leibel et al., 1989). Lipid synthesis by adipocytes is favored by high levels of LPL, insulin, glucose, and triglycerides

(TG). Hydrolysis of stored TG is favored by circumstances tending to lower the availability of these substrates and hormones. Hormone sensitive lipase (HSL) catalyzes the breakdown of the TG molecule into three molecules of free fatty acids (FFA) and one molecule of glycerol. Hormone sensitive lipase can be activated or deactivated by beta-1 or alpha-2 adrenergic receptors, respectively (Leibel et al. 1989). Glucocorticoid receptor number is greater in omental than in abdominal subcutaneous adipose tissue, and this difference may explain the changes in fat distribution that occur when plasma corticosteroid concentration are chronically elevated (Rebuffe-Scrive, Lundholm & Bjorntorp, 1985).

Androgens and body fat distribution

Haffner et al. (1988) cited by Kissebah and Peiris (1989) found a highly significant decrease in the plasma level of sex hormone binding globulin (SHBG) and an increase in percent free testosterone (%FT) with increasing WHR in healthy, premenopausal females without significant history of hirsutism, amenorrhea, or clinical evidence of endocrine disorders. Since plasma levels of SHBG are determined largely by the androgen/estrogen balance, the decrease in SHBG and the increase in %FT indicates a relative increase in androgenic activity. Kirschner and Samojlik, (1991) found that obese females with AO had higher free testosterone levels (98.8 $\pm$ 39.2 vs. 82.2 $\pm$ 33 pmol/l) and

lower SHBG levels (16.1 $\pm$ 5.7 vs. 18.9 $\pm$ 6.1 nmol/l) when compared with obese females with GFO ($p<0.05$). Decreased SHBG have been reported in obese premenopausal females (Kissebah, Peiris & Evans, 1988). Decreased SHBG and increased %FT levels have been observed in obese males who also demonstrated decreased total testosterone levels.

The importance of androgenic/estrogenic activity on body fat distribution is supported by the following observations:

1. Vermeulen et al. (1969) cited by Kissebah and Peiris (1989) reported that the onset of androgen secretion in the pubertal male or administration of exogenous testosterone to the hypogonadal male is accompanied by localization of fat in the upper body and a decrease in SHBG levels.

2. In subjects that had sexual transformation, after 45-months of testosterone treatment, females increased upper body adipocyte cell volumes, while estrogen therapy in males increased fat cell number in the femoral area after 34-months of treatment. No p-values were reported (Vague, Meignen & Negrin, 1984).

3. Yen (1989) cited by Kissebah and Peiris (1989) reported an increased fat deposition and increased androgen production in females with polycystic ovary syndrome, obesity, and excess plasma androgens. Many of these females with polycystic ovary syndrome exhibit a predominance of upper body fat.

4. Sparrow, Bosse, and Rowe (1980) found a relationship between body fat distribution and hormone levels. They found that estradiol levels were higher in males with gluteofemoral obesity ($r=0.22$; $p=0.03$) and lower in males with abdominal obesity ($r=-0.19$; $p=0.05$) after controlling for age.

Evans, Hoffmann, Kalkhoff, and Kissebah (1983) found that WHR was negatively correlated with SHBG ($r=-0.49$; $p<0.001$) and with %free testosterone (%FT) ($r=0.44$; $p<0.001$) in premenopausal females. This strong correlation between increased androgenic activity and WHR suggests that body fat distribution might be a manifestation of increased exposure to unbound androgens (Evans et al., 1983). The increased androgenic activity may influence the deposition of adipocytes in areas around the waist that are morphologically and metabolically different from those deposited in the gluteofemoral region. In addition, androgens could increase plasma FFA flux and overexpose hepatic and extrahepatic tissues to FFA. This mechanism is suggested by the following observations: Upper body adipocytes are larger than gluteofemoral adipocytes and exhibit high rates of basal and catecholamine stimulated lipolysis, maybe due to an increased beta to alpha adrenergic activities and to a diminish sensitivity to the antilipolytic action of insulin (Rebuffe-Scrive et al., 1987). Ostman et al. (1979) cited by Leibel et al (1989)

reported that the lipolytic sensitivity of the abdominal regions of adipose tissue was higher than that of the gluteal-femoral regions, especially the intra-abdominal, omental fat cells. Leibel and Hirsch (1985) reported an enhanced alpha-2 receptor activity in abdominal subcutaneous adipocytes of males, as compared to females. They suggested that this situation may contribute to a greater tendency of males to accumulate fat in the abdominal region. Richelsen (1986) found that alpha-2 receptor binding was increased by 73% ($p<0.01$) in gluteal adipocytes of females in comparison to males. The increased in binding was due to a increase in receptor number (438 vs. 262 fmol/mg of protein; $p<0.001$).

Rebuffe-Scrive (1988) found that the gluteofemoral depot is primarily a storage organ dedicated to such female stresses as pregnancy and lactation, and that the abdominal-visceral depot is dedicated primarily to storage of easily and rapidly mobilizable energy reserves. Lactation was associated with an enhanced lipolytic response in femoral adipose tissue. It was not determined if this action was due to increased beta or decreased alpha-2 adrenergic activity. This anatomical and functional specialization is governed by the sex hormone balance.

Upper body obesity is associated primarily with fat cell hypertrophy, whereas lower body obesity is associated primarily with fat cell hyperplasia. Enlarged fat cells have been demonstrated to be relatively resistant to insulin

action in vitro (Stern & Haffner, 1986). According to Bjorntorp, et al. (1981) cited by Stern and Haffner (1986), adipose depots account for only about 5% of total body glucose disposal. Therefore, insulin resistance in this tissue alone should not produce significant total body insulin resistance. Insulin (a lipolytic inhibitor) has less effect on abdominal adipose tissue which may be due to a small number of insulin receptors. Abdominal adipose tissue is more easily mobilized and, when enlarged will cause elevations of circulating FFA in the portal vein. Obese females with abdominal obesity demonstrated an increased FFA flux despite higher plasma insulin levels (Leibel et al., 1989). The potential effects of elevated, circulating FFA on glucose transport and insulin resistance are more pronounced in abdominal obesity. Insulin resistance is also higher in abdominal obesity (Bjorntorp, 1988b). Females specifically accumulate body fat in the gluteofemoral region. This characteristic is probably related by increased lipoprotein lipase activity in the gluteofemoral regions mediated by progesterone and estrogen (Bjorntorp, 1988a). In females with abdominal obesity and irregular ovulation there is an irregular production of progesterone, and the excess fat accumulates in the abdominal region (Hartz et al., 1983). Both androgens and corticosteroids may directly affect abdominal adipose tissue fat storage.

Insulin receptors in obesity

According to Olefski and Kolterman (1981), the effector site of insulin on target cells is its specific receptor. The abnormalities of insulin binding at the receptor site are present with mild insulin resistance, and, with more severe insulin resistance, the postreceptor defects are also involved. Insulin concentration by itself can regulate insulin binding to target cells.

High insulin concentrations decrease the affinity and, eventually reduce receptor number possibly by increasing receptor internalization. There are some explanations for the decrease in insulin binding in obesity with peripheral insulin resistance. It seems that increased insulin is followed by insulin receptor down regulation. Olefski (1976) cited by Bjorntorp (1988a) found a direct relationship between hyperinsulinemia and receptor loss in obesity. He also found obese patients with normal insulin binding, little insulin resistance, and normal plasma insulin levels. These previous observations suggest that the defects of insulin binding to target cells in obesity are secondary to high insulin plasma levels.

Hepatic uptake of insulin in obesity

After insulin is secreted by the pancreatic beta cells, insulin goes through the portal circulation where a major portion is normally taken up by the liver. A simple way to measure this insulin hepatic uptake is to measure the

peripheral molar concentration ratio of insulin/C-peptide. A high ratio indicates little hepatic insulin uptake because the C-peptide is not taken up by the liver. High insulin/C-peptide ratios have been reported in obesity (Bjorntorp, 1988a). Peiris et al. (1989) have shown a decrease in hepatic insulin uptake in abdominal obesity and a negative correlation between insulin clearance and WHR ($p<0.05$). Therefore, one might speculate that the peripheral hyperinsulinemia of abdominal obesity is at least partially due to a decrease in hepatic insulin uptake. Androgens may play a role since testosterone and dihydrotestosterone seem to inhibit hepatic insulin clearance in physiological concentrations (Kissebah et al., 1988).

Analysis of selected studies

The final section of this review of literature represents a critical analysis of four prospective studies (Table 1). This review includes a general description of the findings of each study, a review of the design of these studies (e.g., sample size selection), a review of the methods used to collect blood samples, a review of the methods used to measure body fat and body fat distribution, a review of the criteria used to diagnose diabetes mellitus, and finally, a review of the analytical methods used.

Study Parameters

The main purpose of these four studies was to compare baseline characteristics of subjects who converted to NIDDM with those subjects who remained free of diabetes during the follow up period.

The number of subjects in the four studies was relatively large. The sample size ranged from 146 in the study conducted by Bergstrom et al., (1990), to 1351 in the study conducted by Lundgren et al. (1989). Only females were studied in one study (Lundgren et al. 1989). Only males were included in two studies (Ohlson et al., 1985; Bergstrom et al., 1990). Haffner, Stern et al. (1990) studied a mixed sample of 276 females and 198 males.

The ages of the subjects in these studies ranged from 25 to 64 years of age. Subjects were 25-64 years old in the Haffner, Stern et al. study (1990) and 54 years old in the Ohlson et al. study (1985). Lundgren et al. (1989) studied subjects aged 38, 46, 50, 54, 60 years old.

Haffner, Stern et al. (1990) restricted their sample to those who were free of diabetes at the baseline examination in 1979-1982 and who attended the medical examination 8 years later. The sample represented low income, middle income, and a cluster of suburban census tracts.

The sample selection method varies among the studies. Lundgren et al. (1989) used a systematic sampling method based on date of birth to select their sample. Ohlson et

al. (1985) restricted their sample to males from Goteborg, Sweden born in 1913, and whose date of birth was divisible by 3. Subjects that were diabetics were excluded from the sample. Bergstrom et al. (1990) reexamined during the follow up period 146 of the nondiabetic males including 75 NGT, and 71 IGT. The follow up period varied among the four studies ranging from 30 months in the study conducted by Bergstrom et al. (1990), to 13.5 years in the study conducted by Ohlson et al. (1985).

Blood Sampling

All studies used fasting blood samples for glucose concentration determination and similar blood collection procedures. In addition, Haffner, Stern et al. (1990) determined insulin and, glucose concentration 2-hours after a 75-g glucose load. Bergstrom et al. (1990) also determined glucose concentration after a 75g oral glucose load (Glucola) at 30, 60, 90, 120, and 180 minutes. In addition, plasma insulin, and C-peptide were analyzed. Serum glucose were measured by an automated glucose oxidase method. Plasma insulin and C-peptide were measured by radioimmunoassay. Lundgren et al. (1989) determined serum glucose concentration by the ferric cyanide reduction method adapted for autoanalyzer by Technicon N-26. In the follow up study the glucose oxidase method was used to analyze glucose levels. Ohlson et al. (1985) did not provide information about the procedure used for blood analysis.

Measures of Body fat

All the studies (Haffner, Stern et al., 1990; Lundgren et al., 1989; Ohlson et al., 1985; and Bergstrom et al., 1990) obtained skinfold measurements, weight, height, and controlled for the effect of BMI. Haffner, Stern et al. (1990) and Lundgren et al. (1989) obtain the skinfolds measurement from the right side of the body using a Harpenden's caliper. Ohlson et al. (1985) also used a Harpenden's caliper but they did not specify what side of the body the measurements were taken. Bergstrom et al. (1990) obtained the skinfold measurements from the left side of the body using a Lange caliper. Some of the investigators studied skinfolds ratios to assess fat distribution. Haffner et al. (1990) and Bergstrom et al. (1990) used the ratio of subscapular to triceps skinfold (STR) as a measure of central adiposity, and BMI as a measurement of general adiposity. Lundgren et al. (1989) used the sum of the subscapular and triceps skinfold (SF) to assess body fat. The waist circumference was measured to the nearest 1 mm at the level midway between the lower rib margin and the iliac crest using a steel tape measure. The hip circumference was measured to the nearest 1mm at the widest point between hip and buttocks. All the initial anthropometric measurements were performed by one observer in order to avoid inter-observer differences in the studies by Lundgren et al. (1989) and Ohlson et al. (1985).

Ohlson et al. (1985) obtained the anthropometric measurements using a similar procedure used by Lundgren et al. (1989) for height, weight, BMI, and waist circumference. The hip circumference was measured at the level of the iliac crest. The parathoracic skinfold (midway between the axilla and iliac crest) was taken in addition to the triceps and subscapular skinfolds. Bergstrom et al. (1990) measured the cross-sectional body-fat areas (cm^2) by CT. Four sites were examined: subcutaneous thorax, subcutaneous abdomen, subcutaneous thigh, and intra-abdominal area.

Criteria for diagnosing diabetes mellitus

Haffner, Stern et al. (1990), Lundgren et al. (1989), and Bergstrom et al. (1990) used the criteria of the World Health Organization (WHO) to diagnosed diabetes mellitus. Fasting plasma glucose level equal or greater than 7.8mM and/or 2-hour plasma glucose level equal or greater than 11.1mM are indicative of diabetes. Bergstrom et al. (1990) initially classified subjects as normal glucose tolerance (NGT), impaired glucose tolerance (IGT) or NIDDM. Ohlson et al. (1985) diagnosed subjects as diabetics if they were previously diagnosed as diabetics (by another doctor) or if fasting venous blood glucose was equal or greater than 7mM/l or a glucose value equal or greater than 10.0mM/l 2-hours after an oral glucose load of 100g.

Statistical Analysis

Haffner, Stern et al. (1990) used analysis of covariance in which the STR was controlled for sex. The STR, fasting glucose, and insulin concentration were treated as categorical variables having the highest quartile compared with the lowest three quartiles. However, the results were similar when all risk factors were analyzed as continuous variables. Relative risk (RR) was calculated dividing the incidence in the highest quartile by the incidence in the lowest three quartiles. Both Lundgren et al. (1989), Ohlson et al. (1985), and Bergstrom et al. (1990) used Student t-test to evaluate the differences between baseline and follow up values. In addition, Lundgren et al. (1989), and Ohlson et al., (1985) tested correlations between graded and continuous variables by the Pitman's permutation test which is a nonparametric test for simple correlations and multivariate analysis. The Mantel-Haenszel's procedure was used by Lundgren et al. (1989) when adjusting for confounding variables. All the statistical calculations controlled for age.

In the study by Bergstrom et al. (1990) variables with skewed distributions were analyzed using the Wicoxon's rank-sum test (a non-parametric procedure). The Pearson's correlation coefficient was used to measure linear association between fasting C-peptide levels and intra-abdominal fat. In the univariate analysis of serum glucose

variables, subjects were subdivided into males initially classified with IGT or NGT.

Summary of Study Results

Generally, in the four studies, the subjects who converted to diabetes were older and had greater overall adiposity (BMI), more central adiposity (STR), higher SF, larger WHR, higher fasting and higher 2-hour glucose, higher fasting insulin levels, and higher C-peptide levels than the nonconverters to diabetes. In the study by Haffner, Stern et al. (1990) gender did not make a difference in the proportion of subjects who develop diabetes.

The univariate analysis showed that BMI ($p=0.009$), STR ($p=0.032$), fasting insulin ($p<0.001$), and glucose concentration ($p<0.001$) (Haffner, Stern et al., 1990), waist ($p=0.0012$) and WHR ($p=0.0037$) (Ohlson et al., 1985), and age ($p<0.04$), C-peptide ($p<0.03$), and glucose ($p<0.001$) (Bergstrom et al., 1990) were all significant predictors of the incidence of NIDDM. Haffner, Stern et al. (1990) found that subjects with IGT at baseline had 6.17 times greater risk of developing diabetes than subjects with NGT ($p<0.001$). Subjects in the highest quartile of the insulin distribution had 6.60 times the risk of conversion to diabetes as subjects in the lowest three quartiles ($p<0.001$). In the multiple logistic analysis where each factor was adjusted for all the other risk factors, fasting glucose ($p<0.001$) and insulin ($p=0.006$) concentrations

remained significantly associated with the incidence of NIDDM.

Both, Lundgren et al. (1989) and Ohlson et al. (1985) found an increase in the incidence of diabetes in the upper quintile of BMI, SF, and WHR compared to subjects in the corresponding lowest quintile. Ohlson et al. (1985) found the risk for diabetes in the upper 5% of the distribution of the WHR was 16.6 times higher than the risk in the lowest quintile. Not a single subject in the lowest quintile of BMI developed diabetes as compared with 21.4% of those who did within the upper 5% of the BMI distribution. Lundgren et al. (1989) also found that the correlations between BMI, SF, and WHR and the incidence of diabetes were all significant ($p<0.001$). They also found that for females the incidence for diabetes in the upper quintile increased by 8.0 times for BMI, 22.0 times for SSF, and 13.6 times for WHR compared to females in the corresponding lowest quintile. Lundgren et al. (1989) also found marked differences between mean values for BMI, SF, and WHR in females who developed and who did not develop diabetes. Nine percent of all the females belonged to the fifth quintile of WHR as well as of BMI. Forty four percent of the females who developed diabetes belonged to this group. Females with initially high WHR seemed to increase their serum glucose concentrations during the 12-year study period ($p=0.02$). The same relationship was not seen for BMI and

SF. An increase in BMI and SF was associated with an increase in fasting serum glucose concentration ($p<0.001$). On the other hand, an increase in WHR was not associated with an increase in serum glucose concentration ($p=0.192$). They concluded that both abdominal fat distribution as well as the total amount of fat were important risk factors for diabetes.

Ohlson et al. (1985) found that all the anthropometric measurements were predictors of diabetes incidence. However, when BMI was accounted for, only the waist circumference ($p=0.0012$) and the WHR ($p=0.0037$) remained as predictors for the development of diabetes. After dividing the WHR and BMI into tertiles, they found that the risk of diabetes increased with increasing WHR within each tertile of BMI. The highest risk (15.2%) was observed in the highest tertile for both BMI and WHR while the lowest risk (0.5%) was found in the lowest tertile for both variables. They concluded that both the degree of obesity and the localization of the adipose tissue are risk factors for diabetes. The two factors seemed to be independent of each other and to potentiate each other as risks factors for the development of diabetes.

Bergstrom et al. (1990) found that baseline fasting plasma C-peptide ($p<0.005$), baseline fasting glucose levels, and adjusted fasting C-peptide (C-peptide/glucose) ($p<0.02$) were higher in subjects who developed diabetes. Among the

71 males initially classified as IGT, the initial fasting glucose and 120-minute glucose levels were significantly elevated in those who subsequently developed diabetes. Age, C-peptide, and glucose levels at 120-minutes were independently predictive for NIDDM development. Only the initial intra-abdominal fat area assessed by CT was significantly higher in males who developed NIDDM ($p<0.005$).

The STR also evaluated by Haffner, Stern et al. (1990) was not different between the two groups. The intra-abdominal fat area and the fasting C-peptide levels were linearly correlated ($r=0.263$; $p=0.002$). Twenty percent (9 of 45) of the males in the quadrant defined by high fasting C-peptide level and high intra-abdominal fat area subsequently developed NIDDM, while only 2.5% (1 of 40) developed diabetes in the quadrant defined by low fasting C-peptide level and low intra-abdominal fat area. This longitudinal study was the first to demonstrate that an elevated fasting C-peptide level was associated with a greater risk of subsequently developing diabetes, and that a direct measure of intra-abdominal fat area as determined by CT was associated with the subsequent development of diabetes. They concluded that an increased fasting C-peptide level and an increased deposition of intra-abdominal fat were antecedent events in the pathogenesis of NIDDM.

Not one of these studies controlled for dietary intake or for physical activity which are two variables closely

related to the pathogenesis of NIDDM. In the studies where females were included (Haffner, Stern et al. 1990; Lundgren et al. 1989), no discrimination between premenopausal and postmenopausal females was made.

Table 1
Summary table for studies related to glucose, insulin, Non-Insulin Dependent Diabetes Mellitus, body fat and body fat distribution.

Investigators	Subjects	Methodology	Blood Work	Statistics	Findings
Haffner, Stern, Mitchell, Hazuda, and Patterson, 1990.	474 subjects from The San Antonio Heart Study. 198 males and 276 females Ages 25-64.	Comparison of baseline characteristics of subjects who converted to type II diabetes with those who remained free of diabetes after 8-year follow up. STR=subscapular/ tricep SF ratio as a measure of central adipocity. Height, wt, BMI.	Fasting glucose and insulin, and 2-hour glucose level after a glucose load.	Analysis of Covariance, Multiple logistic regression analysis. Relative risk=RR=incidence in highest quartile/ incidence in the lowest 3 quartiles.	Converters to DM (6%) were older, greater BMI ($p<0.001$), greater STR ($p<0.036$), and higher fasting and 2-hour glucose and fasting insulin ($p<0.001$) than non-converters. BMI ($p<0.009$) STR ($p<0.032$), fasting insulin and glucose ($p<0.001$) were univariate predictors of the incidence of NIDDM. Fasting glucose and insulin remained associated with the incidence of NIDDM after adjusting for all the other variables.
Lundgren, Bengtsson, Blohme, Lapidus, and Sjostrom, 1989.	1351 Swedish women, ages 38, 46, 50, 54, and 60 years old.	Correlation between initial AT amount and distribution and incidence of diabetes and change in serum blood glucose after a 12 yrs of follow up. Ht, wt, BMI, SF (sub-scapular and tricep). Waist girth taken between the lower rib margin and iliac crest. Hip girth taken at widest point between hip and buttocks.	Fasting blood glucose.	Student t-test, Pitman's non-parametric permutation test, Mantel-Haenszel's procedure used when adjusting for confounding variables.	Converters to DM (3%), had higher BMI, SF, and WHR ($p<0.001$). During the 12-yrs follow up an increase in BMI and SF corr with an increase in glucose ($p<0.001$). Women with the initially highest WHR increased their glucose conc ($p<0.02$). The incidence of NIDDM in the upper quintile increased 8X for BMI, 20X for SF, and 13.6X for WHR when compared to lower quintiles. The antropometric vars were corr with the incidence of diabetes ($p<0.001$).

Ohlson, Larsson, Svardsudd, Welin, Eriksson, Wilhelmsen, Bjorntorp, and Tibblin, 1985.	792 Swedish men ages 54 years old.	Comparison of baseline characteristics of subjects who converted to diabetes after a 13.5 years of follow up. Height, wt, BMI. SF were taken at triceps, subscapular and parathoracic (between axilla and iliac crest) area. Waist girth taken at the level of the umbilicus, and hip taken at the iliac crest level.	Fasting blood glucose.	Student t-test, Chi-squared test. Pitman's permutation test, and Isotonic regression analysis.	Converters to diabetes (6.3%) had higher WHR ($p<0.0001$). Glucose was corr to WHR ($r=0.08$; $p<0.05$). Risk for DM in the upper 5% distribution of WHR was 16.6X higher when compared with lower quintiles. In the upper 5% of the BMI distribution 21.4% developed diabetes. Waist ($p<0.001$) and WHR ($p<0.0037$) remained as predictors for the development of diabetes after adjusting for BMI. Risk of DM increased with increasing WHR within each BMI tertile.
Bergstrom, Newell-Morris, Leonetti, Shuman, Wahl, and Fujimoto, 1990.	146 Japanese-American men ages 62, classified at baseline as: Normal glucose tolerance n=75, Impaired glucose tolerance n=71.	Comparison of characteristics of subjects who converted to diabetes after 30-months follow up study. Height, wt, BMI. Skinfolds taken at tricep, bicep, subscapula, STR=subscapular/tricep ratio. Cross-sectional body fat areas were determined by CT at 4 sites: subcutaneous thorax, abdomen, and thigh, and intra-abdominal=IAF.	Fasting glucose, insulin, and C-peptide. Glucose at 30, 60, 90, 120, and 180 min after 75g of oral glucose load.	Two tailed t-test, Wilcoxon's rank sum test, Pearson's corr coeff, Stepwise multiple regression analysis.	Converters to NIDDM (10.3%) had higher baseline C-peptide levels ($p<0.005$), higher C-peptide/glucose ratio ($p<0.02$), and higher IAF ($p<0.005$). C-peptide corr with IAF ($r=0.26$; $p<0.002$). In the quadrant defined by high C-peptide and high IAF, 20% developed DM versus 2.5% in the low C-peptide,low IAF quadrant. Age, C-peptide, and glucose levels at 120-min were independently predictive for development of DM.

The relationship between systolic blood pressure (SBP), and diastolic blood pressure (DBP) with obesity and body fat distribution.

Obesity and blood pressure

Considerable epidemiological and clinical evidence exists to support an association between obesity and hypertension. The National Health and Nutrition Examination Survey (NHANES II), a federal survey conducted in the 1970's on a sample of U.S. residents (Van Itallie, 1985) showed that overweight American adults aged 20 to 75 years were 2.9 times more likely than non-overweight people to have hypertension. Hypertension was defined as 160 mm Hg or higher SBP or a 95 mm Hg or higher DBP, or both. Overweight people aged 20 to 45 years were 5.6 times more likely to have hypertension than were non-overweight people of the same age. The relative risk among overweight Americans aged 45 to 75 years was double that of non-overweight people in the same age range.

In the Framingham study (Kannel, Brand, Skinner, Dawber, & McNamara, 1967), the risk of developing hypertension increased with increased body weight. In the most obese group, 46% were hypertensive. In the same population, the prevalence of obesity was much greater in hypertensive than in normotensive.

Epidemiological studies have demonstrated that age is positively correlated with blood pressure (BP), which is partly related to the increased adiposity associated with

aging (Lucas, Estigarribia, Darga, and Reaven, 1985; Gerber, Schnall, and Pickering, 1990). Industrialized populations gain weight as they age, and hypertension is prevalent in these populations (Dustan, 1985).

Chiang, Perlman, and Epstein (1969) hypothesized that between 20 to 30% of hypertensive were 20% or more above the ideal weight. Recently, MacMahon, Cutler, Brittain, and Higgins (1987) found that approximately one-third of the prevalence of hypertension was attributable to obesity in males and in females aged 25 to 64 years.

Adipose tissue distribution and blood pressure

Recent studies indicate that adipose tissue distribution may also be a risk factor for hypertension. Some time ago, Vague (1956) reported his experience on the relationship between body fat distribution and the complications of obesity including hypertension. Vague noted that the metabolic and cardiovascular complications of obesity were associated with the accumulation of excess adipose tissue in the upper body (android pattern) including abdomen and chest. Obese subjects with a body fat distribution that favored the lower body, including the gluteal and femoral regions (gynoid pattern), were less likely to suffer from diabetes, hypertension, and cardiovascular diseases. Recently, the waist circumference (Gerber et al., 1990), the ratio of the intra-abdominal visceral fat area to the subcutaneous fat area (Kanai et

al., 1990), and the WHR (Landin et al., 1989) have been positively correlated with diastolic and systolic blood pressure. These studies suggest that central adiposity has more detrimental effects on blood pressure than peripheral fat accumulation.

Relationship between insulin and blood pressure in obese subjects.

There are associations between hypertension, impaired glucose tolerance, and obesity that suggest a common pathogenic mechanism. Gillum (1987), Landsberg and Krieger (1989), Lucas et al. (1985), and Rocchini (1991) suggested that variations in plasma insulin levels may play a role in the regulation of blood pressure.

Ferrannini, Haffner, and Stern (1990) estimated that by the fifth decade of life, 85% of diabetic individuals are hypertensive and obese, 80% of obese subjects have abnormal glucose tolerance and high blood pressure, and 67% of hypertensive subjects are both diabetic and obese. Insulin resistance and the resultant hyperinsulinemia are the key metabolic abnormalities that link hypertension, obesity, diabetes, and hyperlipidemia (Rocchini, 1991). Rocchini et al. (1989) using the euglycemic hyperinsulinemic clamp technique, found a significant inverse relationship between whole body glucose uptake and blood pressure in obese subjects. They also found a significant correlation between

DBP and fasting insulin concentration in obese adolescents ($r=0.64$; $p<0.001$).

Data from the San Antonio Heart Study (Haffner, Stern, et al., 1990) showed that hyperinsulinemia is more common among Hispanics than among white non-Hispanics. However, the prevalence of hypertension is higher among the white non-Hispanics than among the Hispanics. Therefore, it seems that other factors besides hyperinsulinemia may play a role in the pathogenesis of obesity hypertension.

The hyperinsulinemia of some obese subjects may contribute to the higher blood pressure among the obese as a result of insulin-induced renal sodium retention. Insulin may control blood pressure in obese subjects by a direct effect on renal sodium retention or by releasing norepinephrine (Landsberg, 1987). The sympathetic nervous system stimulates sodium reabsorption by direct effects on renal tubules, by inducing alterations in intrarenal hemodynamics and by stimulating the secretion of renin, all contributing to an increase in blood pressure.

Rocchini (1991) recently proposed a mechanism to explain how insulin resistance may result in the development of hypertension. He stated that the degree to which insulin resistance is tissue- or pathway-specific may determine whether hypertension will develop or not. According to the schema presented by Rocchini (1991) insulin resistance could be selective (affecting primarily glucose metabolism),

tissue-specific (affecting primarily skeletal muscle even though liver, adipocytes, and leukocytes may also be affected), and pathway-specific (glycogen synthesis usually affected). Some of the mechanisms by which insulin resistance could result in hypertension include changes in vascular structure and function, alterations in cation flux, activation of the sympathetic nervous system, and increased renal sodium retention.

The purpose of the last part of this section is to review and critically analyze five research papers published in the literature that specifically examined the effects of body fat distribution on blood pressure (Table 2). This section includes a review of the design of the studies, a review of the methods used to determine blood pressure, a review of the methods to determine body fat and body fat distribution, and finally, a review of the analytical methods used.

These five studies represent relatively diverse populations from Sweden (Landin et al., 1989), Japan (Kanai et al., 1990), Nigeria (Adams-Campbell et al., 1990) and the United States (Gerber et al., 1990; Peiris et al., 1989; and, Adams-Campbell et al., 1990). These studies are unusual because four of the five studies included only females, while Gerber et al. (1990) included only males. From an epidemiological perspective, the sample size in four of these studies was relatively small. The sample size

ranged from 33 (Peiris et al., 1989) to 305 (Adams-Campbell et al., 1990). The total sample was divided into subsamples in several studies which were used to compare differences between populations living in different countries (e.g., Adams-Campbell et al., 1990), differences between normotensive vs. borderline hypertensive vs. hypertensive populations (Kanai et al., 1990), and a group of 40 Swedish females who were matched according to lean vs. obese status as well as WHR using a 2x2 design (Landin et al., 1989).

The age ranges of these populations were quite different. The population evaluated by Adams-Campbell et al. (1990) included very young adult females ranging in age from 18.6 to 22.4 years while Landin et al. (1989) studied middle-aged females 54-56 years of age. The mean age of the population evaluated by Peiris et al. (1989) was 32.2 $\pm$ 0.6 years. Thus, these studies controlled for the effects of age by using a narrow age range in their research. The range in age varied from 31-73 years of age (Kanai et al., 1990) to 30-60 years (Gerber et al., 1990). Gerber et al. (1990) and Kanai et al. (1990) controlled for age in their multiple regressions analyses. In the former study, age was significantly associated with most measures of BP.

WHR was defined using the umbilicus as a landmark in three studies (Landin et al., 1989; Kanai et al., 1990; and Adams-Campbell et al., 1990) while Gerber et al. (1990) and Peiris et al. (1989) used the smallest circumference at the

abdominal region. BMI was also used as an estimate of body fat by (Kanai et al., 1990; Adams-Campbell et al., 1990; and, Gerber et al., 1990). Landin et al. (1989) calculated body fat from estimates of LBM based on total body potassium measurements and Peiris et al. (1989) used hydrostatic weighing to estimate body fat. Kanai et al. (1990) and Peiris et al. (1989) used CT to measure subcutaneous and intra-abdominal body fat. Skinfolds were used by Kanai et al. (1990) and Peiris et al. (1989) to estimate subcutaneous fat.

Blood pressure measurements in all studies were obtained using the same general equipment (i.e., standard mercury sphygmomanometers). Adams-Campbell did not report the "positional" state of the subjects when BP was measured. Landin et al. (1989) measured BP when the subjects had been in a supine position for at least 10 minutes while the other investigators measured BP of subjects in the sitting position. Gerber et al. (1990) examined the effects of body fat distribution on ambulatory, sitting, and supine (during sleep) BP.

Descriptions of all independent and dependent variables were made using descriptive statistics (e.g., means, standard deviations, and standard errors). All investigators except Landin et al. (1989) used correlation coefficients to identify any significant associations between selected dependent and dependent variables. Linear

and multiple regression analyses were used in all studies to measure the relative contribution of each of the selected dependent measures on BP. Landin et al. (1989) evaluated differences between groups using the Pitman's non-parametric test. It is not clear if the other investigators determined if their data were normally distributed. Peiris et al. (1989) used Canonical correlations to determine the relationships between the entire set of selected metabolic variables with the set of selected anthropometric variables. Kanai et al. (1990) used the student t-test for unpaired data to determine statistical differences in the selected dependent and independent variables. P-values were reported for all studies; however, only Landin et al. (1989) clearly established that they used the $p<0.05$ a-priori for their statistical analyses.

Results of these investigations did not consistently support the hypothesis that a strong association was present between body fat distribution and BP. Landin et al. (1989) reported that SBP was higher in obese females with a high WHR (WHR>0.8) compared to lean females with a high WHR as well as lean females with a low WHR (WHR<0.8; $p<0.05$). DBP was about 30mmHg higher ($p<0.01$) among obese females compared to lean females regardless of body fat distribution. However, there was no significant difference in DBP between females according to high vs. low WHR

suggesting that obesity in general, but not body fat distribution affected BP in this group of females.

Gerber et al. (1990) did not find any significant association between WHR and any measure of BP; however, waist ($r=0.20$) and hip circumferences ($r=0.22$) were significantly associated ($p<0.01$) with sleep (supine) SBP. Waist circumference was highly correlated ($p<0.01$) with weight ($r=0.87$), hip circumference ($r=0.94$), and BMI ($r=0.83$). Using stepwise multiple regression, waist circumference was predictive of both sleep SBP and DBP.

Kanai et al. (1990) did not find any significant difference in WHR among 67 Japanese females according to their BP status (i.e., hypertensive vs. borderline hypertensive vs. normotensive). Using CT to measure intra-abdominal visceral fat (VF) and subcutaneous fat (SF), the VF/SF ratio was significantly higher ($p<0.01$) in the hypertensive vs. the normotensive groups. After adjusting for age and BMI, VF/SF ratio was positively correlated with SBP ($r=0.62$; $p<0.001$) and DBP ($r=0.53$; $p<0.001$).

Adams-Campbell et al. (1990) found that Nigerian females had the largest WHR, and also had significantly higher DBP than white females. Among black American females, the BMI ($r=0.24$; $p<0.05$), waist circumference ($r=0.22$; $p<0.05$), and hip circumference ($r=0.19$; $p<0.05$) were significantly correlated with SBP after controlling for age. Among whites, SBP was correlated with BMI ($r=0.34$;

$p<0.01$), with waist circumference ($r=0.40$; $p<0.001$), with hip circumference ($r=0.33$) $p<0.01$), and with the WHR ($r=0.25$; $p<0.01$). Among Nigerian females no significant correlations were found between BP and the anthropometric measures.

Peiris et al. (1989) reported that both SBP and DBP were correlated with abdominal fat area determined by CT ($r=0.52$ for SBP, $r=0.55$ for DBP, $p<0.01$); the WHR ($r=0.55$ for SBP, $r=0.45$ for DBP, $p<0.01$), and total body fat mass ($r=0.38$ for SBP, $r=0.42$ for DBP, $p<0.05$). No significant correlation was found between SBP or DBP with subscapular SF or the subscapular/tricep SF ratio.

Table 2
Summary table for studies related to body fat, body fat distribution, sistolic, and diastolic blood pressure.

Investigators	Subjects	Measurements taken	Blood Work	Statistics	Findings
Peiris, Sothmann, Hoffmann, Hennes, Wilson, Gustafson, and Kissebah. 1989.	33 healthy premenopausal women. Ages: 32.2 ± 0.6	Body fat estimated from body density by hydrostatic weighting. Intra-abdominal fat area estimated by CT at the 4th lumbar vetebrae level. Waist circumference taken at minimal waist circumference. Hip circumference taken at the maximal hip girth. Lange caliper were used for subscapular and tricep skinfold measurement.	OGTT, Fasting insulin, cholesterol, and HDL-C.	Mean ± SE, Linear regression analysis. Multivariate regression analysis.	Total body fat mass, CT, WHR, subscapular SF, and subscapular to tricep SF ratio were positive corr. with cumulative insulin response and triglyceride concentration ($p< 0.01$). Intra-abdominal fat area, WHR, subscap SF and subscap:tricep were inversely related to HDL/chol levels ($p< 0.05$). Intra-abdom. fat area and total body fat mass correlated with SBP and DBP ($p<0.01$). WHR corr with SBP ($r=0.55$) and DBP ($r=0.45$) $p<0.01$. Visceral fat mass by CT was a predictor of SBP and DBP ($p<0.05$).
Gerber, Schnall, Pickering 1990.	135 non-obese normotensive or mildly hypertensive men. Ages: 30-60.	BMI, WHR, waist taken at minimum girth abdomen area. Hip taken at maximum hip area circumference. The effect of body fat distribution on ambulatory, sitting, and supine position blood pressure was assessed.	none	Stepwise multiple regression procedure.	Mean ambulatory work BP > home BP > sleep BP. Waist ($r=0.26$) and hip circumference (0.22) corr with sleep SBP and DBP ($p<0.01$). WHR not corr w/ any BP measurements. Waist girth highly corr with wt ($r=0.87$), hip ($r=0.94$) and BMI ($r=0.83$) $p<0.01$. In Stepwise procedure waist was predictive of sleep SBP and DBP explaining 7% of the variance.

Landin, Krotkiewski, and Smith 1989.	Forty Swedish lean and non-obese post-menopausal women. Ages 54-56. 10 lean women WHR>0.8 were matched for BF and LBM with 10 lean women WHR<0.8. Ten obese women WHR>0.8 were matched for age, fat, and LBM with 10 obese women WHR <0.8.	Waist girth was measured at the umbilicus level. Hip girth was measured over widest part of hip area. Total body potassium was determined to assess LBM. Body fat=body wt-LBM.	OGTT, fasting glucose, insulin, cholesterol and triglycerides.	Mean ± SD. Linear regression analysis. Pitman's non-parametric test to test differences between groups.	SBP higher in obese women WHR>0.8 than in nonobese groups p<0.05. DBP was higher in obese women compared with the lean (p<0.01). For DBP no diff found according WHR. TG were higher in the obese women with WHR>0.08 than in both groups of lean women. No diff. found between the non-obese groups. Obese women had higher fasting glucose, and glucose levels at 30 min during OGTT than lean groups (p<0.01).
Kanai, Matsuzawa, Kutani, Keno, Kobatake, Nagai, Fujioka, Tokunaga, and Tarui, 1990.	67 Japanese obese women. 33 hyper-tensives (HP), 9 borderline hypertensive (BHP), and 25 normotensives (N). Ages 31-73. Mean=50 ± 11 years. Women with SBP≥160 mmHg and DBP≥95 mmHg = HP. Women with SBP<140 mmHg and DBP<90 = N. Women with SBP between 140 and 159 and with DBP between 90 and 94 were classified as BHP.	Height, weight, BMI. For WHR, waist girth was measured at the umbilicus level, hip girth was taken at the widest circumference over the greater trochanter. Triceps, subscapular, and periumbilicar skinfold were taken with an Eiyoken caliper. Subcutaneous and intra-abdominal visceral fat area were measured by CT at the umbilicus level.	Fasting serum TG, TC, HDL-C, OGTT, glucose, and insulin.	Mean ± SD. Student t-test. Linear and multiple regression analysis.	No differences in WHR between HP and N. Visceral/subcutaneous fat ratio (V/S) was higher in HP than in N group (p<0.01). Positive correlation between V/S and SBP (r=0.62; p<0.001) and with DBP (r=0.53; p<0.001) after adjusting for age and BMI. No significant correlation between WHR and BP in any group.

Adams-Campbell, Nwantwa, Okoli, Omene, Haile, and Kuller, 1990.	93 Black American women (BAW). 88 White American (WA), and 124 Nigerian Women (NW). Ages 18.6 to 22.4.	Height, weight, WHR, BMI. Waist girth was taken at the umbilicus level. Hip girth was taken at widest part of the buttocks. BMI>30 Kg/m^2= obese, 30>BMI>24.1= overweight, and BMI<24.1 Kg/m^2 = lean.	none	Pearson's Product Moment Correlation Coefficient. Analysis of Variance.	BAW more overweight and obese than WAW and NW. NW had the highest WHR, and and higher DBP than BAW and WAW. Among BAW, BMI (r=0.24), waist (r=0.22) and hip (r=0.19) were correlated with SBP after controlling for age ($p<0.05$), but not corr with DBP. Among WAW SBP corr with WHR (r=0.25; $p<0.01$), waist (r=0.40; $p<0.001$), hip (r=0.33; $p<0.01$, and with BMI (r=0.34; $p<0.01$). DBP was corr with BMI (r=0.21; p,0.05). Among NW no significant correlations were found between BP and anthropometric measures.

Body Fat, Body Fat Distribution, Plasma Lipoproteins, and Coronary Heart Disease.

The association between obesity and alterations in the lipid and lipoprotein profiles has long been recognized in the literature. The results from NHANES II revealed that the relative risk of hypercholesterolemia for overweight Americans aged 20 to 75 years is 1.5 times that of those who are not overweight (Van Itallie, 1985). Overweight was defined as a BMI $\geq$ 27.8 for males, and a BMI $\geq$ 27.3 for females. Among overweight Americans aged 20 to 45 years, the relative risk of hypercholesterolemia is 2.1 times that of non-overweight Americans in the same age group (Van Itallie, 1985).

Pouliot et al. (1989) found that in non-obese premenopausal females, total adiposity measured by CT was negatively correlated with HDL apo A-1/LDL apoB ($r=-0.47$; $p<0.05$), and positively correlated with LDL-C ($r=0.46$; $p<0.05$), and with LDL-apo B ($r=0.51$; $p<0.05$). In a sample of obese premenopausal females, Despres, Moorjani et al. (1989) found that adiposity measured as BMI was negatively correlated with HDL-C ($r=-0.32$), HDL_2-C ($r=-0.30$), HDL_3-C ($r=-0.28$), and the ratio of HDL-C/LDL-C ($r=-0.30$) $p<0.05$. Similarly in males, Terry, Wood, Haskell, Stefanick, and Krauss (1989) found that BMI was negatively correlated with HDL-C ($r=-0.32$; $p<0.01$), and HDL_2 ($r=-0.31$; $p<0.01$).

Landin et al. (1989) studied the associations between the proportions of abdominal fat (estimated by the WHR) and

TC in a group of lean and obese postmenopausal females. They found that TC was lower in obese females with low WHR compared with obese females with high WHR ($p<0.05$). No differences in TC levels were found in the lean group according to WHR, suggesting that obesity is a necessary condition for the association between fat distribution and plasma cholesterol concentration.

Other studies (Table 3) have demonstrated that variations in plasma lipids and lipoproteins are related to the regional distribution of body fat (Despres, Moorjani et al., 1989; Terry et al., 1989; Pouliot et al., 1989; Freedman et al., 1990; Meilahn et al., 1991; Peeples, Carpenter, Israel, and Barakat, 1989; and, Van Gaal et al., 1989). Fujioka, Matsuzawa, Tokunaga, and Tarui (1987) were the first to suggest that the amount of visceral fat is important to consider when assessing the association between body fat distribution and lipoprotein levels.

Investigators who have used CT and or WHR to evaluate regional body fat distribution have found that females with a higher proportion of abdominal fat tend to have increased LDL-C, triglycerides, Apo B levels, and decreased HDL-C levels (Despres, Moorjani et al., 1989; Pouliot et al., 1989). These studies suggest that the relationship between obesity and HDL-C levels is primarily explained by the amount of abdominal fat. Despres, Moorjani et al. (1989) found that abdominal fat measured by CAT, independent of

total body fat, was negatively correlated with HDL-C ($r=-0.35$; $p<0.01$), HDL_2-C ($r=-0.37$; $p<0.01$), HDL-C/LDL-C ($r=-0.40$; $p<0.01$), and HDL_2-C/HDL_3-C ($r=-0.32$; $p<0.05$) ratios. They also found negative correlations between WHR and HDL-C ($r=-0.47$; $p<0.001$), HDL_2-C ($r=-0.43$; $p<0.01$), and HDL_3-C ($r=-0.44$; $p<0.01$).

Role of the Lipoprotein Lipases

Lipoprotein lipases (LPL) and hepatic-lipases (HL) play important roles in lipoprotein metabolism. Nikkila, Taskinen, and Kekki (1978) found that high LPL activity in adipose tissue was associated with high HDL levels ($r=0.66$; $p<0.001$), while high HL activity has been associated with low HDL levels. Despres, Ferland et al. (1989) examined the association between LPL, HL and plasma lipoprotein levels in 16 obese premenopausal females. They found that HL activity was negatively correlated with HDL_2-C ($r=-0.60$; $p< 0.05$), but positively correlated with deep abdominal fat after adjusting for total adiposity ($r=0.48$; $p< 0.05$). HL may play a role in the catabolism of HDL_2 or in the conversion of HDL_2 to HDL_3. The mechanism by which intra-abdominal fat accumulation is correlated with plasma HL activity is unknown. This relationship may also be affected by sex steroids that are associated with regional body fat distribution (Rebuffe-Scrive, 1988).

Role of sex steroids

Obese females with a high proportion of abdominal fat, had higher plasma free testosterone levels, and lower sex hormone binding globulin (SHBG) than obese females with a peripheral fat accumulation, suggesting that obese females with high androgenic activity could be at higher risk of developing CHD (Leibel, 1989).

Tikkanen and Nikkila (1987) reported that sex steroids affect plasma HDL_2-C levels by up- or down-regulating the HL activity. Steroids with androgenic activity increased the HL activity and reduced plasma HDL_2-C levels, while estrogenic steroids decreased HL activity and increased HDL_2-C concentrations.

Estrogens may also increase HDL-C by increasing apo A-1 synthesis. Apo A-1 is the major proteic component associated with HDL and apo B is the major proteic component associated with VLDL and LDL (Hunt and Groff, 1990). These results indicate that variations in sex steroids may represent an important factor for the association between intra-abdominal fat and HL activity. These studies contrast with the results by Soler, Folsom, Kaye, and Prineas (1989) who found that WHR was significantly associated with plasma TG (beta=2.17 $\pm$ 0.65), HDL-C (beta=-52.4 $\pm$ 19.5), apo A-1 (beta=-73.4 $\pm$ 32.0), and apo B (beta=75.8 $\pm$ 30.4) $p<0.05$ after adjusting for insulin, sex hormone binding globulin (SHBG), and estrone level. These results suggest that other

mechanisms besides sex hormone levels affect the fat distribution-lipoprotein association.

Role of glucocorticoids

Glucocorticoids may affect the body fat distribution-lipids association. A higher cortisol production rate has been reported in subjects with abdominal obesity compared to individuals with peripheral fat accumulation (Vague et al., 1985) cited by Bjorntorp (1988a). According to Bjorntorp (1991) high cortisol levels in abdominal obesity may lead to an increased VLDL production and subsequently to a decreased clearance of LDL through the apo B, and E receptor.

The precise role of obesity in the etiology of coronary heart diseases is not clear. According to the studies of Larsson et al. (1984), and Lapidus, Bengtsson, Larsson, Pennert, Rybo, and Sjostrom (1984) the changes in plasma lipid and lipoprotein profile after several years of follow up could be partly responsible for the relationship between body fat distribution and the incidence of coronary heart disease (CHD). Since dyslipoproteinemic states have been associated with the development of CHD, the relationship of fat distribution to plasma lipids and lipoproteins could be an additional factor linking abdominal fat to CHD (Despres, 1991).

Various prospective studies on the relationship between body fat distribution and CHD have been reported in the literature. Higgins, Kannel, Garrison, Pinsky, and Stokes

III (1988) reported that the relative risk of death increased 1.5 for males and 1.3 for females in the fifth quintile values of BMI, waist girth, and waist/height ratio in the Framingham study (a 24-year follow up study for the incidence of CHD for males and females). In addition, within each tertile of BMI the risk of CHD increased with increasing subscapular skinfold thickness. In the Honolulu Heart Program (a 12-year follow up study in males), the risk of CHD doubled in highest tertile compared to lowest tertile of SSF ($p < 0.01$) (Donahue, Abbott, Bloom, Reed, and Yano, 1987). Larsson et al. (1984) reported that WHR was a significant predictor for stroke and CHD even after adjusting for the degree of obesity. Within each tertile of BMI, the risk of stroke, CHD, and death doubled in the highest WHR tertile compared to the lowest WHR tertile. Similarly, in a prospective study of females by Lapidus et al. (1984), the WHR was the best anthropometric predictor for CHD. The probability of remaining free from CHD was higher for those in the lowest quintile of WHR than for those in the highest quintile. Among females with the lowest WHR not a single females developed myocardial infarction or stroke. When they compared females in the top 5% of the distribution with females in the lowest quintile for WHR, the risk ratios were 14.8 for myocardial infarction, 11.0 for stroke, and 4.8 for death from any cause.

These previous prospective studies consistently show that truncal or abdominal fatness assessed either by skinfolds or circumferences, is a risk factor for CHD. However, these findings do not mean that abdominal fatness causes CHD since there are other possible explanations for the association between obesity (including abdominal obesity) and CHD, (e.g., diet, exercise, stress, smoking, environment, and genetic predisposition among others).

Adiposity is also associated with the prevalence of hypertension, glucose intolerance, and hyperinsulinemia. Bjorntorp (1985) has suggested that the association between obesity and CHD is moderate because a lag period occurs prior to the detection of complications associated with obesity.

The last part of this section consists of a critical review of seven cross-sectional studies published in the literature that examined the relationship between body fat distribution, lipids, and lipoproteins profile (Table 3).

Study Parameters

These studies were conducted using different populations. Both Pouliot et al. (1989); and, Despres, Moorjani et al. (1989) examined Canadian lean and obese premenopausal females, respectively. Van Gaal et al. (1989) examined a group of Belgian males and females. The other

four studies were conducted in the United States, and included a mixed sample of American males and females.

The ages of subjects ranged from 30 in the study by Terry et al. (1989) to 60 in the study by Peeples et al. (1989). Van Gaal et al. (1989) did not report subjects' ages.

The sample size in these studies ranged from nine pairs of males (Peeples et al. 1989) matched for age and body fat, but differing in WHR, to 415 females and 709 males studied by Freedman et al. (1990). Meilahn et al. (1991) used a relatively large sample consisting of 429 females who were divided according menopausal state. Van Gaal et al. (1989) classified the 43 males and the 148 females according to major area of fat deposition (e,g., abdominal or gluteofemoral). Terry et al. (1989) studied males below 140% of ideal body weight, while Pouliot et al. (1989) and Despres, Moorjani et al. (1989) studied a group of lean premenopausal females, and a group of obese premenopausal females, respectively.

Anthropometric measurements

WHR and BMI were used as an estimate for body fat distribution, and as an estimate of general obesity, respectively, in all seven studies. However, the measurement site for the waist and the hip circumferences were not consistent among the studies. Freedman et al. (1990); and Terry et al. (1989) measured waist circumference

at the umbilicus and hip circumference at the widest part of the hips and buttocks. Van Gaal et al. (1989), and Peeples et al. (1989) measured waist circumference at the umbilicus but measured hip circumference in the iliac crest. Meilahn et al. (1991), Despres, Moorjani et al. (1989), and Pouliot et al. (1989) measured waist circumference at the smallest area of the torso and hip circumference at the widest part of the hips and buttocks.

Body density was determined by hydrostatic weighing and percent body fat was calculated from body density using Siri's equation in four of the seven studies (Pouliot et al., 1989; Peeples et al., 1989; Terry et al., 1989; and Despres, Moorjani et al., 1989. Despres, Moorjani et al. (1989) and Pouliot et al. (1989) used computed axial tomography for the determination of deep and subcutaneous abdominal adipose tissue at the thoracic level (Th8-Th9) and at the abdominal level (L4-L5), and at the mid-thigh region adipose tissue (mid distance between the knee joint and the iliac crest). Both groups of investigators used the same scanner and the same procedure. Despres, Moorjani et al. (1989) found a close correlation ($r=0.94$, $p<0.0001$) between the adipose tissue volume obtained by computed tomography and body fat mass derived from hydrostatic weighing. SF thicknesses were used to estimated body fat and body fat distribution in only one of the studies (Terry et al.,

1989). The subscapular to triceps skinfold thickness ratio (STR) was used as an estimate for central adiposity.

Blood work

Six studies determined TC levels, TG, and HDL-C. In addition, Meilahn et al. (1991), Despres, Moorjani et al. (1989), and Pouliot et al. (1989) determined HDL-C, HDL_2-C, and HDL_3-C. Freedman et al. (1990) and Peeples et al. (1989) determined the TC/HDL-C ratio, and ApoA-1. Van Gaal et al. (1989) determined LDL-C and the TC/HDL-C ratio that they used as an atherogenic index (AI). Despres, Moorjani et al. (1989), Pouliot et al. (1989), and Terry et al. (1989) in addition to the basic lipoproteins and lipids, determined a variety of lipoprotein subfractions and ratios.

Statistical Analysis

Pouliot et al. (1989), Freedman et al. (1990), Terry et al. (1989), and Despres, Moorjani et al. (1989) used the Pearson's product-moment correlation coefficient and partial correlations adjusting for other measures of adiposity to measure relationships between variables. Meilahn et al. (1991) used nonparametric tests to assess associations between variables. Freedman et al. (1990), Van Gaal et al. (1989), Peeples et al. (1989), and Despres, Moorjani et al. (1989) used a t-test to assess differences in lipids and lipoproteins among groups. Meliahn et al. (1991), Freedman et al. (1990), and Despres, Moorjani et al. (1989) used multiple regression analysis to evaluate the variance in TC,

lipoproteins, and apoproteins levels that could be explained by body fat, and body fat distribution.

Results

Van Gaal et al. (1989) found that males with abdominal obesity (AO) had higher TG ($p<0.05$) and lower HDL-C ($p<0.005$) than males with GFO, while females with AO had higher levels of TG ($p<0.001$) and TC ($p<0.05$) than females with GFO. Similarly, Peeples et al. (1989) found that males with AO had higher TG (89 $\pm$ 13 vs. 151 $\pm$ 12), TC/HDL-C (3.39 $\pm$ 0.5 vs. 4.95 $\pm$ 0.4), and Apo B levels (95 $\pm$ 7 vs. 138 $\pm$ 8) than males with GFO ($p<0.05$), but lower levels of HDL-C (53 $\pm$ 7 vs. 38 $\pm$ 4), Apo A-1 (100 $\pm$ 7 vs. 84 $\pm$ 8), and Apo A-1/ Apo B ratio (1.11 $\pm$ 0.19 vs. 0.64 $\pm$ 0.05) than males with GFO ($p<0.05$). Terry et al. (1989) found that after adjusting for %BF and STR, the WHR was negatively correlated with HDL-C ($r=-0.32$; $p<0.01$), and positively correlated with TG ($r=0.27$; $p<0.05$).

Freedman et al. (1990) also found a positive correlation between WHR and TG (males; $r=0.37$, females; $r=0.38$; $p<0.001$), TC (males; $r=0.27$, females; $r=0.26$; $p<0.001$), apo B (males; $r=0.30$, females; $r=0.34$; $p<0.001$), TC/HDL-C (males; $r=0.35$, females; $r=0.30$; $p<0.001$), and a negative correlation between WHR and HDL-C (males; $r=-0.22$, $p<0.001$, females; $r=-0.14$, $p<0.01$), and apo A-1 (males; $r=-0.14$, $p<0.001$). However, it is not clear if these correlations were adjusted by other measures of general

obesity. Despres, Moorjani et al. (1989) found similar results. WHR was negatively correlated with HDL-C ($r=-0.47$; $p<0.001$), HDL_2-C ($r=-0.43$, $p<0.01$), and HDL_3-C ($r=-0.44$, $p<0.01$). Deep abdominal fat (DAF) was negatively correlated with HDL-C ($r=-0.35$, $p<0.01$), HDL_2-C ($r=-0.37$, $p<0.01$), and HDL_3-C ($r=-0.27$, $0.05<p<0.06$). WHR was a better predictor than DAF for HDL-C, HDL_2-C, and Apo A-1 levels, while DAF was better than WHR for the lipoprotein ratios. Meilahn et al. (1991) found that WHR and BMI divided into quintiles were negatively associated with HDL-C, HDL_2-C, and HDL_3-C levels ($p<0.01$). For females in the highest quintile of BMI, HDL-C, HDL_2-C, and HDL_3-C were, respectively, 15mg/dl, 10.5mg/dl, and 4.5mg/dl lower than for females in the lowest quintile of BMI ($p<0.01$). For females in the highest quintile of WHR, HDL-C, HDL_2-C, and HDL_3-C were, respectively, 14mg/dl, 10mg/dl, and 4.4mg/dl lower than for females in the lowest quintile of WHR ($p<0.01$). Apo A-1 did not vary significantly by WHR ($p=0.22$), but tended to be lower among females with a high WHR. However, apo A-1 was negatively associated with BMI ($p<0.01$). When the sample was cross-stratified by BMI and WHR in tertiles, HDL_2-C showed a decrease with increased BMI and WHR, (no statistical value was reported). When the sample was divided according to certain "healthy" habits such as exercise habits and cigarette smoking, HDL-C was 18mg lower in the unhealthy behavior group than in the

healthy behavior group ($p<0.05$). The unhealthy behavior group included females who smoked, who were in the highest two quintiles for BMI, and in the lowest two categories of physical activity. Pouliot et al. (1989) reported that total adiposity measured as body density was positively correlated with LDL-C ($r=0.46$), LDL apo B ($r=0.51$), and negatively correlated with HDL apo A-1/LDL apo B ($r=-0.47$) ($p<0.05$). Adipose tissue volume (measured by CAT), BMI, and WHR were not correlated with HDL-C, HDL_2-C or HDL_3-C. The abdominal fat cell weight correlated negatively with HDL-apo A-1 ($r=-0.51$; $p<0.05$), and HDL_2-C ($r=-0.51$; $p<0.05$).

Conclusions:

Six of the seven studies consistently reported a significant negative correlation between WHR and lipoproteins. WHR was negatively correlated with HDL-C (Freedman et al., 1990 (males: $r=-0.22$, $p<0.001$; females: $r=-0.14$, $p<0.01$); Van Gaal et al., 1989 ($p<0.005$); Terry et al., 1989 ($r=-0.32$, $p<0.01$); Peeples et al., 1989 ($p<0.05$); and Despres, Moorjani et al., 1989 ($r=-0.47$, $p<0.001$), with HDL_2-C (Meilahn et al., 1991 ($p<0.01$); and Despres, Moorjani et al., 1989, ($r=-0.43$, $p<0.01$), and with HDL_3-C (Despres, Moorjani et al., 1989, $r=-0.44$, $p<0.01$). Pouliot et al. (1989) did not found any correlation between WHR or adipose tissue volume measured by CT and HDL-C, HDL_2-C, or HDL_3-C. Pouliot et al. (1989) explained that their findings suggest that in lean premenopausal females, variations in WHR did

not reflect the variations in regional fat distribution and fat cell size that are associated with an altered lipoprotein-lipid profile.

These results support previous reports of associations between regional adiposity patterns and plasma lipid and lipoprotein cholesterol concentrations.

Table 3
Summary table for studies related to lipids and lipoproteins, body fat and body fat distribution.

Investigators	Subjects	Measurements Taken	Blood Work	Statistics	Findings
Freedman, Jacobsen, Barboriak, Sobocinski, Anderson, Kissebah, Sasse and Gruchow, 1990.	415 women, mean age = 39. 709 men, mean age = 40.	Weight, Height, BMI, Waist girth was taken at umbilicus level. Hip girth was taken at the widest part of the hips and buttocks.	Cholesterol, triglycerides, HDL-C, Apo B, Apo A1.	Wilcoxon Chi-square test. Pearson correlation coeff. Regression analysis adjusting for covariates, Paired t-test.	Higher levels of TG, TC/HDL-C, and Apo B among men ($p<0.001$). WHR and BMI higher in men ($p<0.001$). WHR corr with: men women (r-values) TC: 0.27 0.26 TG: 0.37 0.38 ApoB 0.30 0.34 TC/HDLC 0.35 0.30 HDLC -0.22 -0.14 apo A1 -0.14 -- ($p<0.001$)
Van Gaal, Vansant, and Leeuw, 1989.	Belgian Women=148 Men=43 Women: with abdominal obesity (AO)= 118, with gluteo-femoral obesity (GFO)=30. Men: AO=24, GFO=19.	Waist girth taken at umbilicus level. Hip girth taken at the iliac crest level.	TC, TG, LDL-C, HDL-C, Atherogenic Index=(AI) AI=TC/HDL-C.	Unpaired t-test.	TG, HDL-C, and AI were diff between sexes ($p<0.001$). Men higher in TG and AI. Men with AO had higher TG ($p<0.05$) and lower HDL-C ($p<0.005$). Women with AO had higher TG ($p<0.001$) and TC ($p<0.05$). Females AI higher for AO groups ($p<0.005$).

Terry, Wood, Haskell, Stefanick, and Krauss, 1989.	81 men, ages 30-55, below 140% of ideal weight.	Ht, wt, BMI, WHR, STR, waist girth taken at umbilicus level, hip girth taken at the largest area around buttocks. SF taken with Harpenden caliper in subscapular, abdominal, suprailiac, midthigh, and calf areas. %BF estimated by hydrostatic weighing. 66 people completed a 3-day diet record.	Cholesterol, Serum lipoprotein mass concentration, HDL-C, HDL_2, HDL_3, LDL, VLDL.	Pearson's Product Moment correlation coefficient, Partial correlations, $p < 0.05$ considered significant.	After adjusting for %BF and STR, WHR corr with: r-value p-value TG 0.27 $p<0.05$ HDL_2 -0.47 $p<0.0001$ HDL-C -0.32 $p<0.01$ No corr between HDL_3 and WHR. WHR was not corr with Kcals, fat, protein, carbohydrate or alcohol intake. Polyunsaturated fat/1000 Kcals was neg corr with WHR.
Peeples, Carpenter, Israel, and Barakat, 1989.	Nine pairs of men matched for age and body fat, with different WHR. Ages 34-60.	Waist girth taken at umbilicus level, hip girth taken at superior iliac spine level. WHR > 1.0= AO. WHR < 1.0= GFO %BF estimated by hydrostatic weighing.	TG, TC, HDL-C, LDL-C, Apo A1, ApoB.	Two tailed student t-test.	Subjects with AA had lower levels of: HDL-C: 53 $\pm$ 7 vs 38 $\pm$ 4 ApoA1: 100 $\pm$ 7 vs 84 $\pm$ 8 ApoA1/ApoB: 1.11 $\pm$ 0.19 vs 0.64 $\pm$ 0.05, ($p<0.05$) and higher levels of: TG: 89 $\pm$ 13 vs 151 $\pm$ 12 TC/HDLC: 3.39 $\pm$ 0.5 vs 4.95 $\pm$ 0.4, and Apo B: 95 $\pm$ 7 vs 138 $\pm$ 8 than subjects with GFO. ($p<0.05$).
Meilahn, Kuller, Mathews, Wing, and Caggeula, 1991.	429 women ages 45-54. 282 pre-menopausal, 74 peri-menopausal, 62 post-menopausal, and 11 hysterectomized.	Height, weight, BMI. Waist girth taken at smallest area around natural waist. Hip girth taken at the largest circumference around hips.	TC, HDL-C, HDL_2-C, HDL_3-C, Apo A1.	Spearman's p (non-parametric) corr. Multiple linear regression, 1-way ANOVA. Tests performed separate for each menopausal status.	WHR and BMI in quintiles neg associated with HDL-C, HDL_2-C, and HDL_3-C. When cross-stratified by BMI and WHR (tertiles), HDL_2-C decline with increases in WHR and BMI. Kcals/wk was neg corr with WHR ($r=-0.17$; $p<0.01$).

Despres, Moorjani, Ferland, Tremblay, Lupien, Nadeau, Pinault, Theriault, and Bouchard, 1989.	52-premenopausal Canadian obese women, ages 35.7 ± 5.5 yrs.	Waist girth taken at narrowest part of torso, hip girth taken at maximal extension of buttocks. CT taken for determination of DAF and subcutaneous abdominal adipose tissue (AT) and mid-thigh region. Body density, %BF and fat mass estimated by hydrostatic weighing.	TC, TG, HDL-C, HDL_2-C, HDL_3-C, VLDL, LDL, Apo A1, Apo B.	Pearson's Product Moment Corr Coeff. Student t-test, Multiple regression analysis, Stepwise regression analysis.	WHR was neg corr with: r-value p-value HDL-C -0.47 p<0.001 HDL_2-C -0.43 p<0.01 HDL_3-C -0.44 p<0.01 DAF was neg corr with: HDL-C -0.35 p<0.01 HDL_2-C -0.37 p<0.01 and HDL-C/LDL-C -0.40 p<0.01 WHR was better than DAF as an independent covariate of HDL-C, HDL_2-C, and HDL Apo A1 levels.
Pouliot, Despres, Moorjani, Tremblay, Lupien, Nadeau, Theriault, and Bouchard, 1989.	22-healthy sedentary, lean pre-menopausal Canadian women ages 34.6 ± 3.1. CT taken at thoracic Th8-Th9, and at abdominal L4-L5, and at mid-thigh (mid distance between the knee and the iliac crest.	Waist girth taken at smallest torso area. Hip girth taken at buttock area. Mean fat cell size and wt determined by adipose tissue biopsy. Body density and BF determined by hydrostatic weighing. Deep abdom. and sub. fat areas determined by CT.	TC, TG, HDL-C, HDL_2-C, HDL_3-C, LDL-C, HDL Apo A1, LDL Apo B.	Pearson's Product Moment correlation coefficient.	Total adipocity pos corr with: r-value p-value LDL-C: 0.46 p<0.05 LDLApoB: 0.51 p<0.05 and neg corr with: HDLApoA1/LDLApo B r=-0.43, p<0.05. BMI, WHR and AT were not corr with HDL-C, HDL_2-C or HDL_3-C. Abdominal fat cell weight neg corr with: HDL Apo A1 r=-0.51, and HDL_2-C r=-0.51 (p<0.05).

The Relationship Between Physical Activity, Diet, Obesity, and Body Fat Distribution.

Obesity is the result of a positive energy balance. The accumulation of fat suggests that more food energy has been stored than has been utilized. Increased physical activity leading to increased energy expenditure and subsequently reduced body fat can be an effective treatment for obesity (Krotkiewski, 1988). The critical question is whether physical activity can induce changes in adipose tissue distribution. Two important key factors are physical activity; and, the quality and quantity of food intake.

Effects of aerobic exercise on body fat distribution

Researchers are interested in determining if exercise training can reduce or mobilize fat from different body regions. Despres, Tremblay, Nadeau, and Bouchard (1988) have postulated that since males have larger abdominal fat depots than females, a caloric deficit induced by aerobic exercise may produce a greater fat mobilization in males that females. Tremblay, Despres, and Bouchard (1988) found that after 15-weeks of high intensity exercise, 7-sedentary non-obese males reduced trunk skinfolds (sum of subscapular, suprailiac, and abdomen) by 27% and reduced peripheral or extremities skinfolds (sum of biceps, triceps, thigh, and calf) by 15% suggesting a preferential mobilization of trunk fat. Similarly, Bouchard et al. (1990) reported that trunk and extremities SF decreased 31% and 24%, respectively, in a group of five males after high intensity exercise. Thus,

abdominal fat may be less difficult to mobilize than gluteofemoral fat.

The next section of this review represents a critical analysis of five recently published articles dealing specifically with the effect of physical activity on body fat, and body fat distribution measured by BMI, WHR, skinfolds ratio, or by CT (Table 4).

Four of the five studies (Anderson et al., 1991; Bouchard et al., 1990; Bjorkelund et al., 1991; and Marti et al., 1990) were longitudinal studies on the effects of an exercise intervention program on body composition. Tremblay, Despres et al. (1990) conducted a cross-sectional study in which they evaluated relationships between estimates of leisure-time energy expenditure with anthropometric measures.

The ages of the subjects were relatively similar in four of the five studies ranging from an average of 25 years (Bouchard et al., 1990) to an average of 39 years (Marti et al., 1990). Bjorkelund et al. (1991) studied an older group of females (average age 55 years). Two of the research groups (Bouchard et al., 1988; and, Marti et al., 1990) studied 5 and 65 males, respectively. Bjorkelund et al. (1991) studied a group of 65 females. Anderson et al. (1991) and Tremblay, Despres et al. (1990) included both males and females; however, they analyzed the data for males and females independently.

In order to compare males with females of a similar body fat mass, Anderson et al. (1991) divided the females group arbitrarily in lean and obese groups based on percent body fat. This resulted in one group of females with a mean BF of 24.8 kg, and another group with a mean BF of 31.2 kg. Bjorkelund et al. (1991) developed three groups according BMI and WHR. Group #1 included females with gluteofemoral obesity (GFO); group #2 included females with abdominal obesity (AO); and, group #3 included females with general obesity. Tremblay, Despres et al. (1990) categorized their sample by gender, into four groups on the basis of the mets value for leisure-time activities estimated by the used of a questionnaire. Group A: mets<5; group B: 5≤mets<7; group C: 7≤mets<9; and group D: mets≥9. A met was defined as the energy cost of the activity expressed as kilocalories expended per kilogram of body weight per hour of activity (1met= 1 kcalorie/kg of body weight/hour of activity). All of these subjects were outpatients except those studied by Bouchard et al. (1990) who lived as inpatients in a research center for four months.

The WHR was used as an estimate of body fat distribution in every study. Anderson et al. (1991) defined the waist circumference at the level of the umbilicus. Bouchard et al. (1990) and Tremblay, Despres et al. (1990) measured the waist circumference at the smallest area of the trunk, while Bjorkelund et al. (1991) defined the waist area

between the lower rib margin and the iliac crest. Marti et al. (1990) did not specify the area used for measuring waist or hip circumference. For the other four studies, hip circumference was measured at the widest part between hips and buttocks. In addition to using various estimates of WHR, other measures of body composition have been used. These measures included: K^{40} estimates of lean body mass (Anderson et al., 1991), underwater weighing to estimate body density (Bouchard et al., 1990), bioelectrical impedance to estimate body fat (Marti et al., 1990), and skinfolds measurements to estimate subcutaneous fat (Bouchard et al., 1990; Marti et al., 1990; and Tremblay, Despres et al., 1990).

The exercise prescription and the kind of activities prescribed varied among these studies. The duration of the program lasted from 12 weeks (Anderson et al., 1991; Bjorkelund et al., 1991) to 16 weeks (Bouchard et al., 1990; Marti et al., 1990). The type of exercise was mainly aerobic. Exercise prescription included cycling twice a day for 53-minutes (Bouchard et al., 1990), walking 1-hour every two weeks or jogging 120-minutes/week (Bjorkelund et al., 1991; Marti et al., 1990) or a combination of high intensity exercise, mixed with less intense exercise such as jogging (Anderson et al., 1991).

Diet was monitored in 3 of the 4 studies that included physical activity. Marti et al. (1990) did not assess diet

but subjects were asked to keep diet constant. Anderson et al. (1991) collected a diet history 3-times during the study but the participants did not receive any dietary advice. Bjorkelund et al. (1991) provided the subjects with food and nutrition education, and cooking activities. Bouchard et al. (1990) monitored daily food intake to make sure each subject ate only the amount of energy prescribed.

Results:

In most of the studies, the subjects experienced a decrease in body weight, BMI, waist circumference, hip circumference, and percent of body fat except for the subjects studied by Marti et al. (1990). Only WHR decreased significantly in the latter study. WHR was not reduced in every study. Both males and females had a similar decreased in hip and waist circumference ($p<0.05$) leading to an unaltered change in WHR in the study by Anderson et al (1991). Bouchard et al. (1990) found that the subcutaneous fat in the trunk decreased more (31%) than the subcutaneous fat in the extremities (24%), with no change in WHR. Bjorkelund et al. (1991) found that females with abdominal obesity decreased waist circumference by 3.9%, hip circumference by 1.3% and WHR 2.4% while the females with general obesity or gluteofemoral obesity did not change waist or hip circumference or WHR. Tremblay, Despres et al. (1990) found that both males and females categorized in the

highest activity intensity group where characterized by a reduced WHR even after controlling for SSF ($p<0.05$).

A common finding among the 6 studies was that the fattest subjects tended to lose more weight and more fat. Also the subjects with abdominal obesity decreased WHR while the subjects with gluteofemoral obesity seemed to be more resistant to changes in WHR (Bjorkelund et al., 1991).

The reason for the more rapid decrease in abdominal fat in abdominal obesity in comparison to gluteofemoral obesity could be due to a combination of factors:

1. higher lipolytic activity in the upper abdominal region in comparison with the gluteofemoral region (Rebuffe-Scrive et al., 1988);

2. higher LPL activity in the gluteofemoral region in gynoid obesity (Leibel et al., 1989);

3. the lipolytic response to norepinephrine (NE) is greater in abdominal than in femoral adipocytes in premenopausal females. Femoral and gluteal LPL activity is greater in premenopausal females than in males. This high gluteal-femoral LPL activity disappears with menopause, which is associated with the female adoption of an android male habitus pattern. Administration of estrogen plus levonorgestrel specifically increased femoral LPL activity in postmenopausal females (Rebuffe-Scrive et al., 1987);

4. the contribution of the fat mobilization from the intra-abdominal fat depots, in addition to subcutaneous fat,

exerting an additive effect on the decrease in the waist circumference (Krotkiewski, 1988). Intra-abdominal fat has higher basal and catecholamine-stimulated lipolysis activities (Fried and Kral, 1987);

5. Vansant, Den Besten, Weststrate, and Deurenberg (1988) reported that abdominal fat cells are relatively larger than gluteofemoral fat cells, and that in the gluteofemoral area the number of fat cells is elevated. Therefore, the gluteofemoral or hyperplastic obesity would be more resistant to weight loss than abdominal or hypertrophic obesity.

Effect of diet on body fat distribution:

Most of the available data related to alterations in adipose tissue distribution with nutritional intervention deals with changes in subcutaneous fat thicknesses. Most of the literature on nutritional interventions focused on changes in total body composition and not on changes in body fat distribution. The quality of food intake may indirectly affect body composition. Krotkiewski (1988) reported that an increase in the percentage of fat intake depresses the synthesis of SHBG, which in turn leads to an increased concentration of free testosterone. Testosterone, like other anabolic steroids induces changes that give rise to metabolic abnormalities similar to those observed in abdominal obesity.

Vansant et al. (1988), Krotkiewski (1988), and Wadden et al. (1988) studied the effect of a low calorie diet on body fat distribution in a group of females (Table 4). In addition Wadden et al. (1988) assessed the effect of behavior therapy alone or in combination with a low calorie diet on body fat distribution. Vansant et al. (1988) divided their group according to WHR, matching for weight, age, and BMI. The subjects in the three studies consumed very low calorie diets (VLCD); 1000Kcals/day (Vansant et al., 1988), 544Kcals/day (Krotkiewski, 1988), and from 400 to 1200 kcals (Wadden et al., 1988). The duration of the diet treatments were 4-weeks (Krotkiewski, 1988), 4-6 months (Wadden et al., 1988), and 8-weeks (Vansant et al., 1988).

Results:

Vansant et al. (1988), Wadden et al. (1988), and Krotkiewski et al, (1988) found that subjects, especially those with abdominal obesity, had a significant decrease in body weight, and WHR. Vansant et al. (1988) found that the abdominal obese group decreased WHR ($p<0.01$) but the gluteofemoral obese group did not. Similarly, Wadden et al. (1988) found that the abdominal obese group decreased WHR by 2.7% versus 0.1% in the gluteofemoral obese group. Krotkiewski (1988) found a decrease in WHR of 3% at the end of the first two-weeks, and a decrease of 6% at the end of four weeks. At both intervals, Krotkiewski (1988) found that fat cell weight decreased more in the abdominal region

(14%), compared to the gluteofemoral region (7%). The group studied by Wadden et al. (1988) that received a combination of a low kcalorie diet plus behavior therapy lost more fat than the group that received the low calorie diet or behavior therapy alone ($p<0.053$). No information was reported about changes in WHR according to treatment.

Summary

It seems that subjects with isolated abdominal obesity benefit more from exercise and/or diet intervention programs than subjects with general obesity (Bjorkelund et al., 1991). In subjects with general obesity, exercise failed to modify the WHR even when they had a decrease in waist and hip circumference (Anderson et al., 1991). Subjects consuming low calorie diets decreased their WHR. With exercise intervention some subjects reduced %body fat, BMI, and subcutaneous fat without changes in WHR (Anderson et al., 1991; Bouchard et al., 1990) suggesting that fat distribution may be determined by a strong genetic component. Subcutaneous fat and WHR were generally lower in subjects who regularly practiced vigorous physical activities (Tremblay, Despres et al., 1990). More research on the effects of exercise and/or diet on fat distribution are needed. The intervention programs should be longer in duration and body fat distribution should be assessed with more refined tools.

Table 4
Summary table for studies related to exercise and diet and the effect on body fat and body fat distribution.

Investigators	Subjects	Measurements taken	Treatment	Statistics	Findings
Anderson, Xu, Rebuffe-Scrive, Terning, Krotkiewski, and Bjorntorp, 1991.	22 pre-menopausal women and 9 men. Selection criteria: ages 25 to 40 yrs and BMI 24-27.	Weight, ht, BMI, WHR waist girth taken at the umbilicus level, hip girth taken at the widest part of the hip region. Lean body mass (LBM) estimated by K40. Body fat=body wt-LBM.	60-min sessions 3X/wk for 12 wks consisting of 10-min warm up plus 3 periods of strenuous exercise (5-min each) with a mean intensity of aprox 80% of maximal working capacity. This was interspersed with less intensity exercise like jogging, coordination and strength exercises. Exercise was ended with a 10-min cool down.	Student t-test, ANOVA.	Men decreased BW, BMI, waist, hip circumference and body fat ($p<0.05$). No changes in WHR. Leaner women decreased waist ($p<0.05$) and hip ($p<0.01$) and increased LBM ($p<0.05$). Obese women decreased waist ($p<0.001$), hip ($p<0.05$), and body fat ($p<0.05$) and increased LBM ($p<0.05$). No WHR changes. Obese women had a significant decrease in energy intake.
Bouchard, Tremblay, Nadeau, Dussault, Despres, Theriault, Lupien, Serresse, Boulay, and Fournier, 1990.	5-men,moderate overweight BMI=27.5 $\pm$ 2.9 Ages 25 $\pm$ 3.	Weight, ht, BMI, body density determined by underwater weighing. Waist girth taken at smallest area around the trunk, hip girth taken at the widest part around the buttocks. WHR was determined. Ten skinfolds measurements were taken and the trunk/extremities skinfold ratio was determined.	Two 53-min sessions/day, 6-days/wk on a bicycle ergometer for 16 weeks. Exercise induced a 4.2 MJ/day (1000 kcals) energy surplus above RMR.	Duncan multiple range test, ANOVA.	Body wt, BMI, %BF, and fat mass decreased ($p<0.001$). Body density increased ($p<0.01$) and the sum of the 10 skinfold measurements decreased ($p<0.001$). Subcutaneous fat in the trunk decreased by 31% and the subcutaneous fat in the extremities decreased by 24% ($p<0.001$). No changes in WHR, trunk/extremities skinfold ratio or in fat-free mass.

Bjorkelund, Bengtsson, Carazo, Palm, Tarschys, and Wassen, 1991.	65-women group 1: 22 women with: BMI $\geq$ 30 and WHR < 0.82, group 2: 27 women with: BMI < 30 and WHR $\geq$ 0.82, group 3: 16 women with: BMI $\geq$ 30 and WHR $\geq$ 0.82. Ages 45-64.	Weight, ht, BMI, waist girth taken between the lower rib margin and the iliac crest. Hip girth taken at the widest point between hips and buttocks.	Nutrition education meetings 3 hours every two weeks and walking for 1-hour. Duration of the program=12 weeks.	Student t-test, Duncan multiple range test.	Group #2 decreased BW by 4%, BMI by 3.9%, and waist girth by 3.9% ($p<0.001$). WHR was reduced by 2.4% ($p<0.01$). Group #1 reduced BW and BMI ($p<0.05$). No differences for group #3. Group #2 had greater reductions in WHR than group #1 and group #3 ($p<0.01$).
Marti, Suter, Riesen, Tschopp, Wanner, and Gutzwiller, 1990.	61-sedentary Swiss men, ages 38.8 $\pm$ 8.9. 39 jogging group, 22 controls.	Height, wt, BMI, WHR, 4-SF taken: (suprailiac, subscapular, tricep, and radial). Body fat estimated by bioelectrical impedance measurement.	Home base program of 120-min/wk jogging or jogging/walking divided into 2 to 6 sessions/wk for 16 weeks. Intensity at 85% of HR at the anaerobic threshold.	Unpaired t-test, Pearson's Product Moment corr coeff.	BMI, SK, %BF, and WHR decreased during the intervention program. Only WHR achieved statistical significance ($p<0.001$).
Tremblay, Despres, Leblanc, Craig. Ferris, Stephens, and Bouchard, 1990.	1366 women and 1257 men participants in the 1981 Canada Fitness Survey ages: 20-49. Groups: A: mets<5 B: 5$\leq$mets<7 C: 7$\leq$mets<9 D: mets$\geq$9.	Height, weight, BMI. Waist girth taken at smallest area around the trunk, hip girth taken at widest part around buttocks. WHR was determined. SF: bicep, tricep, suprailiac, subscapular and calf.	Energy expenditure of leisure activities estimated by a questionnaire. met=1kcal/kg/hour of activity. Subjects were divided into 4-groups on basis of the mets values according activities performed.	ANOVA, ANCOVA controlling for SSF.	Men and women categorized in the high met group were characterized by the lowest WHR even after controlling for SF ($p<0.05$). Women in groups C and D had lower skinfolds than women in group A. Men in group D had lower skinfolds than men in group A ($p<0.05$).

Vansant, Den Besten, Weststrate, and Deurenberg, 1988.	17 pre-menopausal obese women BMI > 27, ages 28-44 yrs, divided into: 9 AO, WHR>0.8 and 8 GFO WHR<0.8. Groups were matched for age, wt and BMI.	Weight, ht, BMI, WHR. Body fat mass estimated by under-water weighing.	8-week diet of 4.2MJ/day (1000 Kcals/day) providing 20% protein, 30% fat. A 24-hr diet recall was collected every two weeks.	Student t-tests and paired t-test.	Both groups had a decrease in BMI and %BF. Body fat mass decreased an average of 7.0 Kg. WHR decreased in the AO group ($p<0.01$). WHR did not change in the GFO group. Waist girth decrease more in the AO than in the GFO group but it was not statistically significant.
Wadden, Stunkard, Johnston, Wang, Pierson, Van Itallie, Costello, and Pena, 1988.	68-women ages 42.5 $\pm$ 9.5 yrs divided into: group #1: 22 women in a VLCD, 400-500 Kcals for 2 months and 1000-1200 Kcals for other 2 months. Group #2: 22 women Behavior therapy and 1000-1200 Kcal diet for 6-months. Group #3: 24 women with a combination of groups 1 and 2.	Body fat was evaluated by total body K, total body water, and by anthropometry. Waist girth was taken at smallest area of torso, hip girth was taken at the iliac crest level. Five circumferences were taken: arm, chest, waist, iliac crest, and thigh.	Women were divided into 3 groups receiving: a low calorie diet, behavior therapy or a combination of both.	Paired t-test, ANOVA.	Group #1 lost 10.4 $\pm$ 4.1 Kg, group #2 lost 10.8 $\pm$ 6.3 Kg, group #3 lost 15.2 $\pm$ 7.6 Kg. Group #3 lost significantly more than groups 1 and 2 ($p<0.03$). Group #3 lost more fat than the other groups ($p<0.053$). Heavier and fatter subjects lost more wt and fat. WHR decreased by 1.2 % in the 3 groups ($p<0.05$). Waist decreased by 8.3% and hip decreased by 7.3%. The % reduction in waist was greater that the one for hips ($p<0.04$). Subjects with AO decreased WHR by 2.7%, subjects with GFO increased WHR by 0.1%. A decrease in the 5 circumferences accounted for 61% of the variance in fat loss.

Krotkiewski, 1988.	25-obese premenopausal women.	Weight, WHR, fat cell weight.	544 cal/day diet for 4-weeks.	T-test.	At the end of 2-weeks, body wt decreased 7.4 Kg ($p<0.05$), fat cell weight decreased 5% in gluteal region and 8% in abdominal region. Waist girth decreased 8% ($p<0.001$), hip 4% ($p<0.05$), and WHR 3% ($p<0.01$). At the end of four-weeks, cell wt decreased 7% in gluteal region, 14% in abdominal region. Waist was reduced by 10%, hip 5%, and WHR 6% ($p<0.001$).

The Relationship Between Exercise, Glucose, Insulin, Lipoproteins, Systolic Blood Pressure, and Diastolic Blood Pressure.

Exercise and the effect on insulin and glucose levels

Training can reduce plasma insulin without any deterioration in glucose tolerance (Tremblay, Nadeau et al., 1990). This information is consistent with the concept that insulin sensitivity is improved in trained people. The low plasma insulin levels observed in trained individuals may be explained by an increased clearance and by a reduced secretion of the hormone.

Inactive individuals have improved insulin sensitivity after endurance training. This observation is supported by experiments with rats. The rate of insulin release from islets of Langerhans of trained rats was lower than that from islets of sedentary controls. According to Rodnick et al. (1987) cited by Vranic and Wasserman (1990) strenuous training increases insulin sensitivity in liver, muscle, and adipocytes in athletes. Krotkiewski et al. (1985) found that moderate exercise improved glycosylated hemoglobin and insulin secretion independently of body weight loss in subjects with NIDDM. Trovati et al. (1984) cited by Vranic and Wasserman (1990) found that insulin sensitivity improved with exercise training in NIDDM patients. In addition, Taylor, Ram, Zimmet, Raper, and Ringrose (1984) found that

the prevalence of NIDDM was two times larger in sedentary than in active males.

In obese subjects a training program may improve insulin sensitivity even with no changes in weight or body composition (Krotkiewski et al., 1985). However, since weight reduction by itself can also improve insulin sensitivity, a combined program of exercise and diet may enhance weight reduction and improve insulin action.

Skeletal muscle is the major site of the increase in insulin action that occurs with training. The skeletal muscle adapts to aerobic exercise training to use fuel and oxygen more efficiently. In addition to skeletal muscle, adipose tissue undergoes several adaptations to training. James, Kraegen, and Chisholm (1985) found that regular physical activity increases insulin-stimulated glucose uptake, oxidation, and incorporation into fatty acids in rat adipocytes. The improvement in insulin action may be related to reduced fat cell size after physical training.

Exercise and the effect on lipoproteins levels

Physical activity may affect lipoprotein levels although other lifestyle habits such as alcohol consumption, cigarette smoking, certain drugs, body fat gain or lost, and diet, may also be involved. According to Haskell (1986) when active males and females are compared with the more sedentary ones, the active ones have lipoprotein patterns associated with a reduced risk of atherosclerosis. Exercise

programs, especially jogging, may be potentially effective as a non-pharmacological way of increasing serum HDL-C (Marti et al., 1990).

Manninen et al. (1988) stated that every 1% increase in HDL-C may translate into as much as a 3% reduction of coronary risk. Marti et al. (1990) found a significant increase in HDL-C levels (0.12mmol/l; $p<0.028$) in a group of joggers when compared to a control-sedentary group after 4-months of exercise. The increase in HDL-C levels was apparently mediated through a decrease in body fat content. Body fat was a more powerful predictor Of HDL-C concentration than were the changes in physical activity. From the regression analysis of change in HDL_2-C, Marti et al. (1990) estimated that a decrease in the sum of 4 SF by 18mm would raise the HDL_2-C concentration by 0.15 mmol/l.

According to Leibel et al. (1989) lipoproteins levels may be affected by body fat distribution and adipose tissue lipolysis. Abdominal adipocytes seems to be more responsive to the lipolysis induced by catecholamines than femoral adipocytes resulting in selective loss of abdominal fat versus gluteofemoral fat. Beta-receptor sensitivity to norepinephrine (NE) is increased with exercise training, probably enhancing the lipolytic effect of catecholamines.

Sopko et al. (1985) and Thompson et al. (1988) found that HDL-C increased without a decrease in fat loss with exercise training. Other investigators (Savage et al.,

1986; and Hagan, Upton, Wong, and Whittam, 1986) found no increase in HDL-C despite a substantial decrease in body fat. Tran and Weltman (1985) cited by Marti et al. (1990) concluded that exercise and weight loss separately and independently increase HDL-C; and, that their effects are additive. The mechanism of the effect of long term exercise on HDL-C concentration is not fully understood (Eckel, 1989). An increase in adipose tissue LPL activity may mediate the conversion of VLDL to HDL. LPL activity increases by exercise training and is higher in runners than in sedentary people. On the other hand, hepatic lipase (HL) is lower in active people, and is decrease by exercise. These changes following endurance exercise training are associated with an improved lipoprotein profile (Wood and Stefanick, 1990). The HL plays a major role in the conversion of HDL_2 to HDL_3, and participates in the conversion of VLDL, IDL, and large LDL to IDL and small LDL.

Wood and Stefanick (1990) reported that LPL activity is greater in red (slow-twitch) muscle fibers than in white (fast-twitch) fibers. In addition, higher levels of HDL-C are observed in people who have higher ratios of red to white fibers than do people with high ratios of white to red fibers. Red fibers play an essential role in endurance activities, such as long distance running.

Effect of exercise training on blood pressure.

According to Hagberg (1990) hypertension is one of the most serious problems in industrialized societies. McArdle et al. (1986) reported that hypertension imposes a chronic, excessive strain on the normal functioning of the cardiovascular system. Uncorrected chronic hypertension can lead to heart failure or stroke. According to Kannel et al. (1984), males with blood pressures greater than 160/95 have a threefold elevation in their risk for developing coronary artery disease and intermittent claudication, and a fourfold increase in their risk for congestive heart failure and stroke. Even males with blood pressures between 140/90 and 160/95 have their risk doubled for these cardiovascular complications. The same relationship seen for males exists for females but their disease prevalence is lower than males at any level of blood pressure.

Although the degree to which regular exercise can benefit a hypertensive condition is still unclear, it appears that both systolic and diastolic blood pressures can be lowered to a modest degree with a program of aerobic type exercise (Seals and Hagberg, 1984). Several studies have examined the relationship between physical activity and blood pressure. Montoye et al. (1972) cited in Hagberg (1990) in a review of 15 epidemiological studies concluded that when a difference was noted between active and inactive populations, the active group always had the lowest blood

pressure. They also found a close relationship between body fatness and blood pressure. They also noted that more active populations were also leaner than sedentary populations. Therefore, these data suggest that physical activity may result in lower systolic and diastolic blood pressure. However this lowering effect in blood pressure may also be the result of less body weight and body fat in active individuals instead of a direct result of exercise. Hagberg (1990) recently concluded that endurance-exercise training results in a lowering of both systolic and diastolic blood pressures by approximately 10 mm Hg in individuals with essential hypertension.

According to Urata et al. (1987) and Kiyonaga et al. (1985) cited by Hagberg (1990) some of the mechanisms proposed to mediate the antihypertensive effect of endurance-exercise training are: the reduction in body weight and body fat, and reductions in plasma norepinephrine levels.

The last part of this section consists of a review of seven research articles published in the literature that have examined the effect of physical activity on glucose, insulin, lipoprotein levels, and systolic and diastolic blood pressure, or a combination of two or more of these parameters (Table 5).

The studies were conducted using different populations: United States (Blumenthal et al., 1991; and Nieman et al.,

1990), Canada (Despres, Tremblay et al., 1990; and Tremblay, Nadeau et al., 1990), Sweden (Andersson et al., 1991; and Bjorkelund et al., 1991), and Switzerland (Marti et al., 1990). Marti et al. (1990), Despres, Tremblay et al. (1990), and Tremblay, Nadeau et al. (1990) evaluated only males. Anderson et al. (1991) studied both males and females. Anderson et al. (1991) analyzed their data for males and females separately since the parameters studied may have a different response for each gender.

The sample sizes for each study were different. Despres, Tremblay et al. (1990) and Tremblay, Nadeau et al. (1990) used a very small sample size of only 5 males. The sample sizes in the other five studies were also relatively small ranging from 21 to 65 subjects.

All the subjects in the seven studies participated in some kind of aerobic exercise. Only two studies (Marti et al., 1990; and Nieman et al., 1990) included a control group of non-exercising subjects. The duration of the exercise programs was not similar in all the studies varying from 5 weeks to 16 weeks. The exercise frequency and intensity were different for each study ranging the frequency from 120-minutes/week to 636-minutes/week, and the intensity from 55 to 80% VO_2 max.

Despres, Tremblay et al. (1990) and Tremblay, Nadeau et al. (1990) working with the same sample used the same exercise intervention previously described by Bouchard,

Tremblay et al. (1990). In these two studies, subjects performed their exercise sessions (two 53-minute sessions per day) on a bicycle ergometer for a period of 100 days, 6-days/week with one day of rest/week. Blumenthal et al. (1991) randomly assigned the group to either aerobic exercise or to a circuit Nautilus training program. Anderson et al. (1991) had the subjects exercise strenuously for 5-minutes three times per session alternating with less intense exercise for 60-minutes. Blumenthal et al. (1991), Marti et al. (1990), Bjorkelund et al. (1991), and Nieman et al. (1990) included walking and/or jogging in the exercise program as part of the aerobic exercise.

Tremblay, Nadeau et al. (1990) and Anderson et al. (1991) examined the effect of aerobic exercise upon glucose, insulin, and C-peptide levels. Bjorkelund et al. (1991) examined the effect of exercise on blood pressure, glucose and TC. Nieman et al. (1991), Despres, Tremblay et al. (1991), Blumenthal et al. (1991), and Marti et al. (1991) examined the effect of aerobic exercise on lipids, specifically TC, HDL-C, LDL-C. Only Marti et al. (1991) included the HDL_2-C and HDL_3-C subfractions.

Tremblay, Nadeau et al. (1990), Despres, Tremblay et al. (1990), and Nieman et al. (1990) controlled the quantity and quality of the diet the subjects received. In the first two studies, the mean energy intakes during the exercise program were 13.8 + 2.0 MJ/day. Subjects received a 1268

calories lactovegetarian diet through the duration of the study in the study by Nieman et al (1990). Anderson et al. (1991) collected a diet history before, during and after the program to verify that the subjects did not change their eating patterns. The participants in this study did not receive any dietary advice during the study. Blumenthal et al. (1991) requested that the subjects follow their usual dietary patterns throughout the study. Dietary habits were assessed by self-report, including a 4-day food diary and a 2-week retrospective food recall questionnaire. Marti et al. (1990) also requested that their subjects keep diet constant but diet was not assessed.

In general, the response of fasting insulin, glucose, TC, and C-peptide values were similar among these studies. Both Tremblay, Nadeau et al. (1990) and Anderson et al. (1991) reported a decrease in insulin values after exercise training ($p=0.006$ and $p=0.05$, respectively) but did not find any changes in fasting glucose. Anderson et al. (1991) found a decrease in C-peptide ($p<0.01$ for males, $p<0.05$ for females), insulin and TC ($p<0.05$) for both males and obese females. No changes in insulin were observed in the group of lean females. Bjorkelund et al. (1991) did not find any decrease in fasting glucose, systolic or diastolic blood pressure in any of the groups even when body fat decreased. Blumenthal et al. (1991) and Anderson et al. (1991) collected systolic and diastolic blood pressure data, but

did not report their findings after intervention. In addition, Blumenthal et al. (1991) found that after adjusting for age and initial lipid values, the aerobic exercise group had lower Apo-II values (41.9 $\pm$ 9.7 vs. 46.7 $\pm$ 4.2 mg/dl, p=0.08) and higher apo A-I/apo A-II ratio (3.5 $\pm$ 0.4 vs. 3.8 $\pm$ 0.5, p=0.08) than the strength exercise group. HDL-C increased slightly but not significantly in both groups. Marti et al. (1990) and Despres, Tremblay et al. (1990) found a significant increase in HDL-C at the end of the program ($p<0.03$ and $p<0.05$, respectively). Despres, Tremblay et al. (1990) also found a decrease in VLDL-TG, TC, and LDL-C, and an increase in HDL-C/LDL-C ($p<0.05$). Marti et al. (1990) reported an increase in HDL-C/TC (t=0.023, p=0.47), and a decrease in VLDL cholesterol (t=-0.25, p=0.009). Nieman found that HDL-C decreased in both groups from baseline to the first 2-weeks from 1.54 to 1.33 mmol/L ($p<0.05$). The non-exercising group decreased HDL-C more than the exercising group from 1.49 to 1.10 mmol/L ($p<0.05$). However, by the fifth week the exercising group increased HDL-C to baseline values (1.54 mmol/L) while the non-exercising group did not (1.33 mmol/L). In this last study, moderate exercise training attenuated the decrease in HDL-C and by the fifth week values were back to baseline concentrations. Both exercising and control groups experienced a decreased in body weight and body fat, TC, TG, LDL-C, and fasting glucose levels ($p<0.05$). These results

are consistent with other studies (Follick et al., 1984; and Kohlmeier et al., 1985) cited by Nieman et al. (1990) who reported that HDL-C decreased in females or remain unchanged during active stages of weight loss.

It is difficult to assess both the cross sectional and longitudinal studies since there are many factors that affect lipids and blood pressure that are difficult to control. Gender, age, race, socioeconomic status, body composition, diet, alcohol consumption, and cigarette smoking are among these factors.

Table 5
Summary table for studies related to diet and exercise and the effect on lipids, lipoproteins, fasting insulin, and glucose.

Investigators	Subjects	Treatment	Blood Work	Statistics	Findings
Blumenthal, Matthews, Fredrikson, Rifai, Schniebolk, German, Steege, and Rodin, 1991.	25-premeno-pausal and 25 post-menopausal non obese women ages 45-57.	Sample was randomly assigned to aerobic exercise or strength/flexibility groups. Aerobic group exercised 3X/wk, consisting of 15-min warm up, 35-min walking and jogging at 70% HR reserve. The strength and flexi-bility group exer-cised 2X/wk, 20-min stretching and flex-ibility exercises and 35-min circuit Nautilus training. Both groups exer-cised for 12 weeks.	TC, LDL-C, HDL-C. Apo A1 and Apo A 11.	Analysis of variance, Analysis of covariance.	After adjusting for age and initial lipids values, the aerobic group had lower Apo AII values, and higher Apo A I/Apo AII ratio (p=0.08). HDL-C increased lightly in both groups.
Marti, Suter, Riesen, Tschopp, Wanner, and Gutzwiller, 1990.	61-sedentary Swiss men, ages 38.8 ± 8.9. 39 jogging group, 22 controls.	Home base program of 120-min/wk jogging or jogging/walking, divided into 2 to 6 sessions/wk for 16 weeks. Intensity at 85% of HR at the anaerobic threshold.	TC, HDL-C, HDL_2-C HDL_3-C. VLDL-C.	Unpaired t-test, Pearson Product Moment corr coeff.	Exercisers increased HDL-C ($p<0.03$), and HDL-C/TC ($p<0.47$), and decreased VLDL-C ($p=0.009$) as compared to controls. HDL_2-C and HDL_3-C did not change significantly. Changes in HDL_2-C corr with changes in SSF ($r=-0.39$, $p<0.001$).
Despres, Tremblay, Moorjani, Lupien, Theriault, Nadeau, and Bouchard, 1990.	5-men, moderate overweight BMI=27.5 ± 2.9 Ages 25 ± 3.	Two 53-min sessions/day, 6-days/wk on a bicycle ergometer. At 55% VO_2max. Exercise induced a 4.2 MJ/day energy surplus above RMR.	TC, TG, HDL-C, and LDL-C.	Duncan multiple range test.	Subjects decreased VLDL-TG, TC, and LDL-C ($p<0.05$), an increased HDL-C and HDL-C/LDL-C increased ($p<0.05$), at the end of the program.

Tremblay, Nadeau, Despres, ST-Jean, Theriault, and Bouchard, 1990.	5-men, moderate overweight BMI=27.5 $\pm$ 2.9 Ages 25 $\pm$ 3.	Same as below.	Glucose, insulin, OGTT, glucagon and C-peptide.	Duncan multiple range test, ANOVA.	Pre and post-prandial insulin levels decreased ($p<0.02$). Fasting insulin ($p=0.006$) and glucagon ($p=0.08$) decreased.
Anderson, Xu, Rebuffe-Scrive, Terning, Krotkiewski and Bjorntorp, 1991.	22 premenopausal women and 9-men. Selection criteria: ages 25-40 yrs and BMI 24-27.	60-min sessions 3X/wk for 12 weeks: 10-min warm up plus 3 periods of strenuous exercise (5-min each) with intensity of aprox. 80% VO_2max. This was interspersed with less intensity exercise: jogging, coordination and strength exercises.	Glucose, insulin, C-peptide, TC.	Student t-test, ANOVA.	Men and obese women decreased C-peptide ($p<0.01$ for men, $p<0.05$ for women) insulin and TC ($p<0.05$). Leaner women decreased TC and C-peptide ($p<0.05$). Obese women decreased energy intake ($p<0.05$).
Bjorkelund, Bengtsson, Carazo, Palm, Tarschys, and Wassen, 1991.	65-women 22 with: BMI $\geq$ 30 and WHR < 0.82 27 with: BMI < 30 and WHR $\geq$ 0.82 16 with: BMI $\geq$ 30 and WHR $\geq$ 0.82. Ages 45-64.	Dietary classes with 3 hours meetings every two weeks and walking for 1-hour for 12-weeks.	Fasting glucose, TC, SBP, and DBP.	Student t-test, Duncan multiple range test.	No significant changes in glucose, TC, SBP or DBP in any group.
Nieman, Haig, Fairchield, De Guia, Dizon, and Register, 1990.	21 mildly obese women (20-40% overweight) randomly divided into exercise (11) and non-exercise group (10).	Group were fed with a 1268-kcal lactovegetarian diet for 5-weeks. The exercise group walked at 60% heart rate reserve 45-min sessions, 5X/week.	TC, glucose, HDL-C, LDL-C.	Pearson's Product Moment corr coeff, ANOVA, Dunn-Sidak procedure, simple univariate t-test.	Both groups decreased HDL-C from baseline to the 1st 2 wks, control group decrease more than the ex-group. By the 5th week the ex-group increase HDL-C to baseline levels. Both groups decrease TC, LDL-C, TG and glucose levels ($p<0.05$), but there was no diff. between groups.

CHAPTER III

METHODOLOGY

The methodology section consists of a description of the participants, the program and its implementation, the laboratory and anthropometric methods used, and the analysis of the data. Within each section, the specific procedures used to collect data and the protocols used to implement the objectives of the study are described.

Subjects

Following completion of the informed consent form approved by the departmental Human Subjects Review Committee (Appendix B), the subjects were recruited from participants in the spring 1990 RESHAPE program through TV and newspaper media. Fifty-five subjects were recruited. There were 20 male subjects and 35 female subjects.

Subjects were excluded from the RESHAPE program if they did not have the appropriate physician's clearance (Appendix C). Subjects who were over 35 years of age or had a medical history of heart disease, diabetes or hypertension, regardless of age, were required to have a physician's clearance. All subjects were given the opportunity to participate regardless of gender or age.

Data Collection

Demographic Information

Demographic data, including age and sex, were collected at the time of the initial visit. Both personal and familial medical history information were collected for CHD, hypertension, diabetes, obesity, cancer, respiratory disease, renal disease, liver disease, GI disease, osteoporosis, and arthritis.

Anthropometric Data

The weight, height, blood pressure, skinfolds thickness, and waist and hip measurement were measured for each subject. Height and weight were determined using a "Detecto" beam balance scale with the attached stadiometer. The scale was calibrated at zero pounds. The participant was weighed without shoes, jewelry, and outer garments. Weight was recorded in pounds to the nearest tenth of a pound. Height was measured at week 0. The measurement was taken to the nearest tenth of an inch. Pounds and inches were converted to kilograms and centimeters, respectively. Lange skinfold calipers were used to determine the four skinfold thickness: triceps, biceps, subscapular, and suprailiac. All measurements were taken on the right side of the body by trained graduate students.

Triceps and biceps skinfolds were measured at a point midway between the lateral margin of the acromion and

olecranon process with the right arm held pendant. The subscapular skinfold was measured at the medial angle of the inferior border of the scapula. The suprailiac skinfold was measured superior and medially from the tip of the iliac crest. Body fat was estimated from the sum of the four skinfolds according to standards developed by Durnin and Womersley (1974) (Appendix D). These variables were measured again at week 12.

Regional adiposity, reflected by the WHR was measured as follows: using a non-stretchable measuring tape, waist circumference was measured at the level of the umbilicus. Hip circumference was measured at the widest part between hip and buttocks.

Body mass index (BMI) = Wt/Ht^2 was calculated for each subject. Obesity was defined according to the criteria of The National Research Council (1989) as described in the Review of Literature chapter.

Diet Analysis

A 4-day diet record was collected for Tuesday, Thursday, Saturdays, and Sundays for each subject during the first week and during the last week of the RESHAPE program. The subjects were instructed on the proper technique for collecting a food record at home (Appendix E). The food record was used because this method is the most reliable and valid dietary survey instrument (Bazzarre & Myers, 1978).

Nutrient values were obtained using The Food Processor II computerized program (Hefferren, 1989). The average daily intake for the 4-day period was used for statistical analysis.

Clinical Data

Blood pressure was measured using a standard mercury sphygmomanometer after the subjects were seated in a quiet area for at least 5 minutes. The first and fifth Korotkoff (disappearance of sound) were taken as the systolic and diastolic pressures, respectively. The average of the two measurements, taken sequentially, was used in data analysis.

Blood Analysis

At the initial screening and again at week 12, approximately 20 ml of blood were drawn from each subject after a 12-hour fast. The blood analysis took place at the UNCG laboratory in the Department of Food and Nutrition and Food Service Management.

Total plasma cholesterol was determined according to the procedure described by Allain, Poon, Chan, Richmond, and Fu (1974) (Sigma Chemical Company kit #352-20) (Appendix F). The procedure generated oxidation products by cholesterol oxidase following cholesterol ester hydrolysis by cholesterol esterase. The use of these enzymes was coupled

with the p-hydroxybenzenesulfonate and 4-aminoantipyrine chromogenic system. The reactions employed were as follows:

1. Cholesterol Esters $\xrightarrow{\text{Cholesterol Esterase}}$ Cholesterol + Fatty Acids

2. Cholesterol + O_2 $\xrightarrow{\text{Cholesterol Oxidase}}$ Cholest-4-en-3-one + H_2O_2

3. $2H_2O_2$ + 4-Aminoantipyrine + p-Hydroxybenzene-sulfonate $\xrightarrow{\text{Peroxidase}}$ Quinoneimine Dye + $4H_2O$

In the last step, hydrogen peroxide reacted with 4-aminoantipyrine and p-hydroxybenzenesulfonate in the presence of peroxidase to yield a quinoneimine dye, which had a maximum absorbance at 500nm. The amount of color produced was directly proportional to the concentration of total cholesterol in the sample. Absorbancies were determined using the Bausch & Lomb Spectronic 2000 spectrophotometer. The HDL-cholesterol fraction was measured following the precipitation of the VLDL and the LDL fractions with heparin manganese according to the procedure described by Warnick and Albers (1978) (Appendix F). The HDL_3-C subfraction was determined by the dextran sulfate precipitation method (MW=15,000) according to Gidez, Miller, Burstein, Slagle, & Eder (1982). The HDL_2-C subfraction was measured by subtracting HDL_3-C from HDL-C.

Glycosylated hemoglobin (HbA1) was determined using the procedure described by Gabbay, Hasty, Breslow, Ellison, Bunn, and Gallop (1977) (Sigma Chemical Company kit # 440,

P. O. Box 14508, St. Louis, MO 63178) (Appendix F). Fasting insulin was measured by radioimmunoassay according to the procedure described by Hales and Randle (1963) (kit #TKIN2 from DPC Diagnostic Products Corporation 5700 West 96th Street Los Angeles, CA 90045) (Appendix F). Fasting glucose levels was measured following the procedure by Stein (1963) (kit #16-UV from Sigma Chemical Company St. Louis, MO). This method uses the enzymatic action of hexokinase and glucose-6-phosphate dehydrogenase on glucose to ultimately produce NADH. Glucose concentration was determined from spectrophotometric changes in absorbance at 340 nm. Absorbancies were measured with the Bausch & Lomb Spectronic 2000 spectrophotometer. Detailed procedure steps are listed in Appendix F. All samples were measured in duplicate. Duplicate samples were re-analyzed if the percent difference was greater than two percent. The average of the duplicate readings was used in data analysis.

Measures of Stress

Each subject's stress level was assessed by two different instruments: the Current Self-Appraisal Questionnaire developed by Bazzarre (unpublished) (Appendix G), and the State-Trait Anxiety Inventory (STAI) developed by Spielberger, Gorsuch, and Lushene (1970) (Appendix H). The purpose of these instruments was to have information about subject's feelings on the day the blood sample and

blood pressure were taken (Current Self Appraisal), and to determine actual levels of A-State intensity induced by stressful experimental procedures (STAI). The A-State scale is a sensitive indicator of the level of transitory anxiety experienced by patients in counseling, psychotherapy, and behavior therapy (Spielberger et al., 1970). Since stress and other factors such as body weight and age can have a marked impact on cardiovascular disease risk factors, an effort was made to evaluate the relative contribution of these factors and diet on the dependent variables.

Intervention Program

Physical Activity and Lifestyle Management Program

Lifestyle workshops took place on Monday evenings from 7:00 to 8:30 p.m. Topics discussed included: lifestyle management, proper foot attire for exercise, nutrition, benefits of physical activity and a healthy diet, evaluation of fad diets, cold weather workouts, stress management, behavior change techniques, cholesterol and fiber, food laboratories on low calorie meals, how to eliminate empty calories, and cutting out fat and sugar.

Walking/Jogging Sessions

The exercise program consisted of "fast" walking therapy sessions which met three times per week (Monday, Wednesday, and Thursday) for 12 weeks. The walking took

place along city streets close to the UNC-G campus. Subjects were encouraged to walk at least two additional times per week on their own.

The sessions began with a 5-10 minute warm-up period. The first exercise session began with 20 minutes of walking/jogging at week 1 and was gradually increased five-minute per week and maintained at 60 minutes per session for weeks 8-12. The exercise sessions ended with a 5-10 minutes cool-down, stretching period.

Walking was performed at a calculated target heart rate of approximately 65-75% of maximal heart rate. The percentage of maximal heart rate for each participant was determined by the Karvonen method.

The Karvonen formula:

220-age= estimated maximal heart rate.

maximal heart rate - resting heart rate= heart rate range.

heart rate range X 0.65 = exercise heart rate.

Exercise heart rate + resting heart rate = target heart rate(65%).

The target heart rate was divided by six to obtain a rate for 10 seconds. Heart rates were recorded before and after each session as well as at intervals during each session. Participants learned how to take a 10 seconds pulse by palpating the radial artery or the external carotid artery. If the rate in 10 seconds exceeded the target range, the

participant was told to decrease their exercise intensity, or to increase their exercise intensity if the rate was below the target range. The exercise sessions were led by exercise therapists with proper training in measuring heart rate, stretching exercises, and CPR certification.

Data Analysis

Data analyses were conducted using SAS (Statistical Analysis System, Cary, NC). The statistical analyses were conducted for males and females, separately. Preliminary analysis included the calculation of descriptive statistics (mean, and standard error of the mean) for the independent variables age, height, body weight, BMI, SSF, %BF, WHR, waist and hip circumferences.

The Pearson's Product Moment Correlation coefficients were used to assess the correlations between the dependent variables: fasting glucose, insulin, HbA1, SBP, DBP, TC, HDL-cholesterol, HDL_2-C, HDL_3-C, and the independent variables (WHR, BMI, and the SSF as well as dietary variables such as kcalories, protein, fat, carbohydrate, cholesterol, polyunsaturated/saturated fat ratio, dietary fiber, calcium, sodium, potassium, and the zinc/cooper, calcium/sodium, and potassium/sodium ratios). The Pearson product moment correlation coefficient was also used to assess associations between changes in SSF, WHR, and body weight, with changes in each of the dependent variables.

Since each group of variables can be measured in several ways, the initial correlation analyses were used to identify the related anthropometric variables (WHR, SSF, and BMI) that were significantly correlated with the dependent variables.

Multiple regression analyses were used to assess the associations between the dependent variables and SSF and WHR. When the associations between the dependent variables and the SSF were estimated, age and WHR were included in the model to adjust for any confounding effect. Age and the SSF were controlled for when the associations between the dependent variables and WHR were estimated.

The relationships between the dependent variables and the categorical WHR variable were estimated using analysis of covariance. The WHR was divided into tertiles for each gender as discussed in the review of the literature section. Age and the SSF were used as covariates.

A paired-difference t-test was used to test the differences between week 0 and week 12 for each of the variables: BW, BMI, SSF, %BF, WHR, waist and hip circumference, stress scales: CSA and STAI, dietary variables: calories, fat, dietary fiber, and cholesterol, and the time taken to walk a mile as a measure of cardiovascular fitness.

CHAPTER IV

RESULTS

The results of this dissertation research are summarized in Tables 6 through 26. This section has been organized to include a general description of the population studied and the results of the statistical analyses for each hypothesis.

This research consisted of two studies: The cross sectional component for hypotheses 1 through 4; and, the longitudinal component for hypotheses 5 through 12. For the cross sectional component, the associations between each of the nine dependent variables (insulin,glucose, Hb A_1, SBP, DBP, TC, HDL-C, HDL_2-C, and HDL_3-C) and the independent variables (age, WHR, SSF, and BMI), were evaluated. For the longitudinal component, changes between week 0 and week 12 were examined in the dependent variables, and in the following anthropometric variables: body weight, BMI, SSF, %BF, and WHR; dietary variables: calories, fat, dietary fiber, and cholesterol; measures of stress: Current self appraisal and STAI scale; and the one-mile test as a measure of cardiovascular fitness. Each hypothesis was tested separately for males and females.

Participation

Fifty-five subjects were recruited from participants in the Spring 1990 RESHAPE program as discussed in the methodology section. There were 20 male subjects and 35 female subjects. Dropouts occurred in each group. At the end of the program 15 male subjects and 21 female subjects remained in the study. The reasons for dropping out were difficulty with parking, problems taking time off from work, and declining motivation. In the final experimental group only 5 females and 3 males returned dietary data at week 12. Eight males and 16 females participated in the final walk evaluation. For the cross sectional study in this dissertation research (hypotheses 1 through 4), data from all the participants at week 0 (baseline) were used. For the longitudinal component of this dissertation research (hypotheses 5 through 12) where comparisons between week 0 and week 12 are made, only data for subjects available from both data collection periods were used. The control group was so small at week 12 that no hypotheses were tested for the control group. Although the small sample size and the less than complete follow-up data limit the generalizability of the results, the data from these participants were analyzed to determine whether there was evidence for an effect of the exercise and nutrition education program on body fat, body fat pattern, and various physiological variables.

Descriptive Characteristics of Participants

The descriptive characteristics of the participants are given in Table 6. The average age for males was 46.9 ± 1.5 years (38 to 62 years). The average age for females was 44.8 ± 2.2 years (17 to 67 years). For males, the BMI was 31.3 ± 1.8, the %BF was 30.8 ± 1.7, the SSF was 83.3 ± 8.6, and the sum of tricep and subscapular SF was 47.6 ± 4.2. For females, the BMI was 26.6 ± 0.8, the %BF was 35.3 ± 0.7, the SSF was 73.4 ± 3.4, and the sum of tricep and subscapular SF was 43.0 ± 1.9. The average WHR for males was 1.05 ± 0.04, while for females the average WHR was 0.90 ± 0.01. Waist circumferences were 113.2 ± 4.4 cm and 97.3 ± 2.4 cm for males and females, respectively. Hip circumferences were 109.1 ± 4.2 cm for males and 108.6 ± 2.2 cm for females.

The WHR was divided into tertiles as a categorical variable to evaluate the association between an increase in WHR tertile and changes in the estimated means of the dependent variables. The ranges used to create the tertiles are presented in the following table:

Ranges of the WHR tertiles

Gender	Tertiles Low	Medium	High
Males	≤0.92	0.92<WHR<1.07	≥ 1.07
Females	≤0.77	0.77<WHR<0.83	≥ 0.83

Table 6

Age and Anthropometric Data for Males and Females Participants at Week 0 (baseline).

Variable	Males (Mean ± SEM)	Females (Mean ± SEM)
Age(yrs)	46.9 ± 1.5	44.8 ± 2.2
n:	16	31
Height (cm)	180.0 ± 1.8	163.0 ± 1.4
n:	15	28
Body weight(Kg)		
Week 0	101.0 ± 5.2	72.4 ± 2.4
n:	16	31
BMI(Wt/Ht^2)		
Week 0	31.3 ± 1.8	26.6 ± 0.8
n:	15	28
SSF (mm)		
Week 0	83.3 ± 8.6	73.4 ± 3.4
n:	16	31
Body fat (%)		
Week 0	30.8 ± 1.7	35.3 ± 0.7
n:	16	31
Waist (cm)		
Week 0	113.2 ± 4.4	97.3 ± 2.4
n:	16	30
Hip (cm)		
Week 0	109.1 ± 4.2	108.6 ± 2.2
n:	16	30
WHR		
Week 0	1.05 ± 0.04	0.90 ± 0.01
n:	16	30

Dietary Variables

Twenty-three females and 12 males completed food records at baseline. The mean calorie intake was 2311 ± 175 and 1740 ± 110 for males and females, respectively. The mean fat percent intake was 37 ± 2 and 36 ± 2%, for males and females, respectively. The mean carbohydrate percent intake was 49 ± 2, and 47 ± 2%, for males and females, respectively. The mean dietary fiber intake was 19 ± 2 and 15 ± 1g, for males and females, respectively.

Pearson product moment correlation coefficients between the dependent variables and the selected dietary variables are presented in Tables 7 through 9. Insulin was significantly correlated with polyunsaturated/saturated fat ratio ($r=-0.64$; $p=0.001$) and with dietary fiber ($r=-0.46$; $p=0.03$) in females ($n=23$). SBP was significantly correlated with dietary cholesterol in males ($r=0.59$; $p=0.03$) ($n=13$). TC was significantly correlated with calories ($r=0.38$; $p=0.04$) and carbohydrates ($r=0.49$; $p=0.009$) in females, and with protein ($r=-0.53$; $p=0.03$) and zinc/cooper ratio ($r=-0.52$; $p=0.04$) in males (Table 8). HDL-C was significantly correlated with calories ($r=0.39$; $p=0.04$), protein ($r=0.55$; $p=0.002$), and fat ($r=0.38$; $p=0.04$) in females (Table 9). Glucose, Hb A_1, DBP, HDL_2-C, and HDL_3-C were not significantly correlated with any dietary variable in males or females. The hypertension risk factor variables (SBP and

Table 7
Pearson Product Moment Correlation Coefficients Between Selected Dietary Variables and Diabetes Risk Factors.

Variable	Insulin	Glucose	Hb A_1
	r-value; p-value		
Calories			
males=13	-0.27; 0.37	0.10; 0.74	-0.27; 0.38
females=23	0.03; 0.89	0.21; 0.33	-0.07; 0.76
Protein			
males=13	-0.06; 0.83	0.37; 0.21	0.12; 0.71
females=23	-0.25; 0.27	0.13; 0.55	-0.00; 0.99
Fat			
males=13	-0.12; 0.69	0.04; 0.90	-0.09; 0.77
females=23	0.18; 0.43	0.26; 0.22	-0.12; 0.57
Carbohydrates			
males=13	-0.32; 0.28	0.08; 0.78	-0.45; 0.12
females=23	-0.08; 0.74	0.02; 0.93	-0.02; 0.92
Cholesterol			
males=13	-0.04; 0.89	0.14; 0.64	-0.23; 0.45
females=23	0.04; 0.84	0.12; 0.57	0.21; 0.32
PS ratio[a]			
males=13	0.12; 0.69	0.09; 0.77	-0.06; 0.85
females=23	-0.64; 0.001*	-0.16; 0.44	0.09; 0.68
Dietary Fiber			
males=13	-0.28; 0.34	0.38; 0.20	0.06; 0.84
females=23	-0.46; 0.03*	-0.08; 0.69	-0.01; 0.98
Zinc/Copper			
males=13	0.48; 0.09	-0.20; 0.50	0.38; 0.20
females=23	0.26; 0.26	0.04; 0.86	-0.01; 0.95

* significant at $p \leq 0.05$ level.
a=polyunsaturated/saturated fat ratio.

Table 8

Pearson Product Moment Correlation Coefficients Between Selected Dietary Variables, Total Cholesterol as CHD Risk Factor and Hypertension Risk Factors.

Variable	SBP	DBP (r-value; p-value)	TC
Kcalories			
males=13	0.14; 0.64	-0.41; 0.17	-0.17; 0.53
females=25	0.10; 0.64	0.11; 0.60	0.38; 0.04*
Protein			
males=13	0.32; 0.29	-0.27; 0.36	-0.53; 0.03*
females=25	0.05; 0.81	0.12; 0.57	0.18; 0.35
Fat			
males=13	0.24; 0.42	-0.40; 0.17	-0.42; 0.10
females=25	0.12; 0.58	0.21; 0.31	0.23; 0.23
Carbohydrates			
males=13	-0.09; 0.78	-0.26; 0.39	0.25; 0.34
females=25	0.08; 0.71	-0.03; 0.89	0.49; 0.009*
Cholesterol			
males=13	0.59; 0.03*	0.10; 0.76	-0.46; 0.07
females=25	-0.14; 0.51	-0.02; 0.91	0.30; 0.12
PS ratio[a]			
males=13	-0.05; 0.87	0.46; 0.11	0.14; 0.61
females=25	0.07; 0.73	0.05; 0.80	-0.06; 0.78
Dietary Fiber			
males=13	-0.22; 0.47	-0.54; 0.06	-0.11; 0.67
females=25	-0.14; 0.49	-0.21; 0.32	0.16; 0.40
Calcium			
males=13	0.12; 0.68	-0.44; 0.12	X
females=25	-0.19; 0.37	-0.16; 0.45	X
Sodium			
males=13	0.21; 0.49	-0.26; 0.40	X
females=25	0.11; 0.60	0.28; 0.18	X
Potassium			
males=13	-0.14; 0.65	-0.45; 0.12	X
females=25	-0.09; 0.67	-0.13; 0.54	X
Calcium:Sodium			
males=13	-0.08; 0.79	-0.46; 0.11	X
females=25	-0.29; 0.16	-0.36; 0.07	X
Potassium:Sodium			
males=13	-0.39; 0.18	-0.23; 0.45	X
females=25	-0.22; 0.29	-0.37; 0.07	X
Zinc:Copper			
males=16	X	X	-0.52; 0.04*
females=	X	X	-0.14; 0.50

* significant at $p \leq 0.05$ level.
a=polyunsaturated/saturated fat ratio
X no correlation coefficient was calculated

Table 9

Pearson Product Moment Correlation Coefficients Between Selected Dietary Variables and CHD Risk Factors.

Variable	HDL-C	HDL_2-C	HDL_3-C
	(r-value; p-value)		
Kcalories			
males=16	0.09; 0.75	0.19; 0.48	0.05; 0.84
females=27	0.39; 0.04*	0.24; 0.23	0.26; 0.20
Protein			
males=16	-0.15; 0.57	0.10; 0.71	-0.24; 0.37
females=27	0.55; 0.002*	0.31; 0.12	0.42; 0.03
Fat			
males=16	0.17; 0.52	0.33; 0.21	0.09; 0.74
females=27	0.38; 0.04*	0.27; 0.17	0.19; 0.35
Carbohydrates			
males=16	-0.04; 0.90	-0.05; 0.84	0.01; 0.97
females=27	0.14; 0.46	0.09; 0.64	0.10; 0.60
Cholesterol			
males=16	0.05; 0.84	0.13; 0.62	-0.02; 0.94
females=27	0.51; 0.50	0.34; 0.07	0.36; 0.06
PS Ratio[a]			
males=16	0.10; 0.71	-0.03; 0.91	0.17; 0.53
females=27	0.15; 0.44	-0.18; 0.36	0.22; 0.27
Dietary Fiber			
males=16	0.09; 0.72	0.28; 0.28	0.03; 0.90
females=27	0.29; 0.13	0.13; 0.52	0.33; 0.10
Zinc:Copper			
males=16	-0.40; 0.12	-0.29; 0.27	-0.42; 0.10
females=27	0.12; 0.55	0.31; 0.13	-0.04; 0.85

* statistically significant at $p \leq 0.05$ level.
a=polyunsaturated/saturated fat ratio.

Table 10

Pearson Product Moment Correlation Coefficients Between Selected Dietary Variables and Anthropometric Variables.

Variable	SSF	WHR	BMI
	(r-value; p-value)		
Calories			
males=12	0.04; 0.89	0.15; 0.61	0.29; 0.36
females=25	0.07; 0.71	0.02; 0.93	0.06; 0.78
Protein			
males=12	-0.06; 0.84	-0.07; 0.80	-0.14; 0.67
females=25	0.05; 0.80	-0.00; 0.98	-0.00; 0.99
Fat			
males=12	0.15; 0.61	-0.22; 0.44	0.37; 0.23
females=25	0.21; 0.30	-0.09; 0.67	0.19; 0.37
Carbohydrates			
males=12	-0.03; 0.91	0.58; 0.02*	0.17; 0.58
females=25	-0.10; 0.61	0.19; 0.37	-0.08; 0.70
Cholesterol			
males=12	0.16; 0.59	0.07; 0.82	0.25; 0.44
females=25	-0.11; 0.60	-0.24; 0.26	-0.10; 0.65
PS Ratio[a]			
males=12	0.28; 0.34	0.14; 0.62	0.09; 0.78
females=25	-0.07; 0.72	0.45; 0.02*	-0.18; 0.41
Dietary Fiber			
males=12	-0.16; 0.59	-0.07; 0.82	0.03; 0.93
females=25	-0.09; 0.66	0.12; 0.57	-0.19; 0.37

* significant at $p \leq 0.05$ level.
a=polyunsaturated:saturated fat ratio.

DBP) were not significantly correlated with calcium, potassium, calcium/sodium ratio, or the potassium/sodium ratio.

Pearson product moment correlation coefficients between selected dietary variables and anthropometric variables are presented in Table 10. WHR was significantly correlated with polyunsaturated/saturated fat ratio in females ($r=0.45$; $p=0.02$), and with dietary intake of carbohydrates in males ($r=0.58$; $p=0.02$). No other significant correlations were found between these variables.

Statistical Hypotheses

The results for each hypothesis tested are reported in Tables 11 through 26. For all hypotheses the null and expected research hypotheses are given.

For the first hypotheses, the Pearson product moment correlation coefficients were calculated in order to identify any significant correlations of the dependent variables with WHR, SSF, and BMI (Table 11).

Hypotheses 1:

H_o: The correlations between the WHR, SSF, and BMI, and the dependent variables: fasting insulin, glucose, Hb A_1, SBP, DBP, TC, HDL-C, HDL_2-C, and HDL_3-C are each equal to zero.

H_A: a. The correlations between the WHR, SSF and BMI with selected diabetes risk factors: fasting insulin, glucose, and Hb A_1 are each positive.

The correlations between WHR and fasting insulin, glucose, and Hb A_1 were not significant. Therefore, the H_o was not rejected for these three dependent variables. SSF was significantly correlated with insulin (r=0.70; p=0.001 for males, and r=0.48; p=0.004 for females), glucose (r=0.49; p=0.024 for males, and r=0.39; p=0.01 for females), and Hb A_1 (r=0.33; p=0.09 for males). Thus, the H_o was rejected for insulin and glucose in males and females, and for Hb A_1 in females. BMI was significantly correlated with insulin (r=0.59; p=0.008 for males, and r=0.49; p=0.005 for females). Therefore, the H_o was rejected for insulin and BMI. Glucose and Hb A_1 were not significantly correlated with BMI. Therefore, the H_o was not rejected for these variables.

b. The correlations between WHR, SSF, and BMI and selected hypertension risk factors: SBP and DBP are each positive.

The correlations between WHR and SBP and DBP were not significant. Therefore, the H_o was not rejected for the association with WHR. SSF was significantly correlated with SBP (r=0.44; p=0.03 for males) and DBP (r=0.58; p=0.004 for males, and r=0.50; p=0.001 for females). Therefore, the H_o was rejected for SSF and SBP in males and for DBP in both

males and females. BMI was significantly correlated with SBP (r=0.54; p=0.001) and DBP (r=0.47; p=0.004) in females. Therefore, the H_o was rejected for BMI and the hypertension risk factor variables for females, but not for males.

c. The correlations between WHR, SSF, and BMI and the selected CHD risk factor: TC are each positive.

The correlations between WHR and TC were 0.49 (p=0.01) for males, and 0.44 (p=0.004) for females. Therefore, the H_o was rejected for TC. The correlation between TC and SSF was statistically significant for females (r=0.28; p=0.05) but was not for males. Therefore, the H_o was rejected for SSF in females. The correlations between BMI and TC were not statistically significant for males nor females. Therefore, the H_o was not rejected for BMI.

d. The correlations between WHR, SSF, and BMI and selected CHD risk factors: HDL-C, HDL_2-C, and HDL_3-C are each negative.

The correlations between WHR and HDL-C, HDL_2-C, and HDL_3-C were not significant. Therefore, the H_o was not rejected for the association between WHR and these three dependent variables. The correlations between SSF and HDL-C, and HDL_3-C were not significant for males nor females. SSF was significantly correlated with HDL_2-C (r=-0.32; p=0.03) in females, but not for males. Therefore, the H_o was rejected for HDL_2-C in females. The H_o was not rejected for the association between HDL-C and HDL_3-C with SSF.

Table 11

Summary Table for Hypotheses 1 Using Pearson Product Moment Correlation Coefficients.

H_0: There are no correlations between WHR, SSF, and BMI and each of the dependent variables.
H_A: The correlation between WHR, SSF and BMI and each of the dependent variables is positive or negative as indicated in the table by + or - sign.

Dependent Variable	H_A	WHR	SSF (r-value; p-value)	BMI
Insulin (uIU/ml)				
males n=17	+	-0.34; 0.91	0.70; 0.001*	0.59; 0.008*
females n=30	+	-0.07; 0.64	0.48; 0.004*	0.49; 0.005*
Glucose ((mg/dl)				
males n=17	+	0.002; 0.49	0.49; 0.024*	0.41; 0.06
females n=32	+	0.17; 0.18	0.39; 0.01*	0.24; 0.11
Hb A_1 (%)				
males n=17	+	-0.27; 0.70	0.33; 0.09	0.26; 0.17
females n=32	+	0.13; 0.24	0.43; 0.007*	0.17; 0.18
SBP (mm/Hg)				
males n=19	+	0.13; 0.29	0.44; 0.03*	0.36; 0.075
females n=34	+	0.21; 0.12	0.27; 0.06	0.54; 0.001*
DBP (mm/Hg)				
males n=19	+	0.24; 0.16	0.58; 0.004*	0.36; 0.08
females n=34	+	0.07; 0.34	0.50; 0.001*	0.47; 0.004*
TC (mg/dl)				
males n=20	+	0.49; 0.01*	-0.14; 0.73	-0.22; 0.81
females n=34	+	0.44; 0.004*	0.28; 0.053*	0.14; 0.22
HDL-C (mg/dl)				
males n=20	-	-0.18; 0.22	-0.06; 0.40	-0.07; 0.39
females n=34	-	-0.02; 0.46	-0.13; 0.22	-0.31; 0.04*
HDL_2-C (mg/dl)				
males n=20	-	-0.09; 0.34	-0.01; 0.47	0.05; 0.58
females n=34	-	-0.09; 0.31	-0.32; 0.03*	-0.38; 0.02*
HDL_3-C (mg/dl)				
males n=20	-	-0.26; 0.13	-0.11; 0.32	-0.14; 0.28
females n=34	-	0.03; 0.56	-0.06; 0.36	-0.16; 0.20

* statistically significant at $p \leq 0.05$ level.

The correlations between BMI and HDL-C (r=-0.31; p=0.04) and HDL_2-C (r=-0.38; p=0.02) was significant for females, but not males. The correlation between BMI and HDL_3-C was not significant for either gender. Therefore, the H_o was rejected for BMI and HDL-C and HDL_2-C in females, but not for HDL_3-C.

Associations between SSF as well as WHR and the dependent variables.

Multiple regression analyses were used to evaluate the associations between the dependent variables and the SSF (hypotheses 2), or the WHR (hypotheses 3). When the associations between the dependent variables and SSF were assessed, age and WHR were included in the model to adjust for any confounding effect (Table 12). Age and the SSF were controlled for when the associations between the dependent variables and WHR were evaluated (Table 13).

Hypotheses 2:

H_o: After controlling for the effects of the variables age and WHR, the regression coefficient for the SSF is zero for each of the dependent variables: insulin, glucose, Hb A_1, SBP, DBP, TC, HDL-C, HDL_2-C and HDL_3-C.

H_A: After controlling for the effects of the variables age and WHR, the regression coefficient for the SSF is greater than zero for each of:

a. Diabetes risk factors: insulin, glucose, and Hb A_1.

For insulin and glucose, the regression coefficients for SSF were significantly greater than zero for both males and females. The regression coefficient for insulin was 0.17 $\pm$ 0.05 (p=0.002) for males and 0.18 $\pm$ 0.04 (p=0.0002) for females. The regression coefficient for glucose was 0.57 $\pm$ 0.24 (p=0.017) for males and 0.21 $\pm$ 0.09 (p=0.015) for females. Therefore, the H_o was rejected for these dependent variables. For Hb A_1, the regression coefficient for SSF was significantly greater than zero for females (0.02 $\pm$ 0.01; p=0.009) but was not for males. Therefore, the H_o for the variable Hb A_1 was rejected for females, but was not rejected for males.

b. Hypertension risk factors: SBP and DBP.

The regression coefficients were significantly greater than zero for SBP (males: 0.18 $\pm$ 0.07; p=0.009 and females: 0.44 $\pm$ 0.12; p=0.0004), and significantly greater than zero for DBP (males: 0.19 $\pm$ 0.07; p=0.006, and females: 0.16 $\pm$ 0.07; p=0.01). Therefore, the H_o was rejected for both SBP and DBP.

c. CHD risk factor: TC.

For the variable TC, the regression coefficient for the SSF was not significantly different from zero for males or females. Therefore, the H_o for TC was not rejected.

Table 12

Summary Table for Hypotheses #2 Using Multiple Regression Analysis.

H_0: After controlling for age and WHR, the regression coefficient for the sum of skinfolds is zero for each of the dependent variables.

H_A: After controlling for age and WHR, the regression coefficient for sum of skinfolds is positive or negative indicated in the table by (+) or (-) sign for each of the dependent variables.

Dependent Variable	H_A	Statistical Results (b ± SE; p-value)
Insulin (uIU/ml):		
males (n=17)	+	0.17 ± 0.05; 0.002*
females (n=29)	+	0.18 ± 0.04; 0.0002*
Glucose (mg/dl):		
males (n=17)	+	0.57 ± 0.24; 0.017*
females (n=32)	+	0.21 ± 0.09; 0.015*
Hb A_1 (%):		
males (n=17)	+	0.01 ± 0.01; 0.18
females (n=31)	+	0.02 ± 0.01; 0.009*
SBP (mm/Hg):		
males (n=18)	+	0.18 ± 0.07; 0.009*
females (n=33)	+	0.44 ± 0.12; 0.0004*
DBP (mm/Hg):		
males (n=19)	+	0.19 ± 0.07; 0.006*
females (n=33)	+	0.16 ± 0.07; 0.01*
TC (mg/dl):		
males (n=20)	+	-0.13 ± 0.21; 0.74
females (n=33)	+	0.28 ± 0.26; 0.15
HDL-C (mg/dl):		
males (n=20)	-	-0.02 ± 0.08; 0.38
females (n=33)	-	-0.14 ± 0.08; 0.06
HDL_2-C (mg/dl):		
males (n=20)	-	-0.002 ± 0.04; 0.47
females (n=34)	-	-0.10 ± 0.05; 0.04*
HDL_3-C (mg/dl):		
males (n=19)	-	-0.13 ± 0.04; 0.002*
females (n=34)	-	-0.04 ± 0.06; 0.25

* significant at $p \leq 0.05$ level

d. After controlling for the effects of the variables age and WHR, the regression coefficient for the SSF is less than zero for each of the CHD risk factors: HDL-C, HDL_2-C, and HDL_3-C.

For the variables HDL-C and HDL_2-C, the regression coefficients for SSF were significantly less than zero for females (HDL-C: -0.14 ± 0.08; $p=0.06$, and HDL_2-C: -0.10 ± 0.05; $p=0.04$) but not significantly different from zero for males. Therefore, the H_o was rejected for females, but was not rejected for males for these two dependent variables.

For the variable HDL_3-C, the regression coefficient for SSF was significantly less than zero for males (-0.13 ± 0.04; $p=0.002$) but not for females. Therefore, the H_o for the variable HDL_3-C was rejected for males, but was not rejected for females.

Hypotheses 3:

H_o: After controlling for the effects of SSF and age, the regression coefficient for WHR is zero for each of the dependent variables: insulin, glucose, Hb A_1, SBP, DBP, TC, HDL-C, HDL_2-C, and HDL_3-C (Table 13).

H_A: After controlling for the effects of age and the SSF, the regression coefficient for WHR is greater than zero for each of:

a. Diabetes risk factors: insulin, glucose, and Hb A_1.

For the variables insulin, glucose, and Hb A_1, the regression coefficient for WHR was not statistically different from zero. Therefore, the H_o was not rejected for these dependent variables.

b. Hypertension risk factors: SBP and DBP.

For SBP and DBP the regression coefficient for WHR was not larger than zero. Therefore, the H_o was not rejected for these dependent variables.

c. CHD risk factor: TC.

For TC, the regression coefficients were significantly greater than zero for both males and females. The regression coefficients were 90.53 $\pm$ 40.84 (p=0.02) for males, and 125.29 $\pm$ 80.06 (p=0.06) for females. Therefore, the H_o was rejected for both males and females.

d. After controlling for the effects of age and the SSF, the regression coefficient for WHR is less than zero for each of the CHD risk factors: HDL-C, HDL_2-C, and HDL_3-C.

For the variables HDL-C, HDL_2-C, and HDL_3-C the regression coefficients for WHR were not statistically different from zero for males nor females. Therefore, the H_o was not rejected.

Table 13

Summary Table for Hypotheses #3 Using Multiple Regression Analysis.

H_0: After controlling for age and sum of skinfolds, the regression coefficient for WHR is zero for each of the dependent variables.

H_A: After controlling for age and sum of skinfolds, the regression coefficient for WHR is positive or negative indicated in the table by (+) or (-) sign for each of the dependent variables.

Dependent Variable	H_A	Statistical Results (b ± SE; p-value)
Insulin (uIU/ml):		
males (n=17)	+	-10.81 ± 9.17; 0.87
females (n=29)	+	11.80 ± 13.38; 0.19
Glucose (mg/dl):		
males (n=17)	+	18.37 ± 43.84; 0.34
females (n=32)	+	- 8.09 ± 26.96; 0.62
Hb A_1 (%):		
males (n=17)	+	- 1.43 ± 2.31; 0.73
females (n=31)	+	1.74 ± 2.54; 0.25
SBP (mm/Hg):		
males (n=18)	+	15.38 ± 13.33; 0.13
females (n=33)	+	24.41 ± 34.35; 0.24
DBP (mm/Hg):		
males (n=19)	+	16.93 ± 12.92; 0.10
females (n=33)	+	8.86 ± 20.01; 0.33
TC (mg/dl):		
males (n=20)	+	90.53 ± 40.84; 0.02*
females (n=33)	+	125.29 ± 80.06; 0.06
HDL-C (mg/dl):		
males (n=20)	-	-11.81 ± 15.50; 0.23
females (n=33)	-	-40.20 ± 26.40; 0.07
HDL_2-C (mg/dl):		
males (n=20)	-	- 2.88 ± 7.51; 0.35
females (n=34)	-	- 6.41 ± 17.31; 0.36
HDL_3-C (mg/dl):		
males (n=19)	-	- 0.41 ± 6.42; 0.48
females (n=34)	-	-26.92 ± 19.73; 0.09

* significant at $p \leq 0.05$ level.

Relationships between the dependent variables and the WHR divided into tertiles.

For the hypotheses #4 (Table 14), the relationships between the dependent variables and the categorical WHR variable were evaluated using Analysis of Covariance. Age and the SSF were used as covariates.

Hypotheses 4:

H_o: After adjusting for age and SSF, there is no effect of the WHR tertile for each of the dependent variables: insulin, glucose, Hb A_1, SBP, DBP, TC, HDL-C, HDL_2-C, and HDL_3-C.

H_A: After adjusting for SSF and age, an increase in WHR tertile from low to medium to high is associated with:

a. An increase in the estimated means of each of the following diabetes risk factors variables: insulin, glucose, and Hb A_1,

There was not a statistically significant increase in insulin, glucose, or Hb A_1, with an increase in WHR tertile. Therefore, the H_o were not rejected for these variables.

b. An increase in the estimated means of each of the following hypertension risk factors: SBP and DBP.

There was not a statistically significant increase in SBP or in DBP with an increase in WHR tertile. Therefore, the H_o was not rejected for these variables.

Table 14

Summary Table for Hypotheses #4 Using Analysis of Covariance.

H_0: After adjusting for age and sum of skinfolds, there is no effect of the WHR tertile for each of the dependent variables.

H_A: After adjusting for age and sum of skinfolds, an increase in the WHR tertile from low to medium to high is associated with an increase or decrease in the estimated mean for each dependent variable as indicated in the table by the (+) or (-) sign.

Dependent Variable	H_A	Statistical Results (Mean ± SEM) Low	Medium	High	p-value
Insulin (uIU/ml):					
males (n=17)	+	14.0 ± 0.0	24.2 ± 1.4	18.5 ± 2.6	0.08
females (n=30)	+	13.6 ± 4.2	19.8 ± 2.5	14.1 ± 1.2	0.15
both (n=46)[a]	+	16.7 ± 2.0	16.0 ± 1.5	20.2 ± 1.7	0.16
Glucose (mg/dl):					
males (n=16)	+	90.5 ± 0.0	99.3 ± 5.6	114.8 ± 10.4	0.24
females (n=32)	+	86.7 ± 7.6	93.4 ± 4.2	89.2 ± 2.2	0.62
both (n=47)[a]	+	93.8 ± 3.4	88.8 ± 2.6	98.7 ± 3.1	0.06
Hb A_1 (%):					
males (n=16)	+	5.8 ± 1.7	7.4 ± 0.4	7.8 ± 0.6	0.39
females (n=31)	+	7.0 ± 0.7	6.2 ± 0.4	6.9 ± 0.2	0.40
both (n=47)	+	6.4 ± 0.3	7.2 ± 0.2	7.2 ± 0.3	0.14
SBP (mm/Hg):					
males (n=19)	+	116.5 ± 6.9	126.9 ± 3.4	130.4 ± 6.1	0.33
females (n=34)	+	127.4 ± 8.4	121.9 ± 5.7	118.8 ± 2.9	0.58
both (n=53)	+	119.5 ± 3.4	122.4 ± 2.8	125.7 ± 3.7	0.48
DBP (mm/Hg):					
males (n=19)	+	75.9 ± 5.6	86.0 ± 2.8	86.5 ± 4.9	0.27
females (n=34)	+	75.9 ± 4.6	79.2 ± 3.1	75.5 ± 1.6	0.60
both (n=53)	+	76.6 ± 2.0	78.6 ± 1.7	81.7 ± 2.3	0.28
TC (mg/dl):					
males (n=20)	+	199.6 ± 19.9	209.7 ± 9.5	230.8 ± 17.4	0.47
females (n=34)	+	210.1 ± 15.5	166.9 ± 9.9	211.0 ± 5.5	0.003*
both (n=54)	+	191.1 ± 7.7	209.0 ± 6.8	216.2 ± 8.2	0.08
HDL-C (mg/dl):					
males (n=20)	-	51.8 ± 6.3	45.1 ± 3.0	35.7 ± 5.5	0.18
females (n=35)	-	55.5 ± 7.7	54.9 ± 7.7	58.4 ± 2.7	0.81
both (n=55)	-	54.3 ± 3.3	55.0 ± 2.9	46.4 ± 3.6	0.14
HDL_2-C (mg/dl):					
males (n=20)	-	9.5 ± 3.3	7.5 ± 1.5	6.8 ± 2.9	0.83
females (n=34)	-	15.7 ± 5.0	15.3 ± 2.6	13.2 ± 1.4	0.76
both (n=53)[a]	-	11.7 ± 1.8	11.6 ± 1.4	10.1 ± 1.8	0.77
HDL_3-C (mg/dl):					
males (n=20)	-	43.8 ± 3.3	37.5 ± 1.6	28.9 ± 2.9	0.01*
females (n=34)	-	54.0 ± 5.4	41.1 ± 2.8	44.3 ± 1.6	0.11
both (n=54)	-	44.8 ± 2.0	42.3 ± 1.7	35.9 ± 2.1	0.01*

* significant at $p \leq 0.05$ level

a= one outlier was removed. The sample size does not represent the sum of males plus females.

c. An increase in the estimated means of TC as a CHD risk factors.

For females, there was a significant change in TC levels, which seems to be either from the low to medium tertile or from the medium to the highest tertile. For males, there was an increase in TC with an increase in WHR tertile but the increase was not significant. Therefore, the H_o were not rejected for either males or females.

d. A decrease in the estimated means of each of the following CHD risk factors: HDL-C, HDL_2-C, and HDL_3-C.

HDL-C, HDL_2-C, and HDL_3-C decreased with an increase in the WHR tertile in males, but only the increase in HDL_3-C was statistically significant ($p=0.01$). Therefore, the H_o was rejected for the variable HDL_3-C in males. In females, an increase in WHR was not associated with a decrease in any of these dependent variables. Therefore, the H_o was not rejected for females.

Hypotheses for the Longitudinal Study

For the longitudinal component of this dissertation research, a paired-difference t-test was used to test hypotheses 5 through 9 (Tables 15 to 20). Hypothesis 5 assessed the changes in the levels of each of the variables (insulin, glucose, Hb A_1, SBP, DBP, TC, HDL-C, HDL_2-C, and HDL_3-C) after the 12-week exercise-nutrition program (Table 15).

Hypotheses 5:

H_o: Among the participants of the RESHAPE program, there are no differences between week 0 and week 12 in each of the variables: insulin, glucose, Hb A_1, SBP, DBP, TC, HDL-C, HDL_2-C, and HDL_3-C.

H_A: At the end of the 12-week RESHAPE program, each of the following variables will decrease:

a. Diabetes risk factors: insulin, glucose, and Hb A_1.

Fasting insulin decreased significantly by the end of the 12-week program for both males ($t=4.7 \pm 1.2$; $p=0.002$), and females ($t=4.3 \pm 0.9$; $p=0.0002$). Glucose decreased significantly for both males ($t=10.6 \pm 3.8$; $p=0.008$), and females ($t=5.1 \pm 2.5$; $p=0.03$). Hb A_1 decreased significantly for males ($t=0.9 \pm 0.1$; $p=0.04$), and females ($t=0.9 \pm 0.3$; $p=0.003$). The H_o was rejected for these three dependent variables for both males and females.

b. Hypertension risk factors: SBP and DBP.

SBP decreased significantly at the end of the 12-week program for males ($t=9.7 \pm 2.7$; $p=0.002$) and females ($t=10.6 \pm 3.1$; $p=0.001$). The H_o was rejected for SBP for both males and females. DBP decreased significantly only for males ($t=7.7 \pm 2.4$; $p=0.003$). DBP did not change significantly in females. The H_o was rejected for DBP for males, but was not rejected for females.

Table 15

Summary Table for Hypotheses #5 Using Paired-Difference T-test.

H_0: Among the participants of the RESHAPE program, there are no differences for each of the following variables between week 0 and week 12.

H_A: The participants of the RESHAPE program have lower or higher levels of the following variables at the end of the 12-week program as indicated by the (-) or (+) sign in the table.

Dependent Variable	H_A	Males	Females
Insulin (uIU/ml):			
n:		11	17
Week 0		24.6 ± 2.2	16.9 ± 1.9
Week 12		19.9 ± 2.7	12.6 ± 1.6
Difference	-	4.7 ± 1.2	4.3 ± 0.9
p-value		0.002*	0.0002*
Glucose (mg/dl):			
n:		13	18
Week 0		115.3 ± 8.6	93.6 ± 2.8
Week 12		104.7 ± 7.2	88.6 ± 1.7
Difference	-	10.6 ± 3.8	5.1 ± 2.5
p-value		0.008*	0.03*
Hb A_1 (%):			
n:		12	18
Week 0		7.6 ± 0.4	6.8 ± 0.3
Week 12		6.7 ± 0.3	5.9 ± 0.1
Difference	-	0.9 ± 0.1	0.9 ± 0.3
p-value		0.04*	0.003*
SBP (mm/Hg):			
n:		15	21
Week 0		128.7 ± 3.1	123.3 ± 3.4
Week 12		118.9 ± 1.7	112.7 ± 2.9
Difference	-	9.7 ± 2.7	10.6 ± 3.1
p-value		0.002*	0.001*
DBP (mm/Hg):			
n:		15	21
Week 0		88.0 ± 2.4	76.3 ± 2.1
Week 12		80.3 ± 1.4	75.1 ± 1.7
Difference	-	7.7 ± 2.4	1.1 ± 1.8
p-value		0.003*	0.27
TC (mg/dl):			
n:		15	21
Week 0		215.4 ± 8.8	216.1 ± 8.6
Week 12		185.6 ± 7.3	187.7 ± 6.7
Difference	-	29.8 ± 8.7	28.4 ± 6.8
p-value		0.002*	0.0002*

* significant at $p \leq 0.05$ level.

c. CHD risk factor: TC.

TC decreased significantly in males ($t=29.8 \pm 8.7$; $p=0.002$) and females ($t=28.4 \pm 6.8$; $p=0.0002$) at the end of the 12-week program. The H_o was rejected for both males and females.

d. At the end of the 12-week RESHAPE program, each of the following dependent variables will increase: HDL-C, HDL_2-C, and HDL_3-C.

HDL-C and HDL_3-C decreased instead of increasing in both males and females. The H_o was not rejected for these two variables. HDL_2-C increased in males and females at the end of the program. The difference in HDL_2-C was statistically significant ($t=-2.5 \pm 1.3$; $p=0.04$) only for males. The H_o was rejected for males but not for females.

Hypotheses 6 through 9 (tables 17 through 20) assessed changes after the 12-week program for the following variables: body weight, BMI, SSF, %BF, waist circumference, hip circumference, WHR, calories, fat, dietary fiber, and cholesterol intake, time to walk a mile, as well as the indices of stress: the perceived mood rating scale (CSA) and State-Trait Anxiety Inventory (STAI) .

Table 16

Continuation: Summary Table for Hypotheses #5 Using Paired-Difference T-Test.

H_0: Among the participants of the RESHAPE program, there are no differences for each of the following variables between week 0 and week 12.

H_A: The participants of the RESHAPE program have lower or higher levels of the following variables at the end of the 12-week program as indicated by the (-) or (+) sign in the table.

Dependent Variable	H_A	Males	Females
HDL-C (mg/dl):			
n:		15	21
Week 0		42.5 ± 2.7	59.1 ± 2.7
Week 12		41.6 ± 2.3	54.0 ± 2.3
Difference	+	0.9 ± 3.0	5.1 ± 2.2
p-value		0.62	0.99
HDL_2-C (mg/dl):			
n:		15	19
Week 0		6.9 ± 1.2	15.0 ± 1.8
Week 12		9.4 ± 1.0	16.0 ± 2.2
Difference	+	-2.5 ± 1.3	-1.0 ± 2.1
p-value		0.04*	0.33
HDL_3-C (mg/dl):			
n:		15	20
Week 0		35.6 ± 1.9	45.5 ± 1.6
Week 12		32.5 ± 1.8	38.4 ± 1.9
Difference	+	3.1 ± 2.5	7.1 ± 1.8
p-value		0.88	0.99

* significant at $p \leq 0.05$ level

Hypotheses 6:

H_o: Among the participants of the RESHAPE program, there are no differences in each of BW, BMI, SSF, %BF, waist circumference, hip circumference, and WHR between week 0 and week 12.

H_A: At the end of the 12-week RESHAPE program, each of BW, BMI, SSF, %BF, waist circumference, hip circumference, and WHR, will decrease.

At the end of the RESHAPE program, body weight (males: $t=5.6 \pm 1.5$ Kg; $p=0.001$, females: $t=2.2 \pm 0.6$ Kg; $p=0.0006$), BMI (males: $t=1.8 \pm 0.4$; $p=0.001$, and females: $t=0.9 \pm 0.2$; $p=0.001$), SSF (males: $t=25.1 \pm 4.7$; $p=0.00005$, females: $t=10.2 \pm 2.2$mm; $p=0.0001$), %BF (males: $t=5.1 \pm 0.8$%; $p=0.00005$, and females: $t=2.2 \pm 0.4$%; $p=0.00005$), waist circumference (males: $t=9.1 \pm 3.9$cm; $p=0.004$, and females: $t=3.6 \pm 1.2$cm; $p=0.017$), and hip circumference (males: $t=2.8 \pm 1.5$cm; $p=0.04$ and females: $t=2.1 \pm 0.9$cm; $p=0.013$) were significantly lower than week 0. The H_o were rejected for these independent variables. WHR decreased for males and females, but the change was not statistically significant. The H_o was not rejected for WHR.

Hypotheses 7:

H_o: Among the participants of the RESHAPE program, there are no differences in CSA and STAI scales between week 0 and week 12.

H_A: CSA scale scores will increase, and the STAI scale scores will decrease at the end of the 12-week program among the participants in the RESHAPE program.

Values for CSA were higher at the end of the 12-week program for both males and females. The increase was statistically significant ($t=-3.9 \pm 0.9$; $p=0.0002$) for males only. The H_o was rejected for CSA in males. Values for STAI decreased for both males ($t=3.2 \pm 1.9$; $p=0.06$) and for females ($t=3.1 \pm 2.0$; $p=0.07$). The H_o was rejected for STAI, for males and females.

Hypotheses 8:

H_o: Among the participants of the RESHAPE program, there are no differences in each of calories, fat, dietary fiber, and cholesterol intakes between week 0 and week 12.

H_A: At the end of the 12-week program subjects will have a lower calorie, fat, and cholesterol intake, and a higher dietary fiber intake.

Calorie and fat intake decreased for males and females, but the decrease was significant for males only. The calorie intake decreased 332 ± 100 cals for males ($p=0.04$) while fat intake decreased by 35 ± 9g ($p=0.03$). The H_o for calorie and fat were rejected for males but not females. Cholesterol intake was not reduced significantly in either group. The H_o was not rejected for cholesterol. Dietary fiber intake did not increase significantly. The H_o was not rejected for dietary fiber.

Table 17

Summary Table for Hypotheses #6 Using Paired-Difference T-test.

H_0: Among the participants of the RESHAPE program there are no differences in each of the following variables between week 0 and week 12.

H_A: The participants of the RESHAPE program have lower or higher levels of the following variables at the end of the 12-week program as indicated by the (-) or (+) sign in the table.

Independent Variable	H_A	Males	Females
Body weight (Kg):			
n:		15	21
Week 0		103.1 ± 5.1	74.3 ± 3.2
Week 12	-	97.5 ± 4.2	72.0 ± 3.2
Difference		5.6 ± 1.5	2.2 ± 0.6
p-value		0.001*	0.0006*
BMI (Wt/Ht^2):			
n:		14	19
Week 0		31.8 ± 1.7	27.1 ± 1.0
Week 12	-	30.0 ± 1.5	26.2 ± 1.0
Difference		1.8 ± 0.4	0.9 ± 0.2
p-value		0.001*	0.001*
SSF (mm):			
n:		15	21
Week 0		85.9 ± 8.7	75.6 ± 4.2
Week 12	-	60.8 ± 6.1	65.4 ± 4.1
Difference		25.1 ± 4.7	10.2 ± 2.2
p-value		0.00005*	0.0001*
Body fat (%):			
n:		15	21
Week 0		31.4 ± 1.8	36.1 ± 0.8
Week 12	-	26.2 ± 1.8	33.9 ± 0.8
Difference		5.1 ± 0.8	2.2 ± 0.4
p-value		0.00005*	0.00005*
Waist (cm):			
n:		15	20
Week 0		114.8 ± 4.3	100.4 ± 2.8
Week 12	-	105.7 ± 3.3	96.8 ± 3.1
Difference		9.1 ± 3.9	3.6 ± 1.2
p-value		0.004*	0.017*
Hip (cm):			
n:		15	20
Week 0		110.4 ± 4.3	111.1 ± 2.8
Week 12	-	107.6 ± 3.2	109.0 ± 2.8
Difference		2.8 ± 1.5	2.1 ± 0.9
p-value		0.04*	0.013*
WHR:			
n:		15	20
Week 0		1.05 ± 0.04	0.90 ± 0.01
Week 12	-	0.98 ± 0.01	0.89 ± 0.01
Difference		0.07 ± 0.14	0.01 ± 0.01
p-value		0.07	0.09

* significant at $p \leq 0.05$ level

Table 18

Summary Table for Hypotheses #7 Using Paired-Difference T-test.

H_0: Among the participants of the RESHAPE program there are no differences in stress levels according to the following variables between week 0 and week 12.

H_A: The participants of the RESHAPE program have higher or lower levels of the following variables at the end of the 12-week program as indicated by the (+) or (-) sign in the table.

Independent Variable	H_A	Males	Females
CSA[a]			
n:		12	16
Week 0		33.3 ± 1.1	32.7 ± 1.6
Week 12		37.2 ± 1.2	33.8 ± 1.5
Difference	+	-3.9 ± 0.8	-1.1 ± 1.2
p-value		0.0002*	0.17
STAI[b]			
n:		11	16
Week 0		32.5 ± 2.7	34.2 ± 2.4
Week 12		29.4 ± 2.0	31.1 ± 1.6
Difference	-	3.2 ± 1.9	3.1 ± 2.0
p-value		0.06*	0.07*

* significant at $p \leq 0.10$ level
CSA[a] = Current Self appraisal
STAI[b] = State-Trait Anxiety Inventory

Table 19

Summary Table for Hypotheses #8 Using Paired-Difference T-test.

H_0: Among the participants of the RESHAPE program there are no differences in the intake of selected dietary variables between week 0 and week 12.

H_A: The participants of the RESHAPE program have a higher or lower dietary intake of the following variables at the end of the 12-week program as indicated by the (+) or (-) sign in the table.

Independent Variable	H_A	Males	Females
Sample Size:		3	5
Calories:			
Week 0		2210 ± 242	1579 ± 133
Week 12		1878 ± 214	1355 ± 209
Difference	-	332 ± 100	224 ± 217
p-value		0.04*	0.18
Fat (g):			
Week 0		94 ± 13	62 ± 10
Week 12		59 ± 10	44 ± 7
Difference	-	35 ± 9	18 ± 10
p-value		0.03*	0.07
Fiber (g):			
Week 0		20 ± 4	14 ± 2
Week 12		22 ± 3	19 ± 4
Difference	+	-2 ± 2	-5 ± 3
p-value		0.22	0.09
Cholesterol (mg):			
Week 0		375 ± 132	251 ± 40
Week 12		381 ± 184	206 ± 58
Difference	-	-6 ± 87	45 ± 47
p-value		0.95	0.39

* significant at $p \leq 0.05$ level.

Changes in cardiovascular fitness as measured by changes in the time taken to walk a mile.

Hypothesis 9:

H_o: Among the participants of the RESHAPE program, there are no differences in the time taken to walk a mile between week 0 and week 12.

H_A: The cardiovascular fitness will improve at the end of the 12-week program as measured by a decrease in the time taken to walk a mile.

The time taken to walk a mile decreased significantly at the end of the 12-week program for males ($t=1.3 \pm 0.3$ minutes; $p=0.002$) and females ($t=1.7 \pm 0.6$ minutes; $p=0.009$). The H_o for time to walk a mile was rejected for males and females.

Hypotheses 10 through 12 assessed the associations between changes in SSF, WHR, and body weight, with changes in each of the dependent variables. Pearson Product Moment Correlation Coefficients were used to test hypotheses 10 through 12. Subjects who lost 3 Kg or more of body weight, 6 mm or more of SSF measurement, and subjects whose WHR's were reduced by 0.03 or more were included in these analyses (Tables 21 through 26).

Table 20

Summary Table for Hypothesis #9 Using Paired-Difference T-test.

H_0: Among the participants of the RESHAPE program there is no difference in the time taken to walk a mile between week 0 and week 12.

H_A: At the end of the RESHAPE program the subjects decreased the time taken to walk a mile.

Independent Variable	Males	Females
Time-Mile (minutes)		
n:	8	16
Week 0	15.2 $\pm$ 0.6	17.2 $\pm$ 0.7
Week 12	13.8 $\pm$ 0.5	15.5 $\pm$ 0.4
Difference	1.3 $\pm$ 0.3	1.7 $\pm$ 0.6
p-value	0.002*	0.009*

* significant at $p \leq 0.05$ level.

Hypotheses 10:

H_o: The correlations between the changes in SSF and the changes in each of the following dependent variables: insulin, glucose, Hb A_1, SBP, DBP, TC, HDL-C, HDL_2-C, and HDL_3-C are zero for those who had a decrease in SSF of at least 6mm.

H_A: Favorable reductions in the SSF are positively correlated with changes in each of:

a. Diabetes risk factors: insulin, glucose, and Hb A_1.

Decreases in glucose and Hb A_1 were not significantly correlated with decreases in the SSF for either males or females. Decrease insulin levels were correlated with decreased SSF for males only ($r=0.53$; $p=0.04$).
The H_o for insulin was rejected for males. The H_o was not rejected for glucose and Hb A_1.

b. Hypertension risk factors: SBP and DBP.

A decrease in SBP was not correlated with a decrease in SSF in males or females. The H_o was not rejected for SBP. Decrements in DBP were correlated with decrements in SSF for males ($r=0.49$; $p=0.03$) and females ($r=0.42$; $p=0.06$). The H_o was rejected for DBP for both males and females.

c. CHD risk factor: TC,

Changes in TC were not correlated with changes in SSF. The H_o was not rejected for TC.

Table 21

Summary Table for Hypotheses #10 Using Pearson Product Moment Correlation Coefficients.

H_0: There are no correlations between changes in sum of skinfolds and changes in each of the dependent variables for those subjects who had a decrease in SSF of at least 6mm.

H_A: The correlation between changes in sum of skinfolds and changes in each of the dependent variables is positive as indicated in the table by the (+) sign.

Dependent Variable	H_A	Statistical Results (r value; p value)
Changes in:		
Insulin:		
males (n=12)	+	0.53; 0.04*
females (n=12)	+	0.23; 0.23
both (n=24)	+	0.38; 0.03*
Glucose:		
males (n=14)	+	0.18; 0.27
females (n=13)	+	0.08; 0.40
both (n=27)	+	0.21; 0.15
Hb A_1:		
males (n=13)	+	-0.14; 0.68
females (n=13)	+	0.31; 0.15
both (n=26)	+	0.00; 0.45
SBP:		
males (n=16)	+	0.38; 0.08
females (n=15)	+	0.12; 0.34
both (n=31)	+	0.23; 0.10
DBP:		
males (n=16)	+	0.49; 0.03*
females (n=15)	+	0.42; 0.06
both (n=31)	+	0.51; 0.002*
TC:		
males (n=16)	+	-0.03; 0.53
females (n=14)	+	0.00; 0.99
both (n=30)	+	-0.04; 0.58

* significant at $p \leq 0.05$ level.

Table 22

Continuation: Summary Table for Hypotheses #10 Using Pearson Product Moment Correlation Coefficients.

H_0: There are no correlations between changes in sum of skinfolds and changes in each of the dependent variables for those subjects who had a decrease in SSF of at least 6mm.

H_A: The correlation between changes in sum of skinfolds and the changes in each of the dependent variables is negative as indicated in the table by the (-) sign.

Dependent Variable	H_A	Statistical Results (r-value; p-value)
Changes in:		
HDL-C:		
males (n=16)	-	0.35; 0.91
females (n=14)	-	0.16; 0.71
both (n=30)	-	0.18; 0.84
HDL_2-C:		
males (n=16)	-	0.15; 0.71
females (n=13)	-	-0.71; 0.003*
both (n=29)	-	-0.16; 0.21
HDL_3-C:		
males (n=16)	-	0.55; 0.99
females (n=14)	-	0.26; 0.18
both (n=30)	-	0.32; 0.96

*significant at $p \leq 0.05$ level

d. Favorable reductions in the SSF are negatively correlated with changes in each of the CHD risk factors: HDL-C, HDL_2-C, and HDL_3-C.

A decrease in SSF was correlated with increased HDL_2-C in females ($r=-0.71$; $p=0.003$), but not in males. Decrease SSF was not correlated with increased HDL-C, or HDL_3-C for either males or females. Therefore, the H_o was rejected for HDL_2-C in females.

Hypotheses 11:

H_o: The correlations between the changes in WHR and the changes in each of the following dependent variables: insulin, glucose, Hb A_1, SBP, DBP, TC, HDL-C, HDL_2-C, and HDL_3-C are zero for those who had a decrease in WHR of at least 0.03.

H_A: Favorable reductions in the WHR are positively correlated with changes in each of:

a. Diabetes risk factors: insulin, glucose, Hb A_1.

Decreased WHR was not correlated with decreased insulin, glucose, or Hb A_1. Therefore, the H_o were not rejected for these variables.

b. Hypertension risk factors: SBP and DBP.

Changes in SBP or DBP were not significantly correlated with changes in WHR. The H_o were not rejected for these variables.

Table 23

Summary Table for Hypotheses #11 Using Pearson Product Moment Correlation Coefficients.

H_0: There are no correlations between changes in body fat distribution as measured by WHR and changes in the dependent variables for those who decrease WHR by at least 0.03.

H_A: The correlation between changes in body fat distribution measured by WHR and the changes in the dependent variables is positive as indicated in the table by the (+) sign.

Dependent Variable	H_A	Statistical Results (r value; p value)
Changes in:		
Insulin:		
males (n=7)	+	0.41; 0.18
females (n=7)	+	-0.41; 0.82
both (n=14)	+	-0.11; 0.64
Glucose:		
males (n=9)	+	0.35; 0.18
females (n=8)	+	-0.36; 0.81
both (n=17)	+	0.20; 0.22
Hb A_1:		
males (n=9)	+	-0.00; 0.99
females (n=8)	+	-0.15; 0.64
both (n=17)	+	-0.01; 0.51
SBP:		
males (n=9)	+	-0.45; 0.89
females (n=9)	+	-0.11; 0.61
both (n=18)	+	-0.26; 0.85
DBP:		
males (n=9)	+	0.11; 0.39
females (n=9)	+	0.04; 0.46
both (n=18)	+	0.15; 0.28
TC:		
males (n=9)	+	0.68; 0.02*
females (n=8)	+	-0.03; 0.52
both (n=17)	+	0.43; 0.04*

* significant at $p \leq 0.05$ level.

Table 24

Continuation: Summary Table for Hypotheses #11 Using Pearson Product Moment Correlation Coefficients.

H_0: There are no correlations between changes in body fat distribution as measured by WHR and changes in the dependent variables for those subjects who had a decrease in WHR by at least 0.03.

H_A: The correlation between changes in body fat distribution measured by WHR and the changes in the dependent variables is negative as indicated in the table by the (-) sign.

Dependent Variable	H_A	Statistical Results (r value; p value)
Changes in:		
HDL-C:		
males (n=9)	-	0.29; 0.78
females (n=8)	-	0.60; 0.94
both (n=17)	-	0.18; 0.75
HDL_2-C:		
males (n=9)	-	0.06; 0.56
females (n=8)	-	0.81; 0.99
both (n=17)	-	0.16; 0.73
HDL_3-C:		
males (n=9)	-	0.41; 0.87
females (n=8)	-	-0.06; 0.44
both (n=17)	-	0.02; 0.54

c. CHD risk factor: TC.

Decreased WHR was positively correlated with decreased TC in males (r=0.68; p=0.02) but not females. The H_o was rejected for TC in males only.

d. Favorable reductions in the WHR are negatively correlated with changes in each of the CHD risk factors: HDL-C, HDL_2-C, and HDL_3-C.

Decreased WHR was not correlated with increased HDL-C, HDL_2-C, or HDL_3-C, in males or females. Therefore, the H_o was not rejected.

Hypotheses 12:

H_o: The correlations between the changes in body weight (BW) and the changes in each of the following dependent variables: insulin, glucose, Hb A_1, SBP, DBP, TC, HDL-C, HDL_2-C, and HDL_3-C are not zero for those who had a decrease in BW of at least 3.0 Kg.

H_A: Favorable reductions in BW are positively correlated with changes in each of:

a. Diabetes risk factors: insulin, glucose, Hb A_1.

Decreased BW was not correlated with decreased insulin, glucose, or Hb A_1. The H_o was not rejected for these variables.

b. Hypertension risk factors: SBP and DBP.

Decreased BW was positively correlated with decreased DBP (r=0.46; p=0.06) in females but not in males. Changes

in SBP were not correlated with changes in BW in males or females. The H_o was rejected for DBP in females.

c. CHD risk factor: TC.

Decreased BW was correlated with decreased TC ($r=0.73$; $p=0.002$) in females but not males. The H_o was rejected for TC in females.

d. Favorable reductions in BW are negatively correlated with changes in each of the CHD risk factors: HDL-C, HDL_2-C, and HDL_3-C.

Changes in BW were not correlated with changes in HDL-C, HDL_2-C, or HDL_3-C in males or females. Therefore, the H_o for HDL-C, HDL_2-C, or HDL_3-C were not rejected.

Table 25

Summary Table for Hypotheses #12 Using Pearson Product Moment Correlation Coefficients.

H_0: There are no correlations between changes in body weight and changes in the dependent variables for those who had a decrease in BW of at least 3 Kg.

H_A: The correlation between changes in body weight and the changes in the dependent variables is positive as indicated in the table by the (+) sign.

Dependent Variable	H_A	Statistical Results (r value; p value)
Changes in:		
Insulin:		
males (n=8)	+	-0.01; 0.51
females (n=11)	+	0.24; 0.24
both (n=19)	+	0.08; 0.36
Glucose:		
males (n=10)	+	0.30; 0.20
females (n=11)	+	0.27; 0.21
both (n=21)	+	0.33; 0.14
Hb A_1:		
males (n=10)	+	-0.01; 0.51
females (n=11)	+	-0.06; 0.57
both (n=21)	+	-0.00; 0.50
SBP:		
males (n=11)	+	0.35; 0.15
females (n=13)	+	0.19; 0.27
both (n=24)	+	0.17; 0.21
DBP:		
males (n=11)	+	-0.25; 0.77
females (n=13)	+	0.46; 0.06
both (n=24)	+	0.19; 0.19
TC:		
males (n=11)	+	0.25; 0.22
females (n=13)	+	0.73; 0.002*
both (n=24)	+	0.32; 0.06

* significant at $p \leq 0.05$ level.

Table 26

Continuation: Summary Table for Hypotheses #12 Using Pearson Product Moment Correlation Coefficients.

H_0: There are no correlations between changes in body weight and changes in the dependent variables for those subjects who had a decrease in BW of at least 3 Kg.

H_A: The correlation between changes in body weight and the changes in the dependent variables is negative as indicated in the table by the (-) sign.

Dependent Variable	H_A	Statistical Results (r value; p value)
Changes in:		
HDL-C:		
males (n=11)	-	0.24; 0.76
females (n=13)	-	0.03; 0.54
both (n=24)	-	0.18; 0.81
HDL_2-C:		
males (n=11)	-	0.56; 0.96
females (n=11)	-	0.07; 0.58
both (n=22)	-	0.28; 0.89
HDL_3-C:		
males (n=11)	-	0.06; 0.57
females (n=12)	-	-0.10; 0.38
both (n=23)	-	-0.01; 0.48

CHAPTER V

DISCUSSION

This discussion focuses on the findings according to the specific research hypotheses (H_A) and the relationship of these hypotheses to previous findings reported in the literature. Direct comparisons cannot be made for all studies because the same set of variables included in this study were not used by each group of investigators. P-values greater than 0.05 are not reported in this chapter, except for the stress variables where p-values greater than 0.10 are not reported. Recommendations for future research are addressed in the final section of this chapter.

Hypotheses 1:

H_A: There is a positive correlation between WHR, SSF, and BMI, and:

a. each of the diabetes risk factors: fasting insulin, glucose, and Hb A_1 (Table 11).

WHR was not correlated with insulin, glucose, or Hb A_1 in this investigation, which means that regional obesity is not significantly associated with these diabetes risk factors variables. Hb A_1 levels were measured in this study because obesity increases the risk on NIDDM. These findings

are consistent with some investigations (Van Gaal et al., 1989; and Peeples et al., 1989), but not others (Ohlson et al., 1985; Despres, Nadeau et al., 1989). Fasting insulin and glucose levels were not different among 43 obese males with high or low WHR (Van Gaal et al., 1989). Fasting glucose levels were not different among 9 pairs of nonobese males with different WHR studied by Peeples et al. (1989).

Other investigators have reported positive correlations between diabetes risk factors and WHR, which means that regional fat distribution was significantly correlated with the diabetes risk factors. WHR was significantly correlated with insulin ($r=0.08$; $p<0.05$) in 792 males (BMI=25.0 $\pm$ 3.2) studied by Ohlson et al. (1985). After 13.5 years of follow up, converters to diabetes (6.3%) had higher WHR than nonconverters (0.97 $\pm$ 0.05 vs. 0.92 $\pm$ 0.05; $p<0.0001$) (Ohlson et al., 1985). WHR was positively correlated with glucose ($r=0.49$; $p<0.001$) and insulin ($r=0.41$; $p<0.01$) in 52 obese premenopausal females studied by Despres, Nadeau et al. (1989). Higher fasting glucose levels (100.1 $\pm$ 13.1 vs. 88.9 $\pm$ 7.6 mg/dl; $p<0.001$) and insulin values (20.6 $\pm$ 13.0 vs. 14.3 $\pm$ 4.5 uU/ml; $p<0.025$), were reported in 107 obese females with AO compared to 40 females with GFO (Van Gaal et al., 1989). Obese males with high WHR had higher levels of Hb A_1 than non obese males with low WHR (absolute values were not reported; $p<0.001$). Insulin was significantly

correlated with WHR ($r=0.47$; $p<0.05$) in 75 postmenopausal females (BMI=25.6 $\pm$ 4.7) studied by Soler et al. (1989).

SSF was significantly correlated with insulin (males: $r=0.70$; $p=0.001$ and females: $r=0.48$; $p=0.004$), glucose (males: $r=0.49$; $p=0.02$ and females: $r=0.39$; $p=0.01$), and Hb A_1 in females ($r=0.43$; $p=0.007$) in this dissertation research (Table 11). These findings are consistent with some investigations (Ohlson et al., 1985) but not others (Bergstrom et al., 1990; and Lundgren et al., 1989). SSF (tricep, subscapular, and suprailiac) was a significant predictor ($p<0.0001$) for the development of diabetes in 792 males studied by Ohlson et al. (1985). The SSF at baseline was not correlated with increased serum glucose in 1351 females after 12 years of follow up (Lundgren et al., 1989). The correlation between SSF and Hb A_1 was not assessed in any of the studies previously cited. Hb A_1 was measured in this study because obesity increases the risk for NIDDM.

BMI was significantly correlated with insulin in males ($r=0.59$; $p=0.008$) and females ($r=0.49$; $p=0.005$) in this dissertation research, but was not significantly correlated with glucose or Hb A_1. Different results have been obtained by several investigators. BMI was a significant predictor for the development of NIDDM ($p=0.0003$) in males after 13.5 years follow up (Ohlson et al., 1985). Similarly, BMI was a significant predictor of diabetes ($p<0.05$) after adjusting for age, in 738 Mexican Americans. However, the effect was

no longer statistically significant after WHR was added to the model (Haffner et al., 1987). Insulin ($r=0.47$; $p<0.05$) and glucose ($r=0.34$; $p<0.05$) were significantly correlated with BMI in males (Houmard et al., 1991). BMI was not significantly different between 15 Japanese Americans who developed NIDDM and 131 who did not develop NIDDM (26.5 ± 0.9 vs. 25.4 ± 0.2; $p=0.17$) after 30 months of follow up (Bergstrom et al., 1990).

Fasting insulin, glucose, and Hb A_1 were correlated with total body fat measured as the SSF in this dissertation research. However, insulin was the only diabetes risk factor variable significantly correlated with BMI which is also an index of general obesity. Probably, BMI does not estimate body fat as well as SSF. Stature, i.e., height is one component of BMI, and BMI may be stature dependent over part of the age range (Garn, Leonard, & Hawthorne, 1986). Body fat distribution measured as the WHR was not significantly correlated with the diabetes risk factors. These findings indicate that the diabetes risk factor variables were correlated with general obesity and not with body fat distribution. The place where the waist measurement was taken was not a factor for not finding significant correlations between the diabetes risk factors and WHR since other investigators found significant correlations measuring waist circumference at the umbilicus level (Ohlson et al., 1985; Van Gaal et al., 1989; Soler et

al., 1989). Since WHR was not significantly correlated with SSF (males: r=-0.40; p=0.88, females: r=0.06; p=0.72) or BMI (males: r= -0.60; p=0.80, females: r=0.08; p=0.69) then, total obesity was not a factor diminishing the association between WHR and the diabetes risk factors. However, as in cross-sectional studies, there is the possibility that extraneous variables, not controlled in this study, affected the relationship between WHR and diabetes risk factors. Correlations do not indicate a cause-effect relationship. Thus, the lack of a significant association between body fat distribution and diabetes risk factors does not mean that body fat distribution does not affect diabetes. More studies are required that consider other factors such as hormonal status. Such studies would be ideally based on a large, random sample of obese subjects who reflect a wide range of body fat distribution patterns.

b. There is a positive correlation between WHR, SSF, and BMI and each of the selected hypertension risk factors: SBP and DBP (Table 11).

The positive correlations of WHR with SBP and DBP did not reach statistical significance in this dissertation research (Table 11). These findings are consistent with some investigations (Gerber et al., 1990; Kanai et al., 1990; Adams-Campbell et al., 1990) but not others (Peiris et al., 1989; Van Gaal et al., 1989; Adams-Campbell et al., 1990). WHR was not significantly correlated with SBP or DBP

in non obese males or obese females, in the studies by Gerber et al. (1990) and Kanai et al. (1990), respectively. WHR was not correlated with SBP or DBP in Nigerian females or in American females studied by Adams-Campbell et al. (1990). However, WHR was associated to SBP and DBP in several studies (Peiris et al., 1989; r=0.55 for SBP and r=0.45 for DBP; p<0.01 in 33 females; and Van Gaal et al., 1989; SBP: 147 $\pm$ 7 in AO vs. 128 $\pm$ 11mm/Hg in GFO; DBP: 89 $\pm$ 7 in AO vs. 81 $\pm$ 6 mm/Hg in GFO, p<0.01). WHR was correlated with SBP (r=0.26; p<0.01), but not with DBP in 88 white American females studied by Adams-Campbell et al. (1990).

In this dissertation research, the SSF was significantly correlated with SBP in males (r=0.44; p=0.03) and females (r=0.44; p=0.06), and with DBP in males (r=0.58; p=0.004) and females (r=0.50; p=0.001). These findings suggest that the hypertension risk factors were associated with total body subcutaneous fat measured as SSF.

In this dissertation research, BMI was significantly correlated with SBP (r=0.54; p=0.001) and DBP (r=0.47; p=0.004) in females, but not in males. BMI was significantly correlated with SBP (r=0.28; p<0.01) and DBP (r=0.33; p<0.01) in 135 males studied by Gerber et al. (1990); and in 93 American Black females (SBP: r=0.24; p<0.05), and 88 White American females (SBP: r=0.34; p<0.01; DBP: r=0.21; p<0.05) studied by Adams-Campbell et al.

(1990). However, BMI was not significantly correlated with SBP or DBP after adjusting for age in 124 Nigerian females (Adams-Campbell et al., 1990), or after adjusting for age and the visceral/subcutaneous fat area ratio, in 57 obese Japanese females studied by Kanai et al. (1990).

In this dissertation research, the hypertension risk factors were more correlated with general obesity measured as SSF and BMI, than with body fat distribution measured as the WHR. The lack of significant correlations between the hypertension risk factors and WHR was not expected. The correlations between SBP or DBP and WHR in obese females reported by Kanai et al. (1990) were not significant. However, the ratio of intra-abdominal visceral fat area to subcutaneous fat area (V/S) measured by CT, was significantly correlated with SBP ($r=0.59$; $p<0.001$) and with DBP ($r=0.52$; $p<0.001$) after adjusting for age and BMI. The V/S ratio was not measured in this dissertation research, however, intra-abdominal fat accumulation may play an important role in the pathogenesis of hypertension in these subjects. A significant association may have been masked by our failure to differentiate between subcutaneous and intra-abdominal fat. The location for measuring waist circumference was probably not a factor in our data analysis since other investigators found significant correlations using the same location (i.e., the umbilicus level) (Van Gaal et al., 1989; and, Adams-Campbell et al., 1990). The

small sample size in this dissertation research does not account for the lack of significant correlations between WHR and the hypertension risk factors. Significant correlations were found by other investigators with a similar sample size (n=33 females) (Peiris et al., 1989). Other confounding factors not controlled in this research such as, socioeconomic status, occupational, psychosocial, genetic factors, cigarette smoking, and alcohol intake, may have affected the hypertension-body fat distribution relationship. Epidemiologic studies indicate that people who regularly consume two drinks or more of alcohol per day (>30 ml of ethanol), have higher mean blood pressure levels and a higher prevalence of hypertension than people who drink less (NRC, 1989). Cigarette smokers tend to be leaner than nonsmokers and tend to have lower BP than nonsmokers; smokers who quit gain several pounds of body fat (NRC, 1989). In these subjects general body fat, and not body fat distribution, was associated with SBP and DBP.

c. There is a positive correlation between WHR, SSF, and BMI and TC (Table 11).

TC was the only dependent variable that was highly correlated with WHR for males ($r=0.49$; $p=0.01$) and females ($r=0.44$; $p=0.004$). TC has been positively correlated with WHR in other studies. In the study by Freedman et al. (1990) WHR was positively correlated with TC in 709 males ($r=0.27$; $p<0.001$) and 415 females ($r=0.26$; $p<0.001$). TC was

higher in females with AO than in females with GFO (absolute values were not reported; $p<0.05$) (Van Gaal et al., 1989). Terry et al. (1989) and Houmard et al. (1991) reported positive correlations between TC and WHR of 0.38 ($p<0.001$) and 0.29 ($p<0.05$), respectively, in males. TC levels were not significantly different between two groups of males with different WHR (Peeples et al., 1989), nor was TC significantly correlated with WHR in 84 postmenopausal females (Soler et al., 1988).

In this dissertation research, SSF was correlated with TC in females ($r=0.28$; $p=0.05$) but not males (Table 11). These findings are consistent with the study by Seidell et al. (1989) but not with other studies (Terry et al., 1989; and, Haffner et al., 1987). Subscapular SF, which is an estimate of upper body subcutaneous fat, was significantly correlated with TC in 85 Dutch females ($r=0.36$; $p<0.001$) and in 87 females from Verona ($r=0.41$; $p<0.001$) studied by Seidell et al. (1989). Percent BF estimated from hydrostatic weighing was correlated with TC ($r=0.28$; $p<0.05$) in 81 males studied by Terry et al. (1989). However, after adjusting for WHR and STR the correlation between TC and %BF was no longer significant. These results indicate that the relationship between %BF and TC was not independent of WHR and STR.

BMI was not significantly correlated with TC in males or females in this dissertation research (Table 11).

These findings are consistent with some investigations (Houmard et al., 1991; Soler et al., 1988) but not with others (Terry et al., 1989; Haffner et al., 1987; and Seidell et al., 1989). BMI was not significantly correlated with TC either in 46 nonobese males studied by Houmard et al. (1991), or in 84 nonobese postmenopausal females studied by Soler et al. (1988). BMI was significantly correlated with TC in 81 nonobese males (Terry et al., 1990: $r=0.21$; $p<0.05$), and in 284 obese males (Haffner et al., 1987: $r=0.11$; $p<0.05$). BMI was correlated with TC in females from Verona ($r=0.45$; $p<0.001$), but not in females in other populations (Seidell et al., 1989).

In this dissertation research, a positive significant correlation was expected between TC and WHR, BMI, and SSF. The results obtained revealed that body fat distribution, measured as the WHR, was more highly correlated with TC than total body fat.

d. There is a negative correlation between WHR, SSF, and BMI and each of the selected CHD risk factors: HDL-C, HDL_2-C, and HDL_3-C.

WHR was not significantly correlated with HDL-C, HDL_2-C, or HDL_3-C in this dissertation research. These findings are consistent with some investigations (Pouliot et al., 1989; Ostlund et al., 1990) but not others (Freedman et al., 1990; Houmard et al., 1991; Peiris et al., 1989; Ostlund et al., 1990; Van Gaal et al., 1989; Terry et al., 1989;

Peeples et al.,1989; Meilahn et al., 1991; and, Despres, Moorjani et al., 1989). WHR was not significantly correlated with HDL-C, HDL_2-C, or HDL_3-C in 22 premenopausal nonobese females (Pouliot et al., 1989) nor with HDL_3-C in 77 males and 69 females 60-70 years of age (Ostlund et al., 1990).

WHR was significantly correlated with HDL-C in several other studies (Freedman et al., 1990: $r=-0.22$; $p<0.001$ in 709 males, and $r=-0.14$; $p<0.01$ in 415 females; Houmard et al., 1991: $r=-0.40$; $p<0.05$ in 46 nonobese males; Peiris et al., 1989: $r=-0.47$; $p<0.01$ in 33 premenopausal obese females; Ostlund et al., 1990: $r=-0.31$; $p<0.01$ in 77 males, and $r=-0.25$; $p<0.05$ in 69 females; Terry et al., 1989: $r=-0.43$; $p<0.0001$ in 73 males; Despres, Moorjani, et al., 1989: $r=-0.47$; $p<0.001$ in 52 premenopausal obese females; Van Gaal et al., 1989: males with AO had lower HDL-C levels ($p<0.005$) than males with GFO (absolute values were not reported); Peeples et al., 1989: males with AO had significantly lower HDL-C levels (38 ± 4 mg/dl vs. 53 ± 7; $p<0.05$) than males with GFO; and, Meilahn et al., 1991: females in the highest quintile of WHR had lower levels of HDL-C ($t=14$ mg/dl; $p<0.01$) than females in the lowest quintile.

WHR was significantly correlated with HDL_2-C in several studies (Ostlund et al., 1990: $r=-0.34$; $p<0.01$ in 77 males and $r=-0.37$; $p<0.01$ in 69 females; Terry et al., 1989: $r=-0.52$; $p<0.0001$ in males; Meilahn et al., 1991: females in

the highest quintile of WHR had lower levels of HDL_2-C (10 mg/dl; $p<0.01$) than females in the lowest quintile. Despres, Moorjani, et al., 1989: $r=-0.43$; $p<0.01$ in obese females.

WHR was also correlated with HDL_3-C ($r=-0.44$; $p<0.01$) (Despres, Moorjani, et al., 1989). Females in the highest quintile of WHR had lower HDL_3-C levels ($t=4.4$ mg/dl; $p<0.01$) than females in the lowest quintile (Meilahn et al., 1991).

The correlations between SSF and HDL-C, and HDL_3-C were not significant in this dissertation research. The correlation between SSF and HDL_2-C was significant for females ($r=-0.32$; $p=0.03$) but not for males.

Subscapular SF which is an estimate of upper body subcutaneous fat was significantly correlated with HDL-C ($r=-0.26$; $p<0.05$) in males studied by Terry et al. (1989). HDL-C was significantly correlated with tricep SF in different female populations: Sweden ($r=-0.31$; $p<0.01$), Poland ($r=-0.35$; $p<0.001$); and, with subscapular SF in females from Sweden ($r=-0.39$; $p<0.001$), Poland ($r=-0.33$; $p<0.01$), and Verona ($r=-0.32$; $p<0.01$). These correlations were no longer significant after adjusting for BMI (Seidell et al., 1989). Subscapular and tricep SF were significantly correlated with HDL-C in 293 males (subscapular: $r=-0.31$; $p<0.001$; and triceps: $r=-0.20$; $p<0.001$) and in 441 females (subscapular: $r=-0.24$; $p<0.001$; and triceps: $r=-0.14$; $p<0.01$) studied by Haffner et al. (1987). These results

suggest that lipoproteins are highly related to upper body fat independent of total obesity. Abdominal subcutaneous fat measured by CT was not significantly correlated with HDL-C in premenopausal obese females (Despres, Ferland et al., 1989); and, Despres, Moorjani et al., 1989), or in non obese females (Pouliot et al., 1989). Percent BF estimated from SSF was not significantly correlated with HDL-C in males or in females (Ostlund et al., 1990).

Percent BF determined from SSF was significantly correlated with HDL_2-C in males ($r=-0.23$; $p<0.05$) and females ($r=-0.24$; $p<0.05$) studied by Ostlund et al. (1990). Abdominal subcutaneous fat measured by CT was not significantly correlated with HDL_2-C in obese females (Despres, Ferland et al., 1989; and, Despres, Moorjani et al., 1989) or in nonobese females (Pouliot et al., 1989). HDL_3-C was not correlated with abdominal subcutaneous fat measured by CT in obese females (Despres, Ferland et al., 1989; and Despres, Moorjani et al., 1989) or in a group of nonobese females (Pouliot et al., 1989). Percent BF determined from SSF was not correlated with HDL_3-C in 77 males and 69 females studied by Ostlund et al. (1990).

BMI was significantly correlated with HDL-C ($r=-0.31$; $p=0.04$) and with HDL_2-C ($r=-0.38$; $p=0.02$) in females, but not in males in this dissertation research. BMI was not significantly correlated with HDL_3-C in males or females. Other investigators found a significant correlation between

BMI and HDL-C. BMI was significantly correlated with HDL-C ($r=-0.40$; $p<0.05$) in 46 obese males studied by Houmard et al. (1991); in 73 males ($r=-0.32$; $p<0.01$) studied by Terry et al. (1989); and, in 284 males ($r=-0.32$; $p<0.001$) studied by Haffner et al. (1987). BMI was also correlated with HDL-C in 52 obese females ($r=-0.32$; $p<0.05$) studied by Despres, Moorjani et al. (1989); in 84 postmenopausal females ($r=-0.24$; $p<0.05$) studied by Soler et al. (1988); in Swedish and Polish females ($r=-0.32$; $p<0.01$) as well as in females ($r=-0.27$; $p<0.01$) from Verona studied by Seidell et al. (1989); and, in 434 females ($r=-0.26$, $p<0.001$) studied by Haffner et al. (1987). BMI was not significantly correlated with HDL-C either in Dutch or Neapolitan females studied by Seidell et al. (1989) or in elderly males or females studied by Ostlund et al. (1990).

BMI was significantly correlated with HDL_2-C in several other studies (Despres, Moorjani et al., 1989: $r=-0.30$; $p<0.05$; and, Terry et al., 1989: $r=-0.31$; $p<0.01$). However, BMI was not correlated with HDL_2-C in a group of elderly males and females studied by Ostlund et al. (1990).

BMI was significantly correlated with HDL_3-C in obese females studied by Despres, Moorjani et al. (1989) ($r=-0.28$; $p<0.05$), but not in 73 middle-aged males studied by Terry et al. (1989) or in elderly males or females studied by Ostlund et al. (1990).

In this dissertation research, HDL-C, HDL_2-C, and HDL_3-C were not significantly correlated with any of the measurements of body fat or body fat distribution in males. In females, BMI was significantly correlated with HDL-C and with HDL_2-C, and SSF was significantly correlated with HDL_2-C. The lack of association between WHR and the lipoproteins in these subjects is not clearly interpretable. There are other factors (exercise habits before coming to the program, previous diets, alcohol intake, cigarette smoking, menopausal state, oral contraceptives use) that might affect the WHR-lipoprotein association. According to Wood and Stefanick (1990) alcohol intake affects HDL-C and HDL-C subfraction concentrations. Cigarette smoking is associated with lower HDL-C levels. HDL-C increased with the cessation of smoking (Wood and Stefanick, 1990). In addition, variations in sex steroids represent an important factor for the association between intra-abdominal fat and HL activity. Steroids with androgenic activity increased the HL activity and reduced plasma HDL_2-C levels, while estrogenic steroids decreased HL activity and increased HDL_2-C (Tikkanen & Nikkila, 1987). Distinctions according to menopausal state were not made in females in this study which may affect the WHR-lipoprotein relationship.

Hypotheses 2 and 3 were not considered in any of the studies previously cited as they were considered in this

research. In some of these studies, the multiple regression tests did not always control for the effects of age and WHR, or age and SSF.

Hypotheses 2:

H_A: After controlling for the effect of the variables age and WHR:

a. the regression coefficient for SSF is greater than zero for each of the diabetes risk factors: insulin, glucose, and Hb A_1 (Table 12).

The regression coefficients for the SSF were significantly greater than zero for insulin (males: 0.17 $\pm$ 0.05; p=0.002, and females: 0.18 $\pm$ 0.04; p=0.0002), and glucose (males: 0.57 $\pm$ 0.24; p=0.017, and females: 0.21 $\pm$ 0.09; p=0.015). The regression coefficient for SSF was significantly larger than zero for Hb A_1 in females (0.02 $\pm$ 0.01; p=0.009) but not males.

SSF was not a significant predictor for the development of diabetes in 792, 54-years-old Swedish males after adjusting for BMI in a 13.5 years follow up study (Ohlson et al., 1985). According to Lohman et al. (1988), SF thicknesses are related to total body fatness through their association with total subcutaneous fat. Obesity is one of the most powerful risk factors for NIDDM (Kissebah et al. (1989). Therefore, a positive SSF regression coefficients for insulin, glucose, and Hb A_1 were expected. These

results suggest that insulin, glucose, and Hb A_1 were related to general adiposity independent of body fat distribution and age.

b. The regression coefficient for SSF is greater than zero for each of the hypertension risk factors: SBP and DBP.

The regression coefficient for SSF was significantly greater than zero for SBP in males 0.18 $\pm$ 0.07 (p=0.009) and in females 0.44 $\pm$ 0.12 (p=0.0004), and significantly greater than zero for DBP in males 0.19 $\pm$ 0.07 (p=0.006) and in females 0.16 $\pm$ 0.07 (p=0.01). These results suggest that in this group of males and females, SBP and DBP were positively correlated with general adiposity measured as the SSF, and that the correlation remained significant after adjusting for the effects of age and body fat distribution.

c. The regression coefficient for SSF is greater than zero for TC.

For TC, the regression coefficient for the SSF was not different from zero for males or females. Consistent with the results from hypothesis 1, TC was positively correlated with WHR in males and females. TC was also positively correlated with SSF in females. However, the correlation between SSF and TC in females was no longer significant after adjusting for WHR and age. These results suggest that TC is not related to general obesity. Terry et al. (1989) found similar results. TC was significantly correlated with %BF estimated from body density ($r=0.28$; $p<0.05$) in 81 males

(Terry et al., 1989). However, the correlation was no longer significant after adjusting for WHR and subscapular/tricep ratio (STR). These results indicate that the relationship between %BF and TC was not independent of WHR and STR. Subscapular SF was significantly correlated with TC after adjusting for BMI in 140 nonobese Dutch females ($r=0.28$; $p<0.001$) studied by Seidell et al.(1989) which means that TC was associated with upper body subcutaneous fat independent of the effect of total body fat.

d. The regression coefficient is less than zero for each of the CHD risk factors: HDL-C, HDL_2-C, and HDL_3-C.

For HDL-C and HDL_2-C, the regression coefficient for SSF was significantly less than zero for females (HDL-C: -0.14 ± 0.08; $p=0.06$, and for HDL_2-C: -0.10 ± 0.05; $p=0.04$), but was not significant for males (Table 12). For HDL_3-C, the regression coefficient for the SSF was significantly less than zero for males (-0.13 ± 0.04; $p=0.002$) but not females. These results suggested that in females, HDL-C and HDL_2-C were correlated with general obesity measured as SSF independently of the effects of age and WHR. In males, HDL_3-C was correlated with SSF independent of the effects of age and WHR. These results suggested that in females general obesity is related with HDL-C and HDL_2-C, while in males general obesity is associated with HDL_3-C levels. The

lack of significant correlations in males between SSF and HDL-C and HDL_2-C was probably because males tend to have less subcutaneous fat compared to females at the same degree of obesity. Significant negative correlations between SSF and HDL-C, HDL_2-C, and HDL_3-C were expected in this dissertation research. After adjusting for WHR and STR, the %BF estimated by body density was not correlated with HDL-C in a group of 81 males studied by Terry et al. (1989). Upper body subcutaneous fat estimated by triceps and subscapular SF were not significantly correlated with HDL-C after adjusting for BMI in females from European countries studied by Seidell et al. (1989).

Hypotheses 3:

H_A: After controlling for the effect of age and SSF:

a. the regression coefficient for WHR is greater than zero for each of the diabetes risk factors: insulin, glucose, and Hb A_1 (Table 13).

For insulin, glucose, and Hb A_1, the regression coefficient for WHR was not greater than zero for males or females. In addition to the simple correlation analysis results cited for hypothesis 1, no other studies have assessed the correlation between WHR and diabetes risk factors variables after adjusting for age and SSF. Ohlson et al. (1985) reported that after adjusting for BMI, WHR at baseline was a significant predictor for the development of

diabetes (statistical test value was not reported; $p<0.0037$). The results of this dissertation research suggest that general obesity estimated as SSF is correlated with the diabetes risk factors: insulin, glucose, and HbA_1 independent of age and body fat distribution measured as the WHR.

b. The regression coefficient for WHR is greater than zero for each of the hypertension risk factors: SBP and DBP.

For SBP and DBP the regression coefficient for WHR was not significantly greater than zero for males or females. SBP was significantly correlated ($r=0.26$; $p<0.01$) with WHR after adjusting for age in white American females studied by Adams-Campbell et al. (1990). In this same study, no significant correlations were found for Nigerians or for black American females. After adjusting for age, DBP was not correlated with WHR in any of the three ethnic groups. The results of this dissertation research suggest that SBP and DBP are significantly correlated with general obesity estimated by the SSF, independently of the effect of age and regional fat distribution measured as the WHR.

c. The regression coefficient for WHR is greater than zero for TC.

The regression coefficient was significantly greater than zero for TC in both males (90.53 ± 40.84; $p=0.02$) and females (125.29 ± 80.06; $p=0.06$). Thus, after controlling for the effect of age and SSF, the WHR was positively

correlated with TC. These results are consistent with the results from hypotheses 1 and 2. TC was more highly correlated with WHR and the correlation remained significant after adjusting for the effects of total subcutaneous fat (SSF) and age. In these subjects, TC levels were not related to total body subcutaneous fat. These results are consistent with the study by Anderson et al. (1988) in which TC and WHR were significantly correlated ($r=0.17$; $p<0.001$) after adjusting for age, BMI, smoking, alcohol intake, exercise, and oral contraceptive use in females, but not males. TC and WHR were significantly correlated ($r=0.31$; $p<0.01$) in 81 middle-aged males after adjusting for %BF and STR (Terry et al., 1989). TC and WHR were significantly correlated after adjusting for BMI ($r=0.29$; $p<0.01$) in nonobese Dutch females studied by Seidell et al. (1989). These results suggest that WHR varies with TC independent of overall fatness or STR. On the other hand, WHR and TC were not significantly correlated after adjusting for BMI, age, and physical activity in 84 postmenopausal females studied by Soler et al. (1988). The lack of significant association among the postmenopausal females studied by Soler et al. (1988) may be due to the fact that these females were not obese. Thus, high levels of total body fat (as a threshold effect) may need to be present in order to observe the negative effects of visceral fat on blood lipids. The results obtained in this research suggested that TC was

significantly correlated with body fat distribution independent of the effects of age and general obesity.

d. The correlation coefficients are less than zero for each of the CHD risk factors: HDL-C, HDL_2-C, and HDL_3-C.

For HDL-C, HDL_2-C, and HDL_3-C the regression coefficients for WHR were not less than zero for males or females. These results suggest that HDL-C, HDL_2-C, and HDL_3-C are not related to body fat distribution but to general obesity or probably other factors such as alcohol intake and cigarette smoking that were not controlled for. WHR and HDL-C were not significantly correlated after adjusting for BMI, among females from different countries studied by Seidell et al. (1989). However, other investigations have found significant correlations between WHR and HDL-C. Anderson et al. (1988) reported a negative correlation between WHR and HDL-C ($r=-0.13$; $p<0.001$) after adjusting for BMI, age, smoking, alcohol intake, and exercise in males, but not in females. Terry et al. (1989) reported a significant negative correlation between WHR and HDL-C ($r=-0.32$; $p<0.01$) after adjusting for STR and %BF in males; Soler et al. (1988) found a negative correlation between WHR and HDL-C (regression coeff.$=-72.5 \pm 16.5$; $p<0.001$) after adjusting for BMI, ethanol intake, and physical activity. The correlations between WHR and HDL_2-C, and HDL_3-C after adjusting for other measures of general obesity were not considered in any of the previous cited studies.

Hypotheses 4:

H_A: After adjusting for the SSF and age, an increase in WHR tertile from low to medium to high is associated with:

a. an increase in the estimated means of each of the following diabetes risk factors: insulin, glucose, and Hb A_1 (Table 14).

There was not a significant increase in insulin, glucose, or Hb A_1, with an increase in WHR tertile in this dissertation research. Lundgren et al. (1989) reported a significant difference ($p<0.01$) in quintiles of WHR between 41 females converted to diabetes and 319 nonconverted. In another study, the risk for diabetes in the upper 5% of the distribution of the WHR was 16.6 times higher than the risk in the lowest quintile ($p<0.05$) (Ohlson et al., 1985). Van Gaal et al. (1989) found that insulin was significantly higher ($p<0.025$) in females with high WHR (20.6 ± 13.0) than in females with low WHR (14.3 ± 4.5 uU/ml). In the same study, glucose was significantly higher ($p<0.001$) in females with high WHR (100.1 ± 13.1) than in females with low WHR (88.9 ± 7.6 mg/dl). The results from these studies suggest that insulin and glucose were related to body fat distribution independent of general obesity. Fasting insulin ($p<0.05$) and glucose ($p<0.005$) were significantly higher in obese females with high or low WHR (Landin et al., 1989) which suggests that insulin and glucose are more related to overall fatness than to regional fat distribution.

In this dissertation research, when the analyses were done for males and females together, the p-values of the statistical tests were non-significant. However, p-values for glucose and for Hb A_1 tended to be much lower when the analyses were combined for both males and females, compared to females alone. Females had a lower WHR than males (1.05 $\pm$ 0.04 in males vs. 0.90 $\pm$ 0.01 in females). The lower WHR among females may suggest that at lower WHRs, the biological effect of WHR does not manifest itself (ie. significant relationships do not occur until some threshold for increased AO is achieved). In addition, the small sample size in each tertile reduced the statistical power.

b. An increase in the estimated means of each of the following hypertension risk factors: SBP and DBP.

There was not a significant increase in SBP or in DBP with an increase in WHR tertiles in this dissertation research. In males there were higher mean SBP and DBP in the highest WHR tertiles, but it was not significant. The large standard errors for each tertile could have masked any significant difference. Landin et al. (1989) found that SBP was about 30 mmHg higher in obese females with AO than in the non obese group ($p<0.05$) . No differences were found in SBP between high WHR and low WHR in nonobese females. DBP was about 15 mmHg higher in the obese females compared with lean females ($p<0.01$). No differences in DBP were found between the groups with different WHR, whether they were

obese or lean (Landin et al., 1989). These results suggest that blood pressure is more dependent on total obesity than on regional obesity, and that obesity must be present for the WHR to have an effect.

c. An increase in the estimated means of the CHD risk factor: TC.

For females, there was a significant difference in the estimated mean for TC between tertiles (p-value=0.003) (Table 14). However, a dose response effect was not found. The group of females in the middle tertile had the lowest TC levels, while the females in the lowest and highest tertiles had similar TC levels (210.1 $\pm$ 15.5 vs. 211.0 $\pm$ 5.5). In males, there was an increase in the estimated mean TC with an increase in WHR tertile, but the difference was not statistically significant. When the test was performed for both genders together, the dose response relationship approached statistical significance (p=0.08). These results suggest that fat distribution may affect TC levels in both males and females. In this dissertation study, specific characteristics of the sample such as sample size, sample selection, large standard errors within each tertile and specific traits for females in the lowest tertile that are not clearly interpretable, may have affected the TC-WHR relationship. There is also the possibility of a threshold effect (i.e., WHR below a certain value may not affect TC).

These results are consistent with other investigations (Peeples et al., 1989; and Soler et al., 1988). Peeples et al. (1989) did not find a significant difference in TC levels between males with high (185 $\pm$ 13 mg/dl) or low WHR (171 $\pm$ 3.9 mg/dl). Soler et al. (1988) reported a non-significant increase in the estimated means for TC with an increase in WHR tertile in 83 females (low=219.7 $\pm$ 5.9, middle=226.0 $\pm$ 7.1, high=233.5 $\pm$ 6.6) after adjusting for BMI, age, and physical activity.

Other investigators have found significant increases in TC levels with an increase in WHR tertiles (Anderson et al.,1988; and Van Gaal et al., 1989). Anderson et al. (1988) reported a significant increase in TC (+18 mg/dl) with an increase in WHR tertiles in 520 females after adjusting for age, smoking, alcohol intake, and oral contraceptives use ($p<0.001$), but the same relationship was not found in males. Van Gaal et al. (1989) found higher TC levels among 118 females with high WHR when compared with 30 females with low WHR (absolute differences were not reported, $p<0.05$). No difference was found in males.

d. After adjusting for SSF and age, an increase in WHR tertile from low to medium to high is associated with a decrease in the estimated means of each of the following dependent variables, CHD risk factors: HDL-C, HDL_2-C, and HDL_3-C.

In males, HDL-C, HDL_2-C, and HDL_3-C decreased with an increase in the WHR tertile, but only HDL_3-C was statistically significant ($p=0.01$). In females, an increase in WHR was not associated with a decrease in any of these dependent variables in this dissertation research. It seems that lipoproteins are not related to body fat distribution in these subjects. There are several factors that could explain the lack of a dose-response effect for lipoproteins in females. Exercise habits before starting in the RESHAPE program, diet, alcohol intake, oral contraceptives use, estrogen replacement therapy, distinction menopausal state, cigarette smoking, history of weight loss, history of CHD, and NIDDM could have masked the WHR tertile-lipoprotein associations. There is the possibility that females in this research did not have enough visceral fat accumulation to observe the associations between deep abdominal fat accumulation and alterations in plasma lipids. In addition, the lower sample size in each tertile decreased the statistical power. Several investigators have reported a significant decrease in HDL-C with increases in the WHR tertiles: Anderson et al. (1988) reported a decrease of -4 mg/dl in males ($p<0.01$), but the decrease was not statistically significant in females. Soler et al. (1988) found a significant increase in HDL-C with a decrease in WHR tertile in females after adjusting for BMI, ethanol intake, and physical activity, (HDL-C for low tertile=66.5 $\pm$ 2.4,

middle=59.1 ± 2.3, and high= 52.6 ± 2.5, $p<0.01$). Mean HDL-C levels were about 14 mg/dl lower ($p<0.01$) in the highest quintiles of WHR in females when compared to females in the lowest quintile (Meilahn et al., 1991).

Other investigators have found significantly lower values for HDL-C in males with high WHR when compared to males with low WHR. Van Gaal et al. (1989) reported higher HDL-C in males with low WHR than in males with high WHR (absolute values for HDL-C were not reported, $p<0.005$); however, the differences in females were not significant. Peeples et al. (1989) reported higher HDL-C (53 ± 7 vs. 38 ± 4 mg/dl; $p<0.05$) in 9 pairs of males with low WHR when compared to males with high WHR. HDL-C was higher among 10 premenopausal obese females with low WHR (48.2 ± 7.0 vs. 37.3 ± 4.8; $p<0.001$) when compared to 10 females with high WHR (Despres, Moorjani et al., 1989).

Two studies examined HDL_2-C and HDL_3-C and the relationships with WHR (Meilahn et al., 1991; and Despres, Moorjani et al., 1989). HDL_2-C was about 10 mg/dl lower ($p<0.01$) in females at the highest WHR quintile when compared to females in the lower quintile (Meilahn et al., 1991). HDL_2-C was higher ($p<0.001$) in obese females with low WHR (19.8 ± 4.0 mg/dl) when compared to females with high WHR (13.8 ± 2.5 mg/dl) (Despres, Moorjani et al., 1989).

HDL_3-C was about 4.4 mg/dl lower ($p<0.01$) in females at the highest WHR quintile when compared to females in the lower quintile (Meilahn et al., 1991). HDL_3-C was higher ($p<0.01$) in obese females with low WHR (28.8 $\pm$ 3.9 mg/dl) when compared to females with high WHR (23.6 $\pm$ 3.0 mg/dl).

Hypotheses 5:

H_A: At the end of the 12-week RESHAPE program, each of the following dependent variables will:

a. decrease: diabetes risk factors insulin, glucose, and Hb A_1.

Fasting insulin (males: -4.7 $\pm$ 1.2 uIU/ml; $p=0.002$, females: -4.3 $\pm$ 0.9 uIU/ml; $p=0.0002$), glucose (males: -10.6 $\pm$ 3.8 mg/dl; $p=0.008$, females: -5.1 $\pm$ 2.5 mg/dl; $p=0.03$), and Hb A_1 levels (males: -0.9 $\pm$ 0.1%; $p=0.04$, females: -0.9 $\pm$ 0.3%; $p=0.003$) decreased significantly by the end of the 12-week program. These results suggest that insulin sensitivity and glucose tolerance were increased in these subjects. None of the previous studies cited assessed changes in Hb A_1 after an exercise intervention program. However, a significant decrease in Hb A_1C (from 8.8 $\pm$ 0.9 to 8.0 $\pm$ 0.6%; $p<0.05$) in adults with insulin-dependent diabetes, after a 12-week walking/jogging program was reported by Bazzarre and Izlar (1986). Hb A_1, reflects the average blood sugar concentration for an extended time period (Gabbay et al., 1977). Hb A_1 remains unaffected by

the short term fluctuations in blood sugar levels (Sigma Diagnostics, P. O. Box 14508, ST. Louis, MO 63178, 1984). Gabbay et al. (1977) reported that a single measurement of Hb A_1 represents an integrated measure of the glucose levels seen by tissues over the preceding several months. Hb A_1 levels may reflect carbohydrate imbalance better than fasting glucose concentration or glucose tolerance tests. Lower levels of insulin, glucose, and Hb A_1 were expected at the end of the 12-week intervention program. Results from hypotheses 1, 2, and 3 are consistent in that the diabetes risk factors were significantly correlated with SSF, independent of the effects of WHR and age. The reductions in diabetes risk factors in these subjects parallel the reductions in SSF.

Other investigators have found a decrease in fasting glucose after an exercise and/or diet intervention program: (Vansant et al., 1988: 9 premenopausal obese females with AO decreased fasting glucose by 0.80 $\pm$ 0.49 mmol/l; $p<0.05$ after an 8-week low calorie diet program; and Nieman et al., 1990: fasting glucose decreased in 21 mildly obese females (5.2 $\pm$ 0.1 vs. 5.0 $\pm$ 0.1 mmol/l; $p<0.05$) after a 5-week exercise and diet program). Other investigators did not find any significant changes in glucose levels after exercise or diet exercise programs. Glucose levels did not change significantly in 5 young males (BMI = 27.5 $\pm$ 2.9) after 100 days of aerobic exercise program (Tremblay, Nadeau

et al., 1990), or in obese females after a 12-week diet, walking program (Bjorkelund et al., 1991; and, Anderson et al., 1991), or in lean males (Anderson et al., 1991).

Changes in fasting insulin were assessed in two studies: insulin decreased (7.4 ± 3.2 vs. 3.9 ± 1.5 uU/ml; $p<0.01$) after 100-day exercise training program in 5 males studied by Tremblay, Nadeau et al. (1990). Insulin decreased by 2.8 ± 0.9 mU/l ($p<0.05$) after a 12 week exercise program in 7 obese females studied by Anderson et al. (1991); however, insulin levels did not decreased significantly in males and leaner females.

b. Decrease hypertension risk factors: SBP and DBP.

SBP decreased significantly at the end of the 12-week program for males (-9.7 ± 2.7 mm/Hg; $p=0.002$) and females (-10.6 ± 3.1 mm/Hg; $p=0.001$). DBP decreased significantly for males (-7.7 ± 2.4 mm/Hg; $p=0.003$) but not females (-1.1 ± 1.8 mm/Hg; $p=0.27$). The nonsignificant reductions in DBP in females could reflect the small, although significant, reductions in BMI and %BF. In this dissertation research, a decrease in SBP and DBP was expected at the end of the program. SBP and DBP were reduced significantly from 124 to 114 and from 82 to 73 mm Hg, respectively, ($p<0.001$) in females studied by Bazzarre et al. (1985). SBP and DBP did not decrease after a 12-week exercise-diet program in 63 obese females (Bjorkelund et al., 1991). The group of subjects in the Bjorkelund et al. (1991) study walked as a

group for only 1 hour every 2 weeks. It was not clear if subjects were encouraged to exercise on their own or if walking charts were filled by the subjects. Maybe, these subjects did not walk long enough to elicit changes in SBP or DBP in these subjects. The subjects in the RESHAPE study walked as a group three times per week for a maximum of an hour. In addition, subjects were encouraged to walk on their own during the rest of the week.

c. Decrease CHD risk factor: TC.

Males (-29.8 $\pm$ 8.7 mg/dl; p=0.002) and females (-28.4 $\pm$ 6.8 mg/dl; p=0.0002) had significantly lower TC levels at the end of the 12-week program. A decrease in TC at the end of the 12-week program was expected. Decreased TC levels could also reflect diet intake modification since these subjects were encouraged to decreased calories, fat, and cholesterol intake. This result is consistent with some investigations (Blumenthal et al., 1991; Nieman et al., 1990; Despres, Tremblay et al., 1990; Anderson et al., 1991), but not others (Bjorkelund et al., 1991; and Marti et al., 1990).

TC decreased from 223 $\pm$ 40 to 217 $\pm$ 42 mg/dl (p=0.08) in premenopausal and postmenopausal nonobese females that exercised either aerobically or by strength exercise (Blumenthal et al., 1991), and from 5.28 $\pm$ 0.22 to 4.61 $\pm$ 0.12 mmol/L (p<0.05) in obese females who followed either a low calorie vegetarian diet, or diet plus exercise (Nieman

et al., 1990). After participating in a 12-week walking/jogging program, TC levels decreased from 198 $\pm$ 35 to 185 $\pm$ 38 mg/dl; $p<0.01$ in females studied by Bazzarre et al. (1985). TC levels were reduced significantly after 25 days of exercise training in males ($p<0.05$) and remained reduced until the completion of the study (Despres, Tremblay et al., 1990; Anderson et al., 1991). Anderson et al. (1991) also found decreased TC in lean (-0.5 ± 0.2; $p<0.05$) and obese females (-0.4 ± 0.2; $p<0.05$) after 12-week exercise program. TC was not reduced either in 63 obese females (Bjorkelund et al., 1991), or in 39 males (Marti et al., 1990) after a jogging/walking program. In this dissertation research, reductions in TC were much larger than any other study cited. In other studies, modifications in diet were not emphasized while in the RESHAPE program, subjects were encouraged to decrease saturated fat, simple sugars, and cholesterol intake. The decreased dietary intakes based on the small number of food records returned at the end of the program do not conclusively demonstrate that all subjects achieved similar reductions in dietary intake. However, the decreased dietary intake is consistent with decreased TC in both males and females, and with clinical trials of diet on decreased TC.

d. Other dependent variables will increase: CHD risk factors: HDL-C, HDL_2-C, and HDL_3-C.

HDL-C and HDL_3-C levels were decreased instead of increasing in both males and females. HDL_2-C levels were higher in males and females at the end of 12 weeks, but the increase was statistically significant for males only (-2.5 $\pm$ 1.3 mg/dl; p=0.04). Since exercise training may improve the lipoprotein lipid profile, an increase in HDL-C, HDL_2-C, and HDL_3-C was expected at the end of the exercise intervention program in this dissertation research study. Since HDL_2-C increased and HDL_3-C tended to decrease, the HDL-C did not change significantly. The failure to find significant increases in HDL-C after an exercise intervention program is consistent with several prospective studies (Blumenthal et al., 1991; Nieman et al., 1990; and, Vansant et al., 1988) that failed to demonstrate improved lipid profile among exercising females.

HDL-C levels were decreased in females that participated either in aerobic exercises or in strength training exercises (Blumenthal et al., 1991). HDL-C levels decreased in a group of obese females after 2-weeks of following either a diet or diet plus exercise (Nieman et al., 1990). By the 5th week, the exercise group increased HDL-C to baseline levels, while the "diet only" group did not. These results suggest that exercise training attenuated the decreased in HDL-C. Similarly, HDL-C did not increase in females with AO or GFO after an 8-week low cals diet program (Vansant et al., 1988). Other investigators

have reported higher HDL-C levels after an exercise intervention program (Marti et al., 1990; and Despres, Tremblay et al., 1990). HDL-C increased in males by 0.12 mmol/l ($p<0.028$) after 16 weeks of jogging/walking program (Marti et al., 1990), and after 100 days of exercise training ($p<0.05$) in a group of males studied by Despres, Tremblay et al. (1990).

Wood et al. (1984) cited by Despres, Tremblay et al. (1990) indicated that a substantial amount of aerobic exercise is needed in order to observe a significant increase in plasma HDL-C. Wood et al. (1984) also found that aerobic exercise and body fat loss were important determinants of HDL-C changes. Gidez and Eder (1984) reported that the increase in HDL-C after weight loss does not occur until months after weight reduction, and that measurements of HDL-C are meaningful only after weight has been maintained for this period. The increase in HDL-C after weight stabilization might be mediated by an increase in adipose tissue LPL. Therefore, subsequent maintenance of reduced weight appear to be an effective means of increasing HDL-C. A diet low in saturated fat may decrease VLDL, LDL-C, and HDL-C (Gidez & Eder, 1984). The subjects in the RESHAPE program were encouraged to decrease fat intake, which may explain why HDL-C did not increase. Hepatic lipase (HL) which is increased in obese subjects, is positively correlated with deep abdominal fat independent of

total body fat (Despres, Ferland et al., 1989). HDL_2-C is negatively correlated with HL activity. The increase in plasma HL activity observed in visceral obesity is partly responsible for reductions in HDL_2-C. Subjects in the RESHAPE program walked for an hour from week 8 through 12, which probably was not long enough to elicit changes (decreased HL activity) in lipoprotein metabolism. WHR was not significantly reduced which probably accounts for the non-increase in lipoproteins. Hormonal effects may have also affected the lack of change in lipoproteins since both HDL_2-C and HL activity are sensitive to sex steroids.

None of the studies previously cited evaluated changes in HDL_3-C. The metabolism of HDL is complex and specific associations between HDL-C subclasses and coronary atherosclerosis are still incompletely understood. Several investigators (Musliner & Krauss, 1988; and, Wallentin & Sundin, 1985) have compared concentrations of HDL subclasses (HDL_2-C and HDL_3-C) in subjects with and without CHD. Most studies have shown that HDL_2-C and HDL_3-C concentrations are decreased in males with CHD. Wallentin and Sundin (1985) found lower levels of HDL-C ($p<0.001$), HDL_2-C ($p<0.001$), and HDL_3-C ($p<0.003$) in patients with coronary artery disease when compared with healthy controls after controlling for obesity, TG, and smoking.

Hypotheses 6:

H_A: At the end of the 12-week program each of body weight (BW), BMI, SSF, percent body fat, waist circumference (WC), hip circumference (HC), and WHR will decrease (Table 17).

BW (males: -5.6 ± 1.5 Kg; p=0.001; and, females: -2.2 ± 0.6 Kg; p=0.0006), BMI (males: -1.8 ± 0.4; p=0.001; and, females: -0.9 ± 0.2; p=0.001), SSF (males: -25.1 ± 4.7mm; p=0.00005; and, females: -10.2 ± 2.2mm; p=0.0001), %BF (males: -5.1 ± 0.8%; p=0.00005; and, females: -2.2 ± 0.4; p=0.00005), waist circumference (WC) (males: -9.1 ± 3.9 cm; p=0.017, and females: -3.6 ± 1.2 cm; p=0.004), and hip circumference (HC) (males: -2.8 ± 1.5 cm; p=0.04; and, females: -2.1 ± 0.9 cm; p=0.013) were significantly lower at the end of the RESHAPE program. Both males and females had a decrease in WHR which approached statistical significance (males: -0.07 ± 0.14; p=0.09; and, females: -0.01 ± 0.01; p=0.07). The decrease in WC was larger than the decrease in HC in both males and females, which theoretically would lead to a decrease in WHR. The findings of this research are consistent with previous results reported in the literature. BW decreased in males that participated in diet and/or exercise programs: (Anderson et al., 1991: -2.0 ± 0.6 Kg; $p<0.05$; Bazzarre et al., 1985: from 200 ± 18 to 191 ± 19 lb; $p<0.01$; and, Bouchard et al., 1990: BW decreased from 86.7 to 78.7 kg ($p<0.01$) after 100-days aerobic exercise. Other

investigators reported a decreased in BW in females after a diet/exercise program: BW decreased by a mean of 2.83 ± 2.46; $p<0.001$ in obese females with AO and by a mean of 3.98 ± 3.92; $p<0.05$ in females with GFO studied by Bjorkelund et al. (1991). Obese females that followed a VLCD alone, behavior therapy alone, or combined treatment lost 10.4 ± 4.1, 10.8 ± 6.3, and 15.2 ± 7.6 kg, respectively, in the study by Wadden et al. (1988). When categorized according to body fat distribution, BW decreased by 10.0 % in obese females with AO, and by 12.3% in obese females with GFO (Wadden et al., 1988). BW decreased from 158 ± 27 to 153 ± 25 lb; $p<0.001$ in females studied by Bazzarre et al., 1985; BW decreased by a mean of 3.5 ± 0.8 kg ($p<0.05$) in obese premenopausal females studied by Krotkiewski et al. (1988); and, by a mean of 9.6 ± 2.4 kg and 10.2 ± 3.3 kg (p-values were not reported) in obese premenopausal females with GFO and AO, respectively, (Vansant et al., 1988). However, no difference in BW was found in males or in females according intensity of usual daily leisure-time activities (Tremblay, Despres et al., 1990), or in females with general obesity after a diet exercise program (Bjorkelund et al., 1991), or in leaner or obese females studied by Anderson et al. (1991) after an aerobic exercise program.

Several investigators reported reductions in BMI after exercise/diet intervention programs: (Bouchard et al., 1990: BMI decreased from 27.5 to 25.0 kg/m^2 ($p<0.001$), in 5-young

males; Bjorkelund et al., 1991: BMI decreased by a mean of 1.50 ± 1.06 ($p<0.05$), and 1.03 ± 0.95 ($p<0.001$) in females with GFO and AO, respectively; Vansant et al., 1988: BMI decreased significantly ($p<0.05$) from 31.6 ± 1.7 to 28.1 ± 1.7, and from 33.9 ± 4.3 to 30.2 ± 4.2 in females with GFO and AO, respectively, after 8-week diet program; and, Tremblay, Despres et al., 1990: BMI was significantly higher ($p<0.05$) in females categorized in the lower intensity of daily leisure activities (less than 5 METS) when compared with females in higher categories (between 7 and 9 METS).

BMI did not decrease significantly in males (Marti et al., 1990) or in leaner or obese females (Anderson et al., 1991), or in females with general obesity (Bjorkelund et al., 1991) after an exercise intervention program. BMI was not different among males categorized by intensity of usual daily leisure-time activities (Tremblay, Despres et al., 1990).

The sum of 10 SF measures, the sum of 5 SF in the trunk area, and the sum of 5 SF in the body extremities area decreased significantly ($p<0.01$) in a group of 5-males after an aerobic exercise program. Subcutaneous fat was reduced by 31% ($p<0.001$), and by 24% ($p<0.001$) in the trunk and the extremities, respectively, (Bouchard et al., 1990). Males and females in the highest category of daily leisure-time activities category had lower SSF measures ($p<0.05$) than males and females in the lowest category (Tremblay, Despres

et al., 1990). SSF were reduced significantly from 85 ± 19 to 64 ± 16 mm; $p<0.001$ in males; and, from 106 ± 37 to 82 ± 27 mm; $p<0.001$ in females studied by Bazzarre et al. (1985). Reductions in SSF were not statistically significant in 39-males studied by Marti et al. (1990) after a 16-week walking/jogging program, probably because only 31% of the males jogged regularly for at least 90 minutes every week during the 4-month period.

Several investigators reported a decrease in BF after an exercise and/or diet intervention program: (Anderson et al., 1991: BF was reduced in males (-2.9 ± 1.4Kg; $p<0.05$) and in obese females (-4.6 ± 1.5Kg; $p<0.05$) after a 12-week aerobic exercise program; Bazzarre et al., 1985: %BF was reduced in males from 29 ± 5 to 25 ± 4%; $p<0.001$; and in females from 38 ± 5 to 35 ± 5%; $p<0.001$ after a 12-week walking/jogging program; Bouchard et al., 1990: %BF was significantly reduced from 18.7% to 12.5% ($p<0.001$) in 5-males after aerobic exercise program; Vansant et al., 1988: %BF was reduced in females with AO from 45.0 ± 3.5 to 41.2 ± 3.2% and from 46.2 ± 6.0 to 42.0 ± 6.8%, in females with GFO and AO, respectively, after a 8-week diet program; Wadden et al., 1988: females with AO and GFO decreased BF by 16%, and by 20.3%, respectively).

Percent BF was not reduced in other studies: (Marti et al., 1990: %BF did not decrease significantly in 61 males

after a walking/jogging program; and, Anderson et al., 1991: BF was not reduced significantly in lean females.

WC may decrease after exercise/diet intervention programs: Anderson et al., 1991: WC decreased in males (-2.9 ± 1.1 cm; $p<0.05$), and in leaner females (-3.2 ± 1.1 cm; P,0.05), and obese females (-4.4 ± 0.2 cm; $p<0.001$); Bjorkelund et al., 1991: WC was reduced significantly (-3.42 ± 3.04 cm; $p<0.001$) in females with AO; Vansant et al., 1988: WC decreased in females with GFO by a mean of 7.3 ± 2.3 cm, and in females with AO by a mean of 9.1 ± 1.9 cm (no p-value was reported); Wadden et al., 1988: WC was reduced by 7.7% in females with AO, and by 7.6% in females with GFO (no p-value was reported); Krotkiewsky et al., 1988: WC decreased by 8% in obese premenopausal females ($p<0.001$) after 2-weeks on a 544 kcal/day diet; Tremblay, Despres et al., 1990: males and females categorized in the highest activity-intensity group (METS<5), were characterized by reduced WC ($p<0.05$). The reduction in WC in the previously cited studies was similar to the reduction by the subjects in this dissertation research (Table 17).

Several investigators reported a decrease in HC after exercise/diet intervention programs. HC decreased by 2.3 ± 0.8 cm; $p<0.05$, in males, by 2.7 ± 0.8 cm; $p<0.01$, in leaner females, and by 2.7 ± 1.1 cm; $P<0.05$, in obese females studied by Anderson et al. (1991); by 7.6 ± 4.3 cm in obese premenopausal females with AO, and, by 9.5 ± 5.9 cm in

females with GFO studied by Vansant et al. (1988) (no p-value was reported). HC was reduced by 5.1% in obese females with AO, by 7.8% in obese females with GFO studied by Wadden et al. (1988) (no p-value was reported); by 4% ($p<0.05$) in obese premenopausal females after 2 weeks on a 544 kcal/day diet (Krotkiewsky et al., 1988). However, HC was not different according activity-intensity group in males or females studied by Tremblay, Despres et al. (1990); or among obese females after participate in exercise/diet intervention program (Bjorkelund et al., 1991).

WHR have been reported to decrease after exercise/diet intervention programs. Females with AO reduced WHR by 2.4% ($p<0.01$) (Bjorkelund et al., 1991); from 0.85 ± 0.04 to 0.82 ± 0.02, $p<0.01$) (Vansant et al., 1988); and, by 2.7% (p-value was not reported) (Wadden et al., 1988). WHR decreased by 3% ($p<0.01$) in premenopausal obese females studied by Krotkiewsky et al. (1988) after 2 weeks on 544 kcal/day diet. WHR was lower in males and females categorized in the highest activity-intensity group ($p<0.05$). This difference was mainly due to WC differences since HC was not different among groups (Tremblay, Despres et al., 1990). WHR was reduced by 0.02 ($p<0.001$) in 61 males studied by Marti et al. (1990) after participation in a walking/jogging program.

Other investigators did not find a decrease in WHR. WHR was not reduced significantly in females with general

obesity or with GFO studied by Bjorkelund et al. (1991), or in females with GFO studied by Vansant et al. (1988). WHR increased by 0.1% in obese females with GFO studied by Wadden et al.,1988) (no p-value was reported).

WHR was not altered by the weight and fat loss in a group of 5 males studied by Bouchard et al. (1990) that participated in aerobic exercise for 4-months, nor in males or females after an aerobic exercise intervention program (Anderson et al., 1991). These previous cited investigations consistently showed that females with GFO are more resistant to changes in WHR.

Both males and females in this dissertation research had a decrease in WHR which approached statistical significance (Table 17). The reduction in WC was larger than the reduction in HC leading to an average decrease in WHR. These results are consistent with the concept that adipocytes in the abdominal area are more lipolytic than adipocytes in the gluteofemoral area (Leibel et al., 1989).

Hypotheses 7:

H_A: CSA scale scores will increase and the STAI scale scores will decrease at the end of the 12-week program among the participants in the RESHAPE program (Table 18).

Values for CSA were higher at the end of the 12-week program for both males and females, but the increase was significant only for males (3.9 $\pm$ 3.8; p=0.0002). Values

for STAI decreased for both males (3.2 ± 1.9; p=0.06) and, females (3.1 ± 2.0; p=0.07). In this dissertation research project, a decrease in the STAI scale and an increase in the CSA scale were expected. None of the studies previously cited, assessed the effect of an exercise program on stress management. WHR has been correlated with several psychological variables such as degree of mental disorder ($p<0.001$), feelings of stress ($p<0.02$), sleeplessness ($p<0.01$), nightmares ($p<0.01$), regular use of tranquilizers ($p<0.007$), regular use of antidepressants ($p<0.02$), number of accidents ($p<0.03$), and number of fractures ($p<0.03$) indicating accident proneness as well as mental disorders, in females (values for the correlations were not reported) (Lapidus et al., 1989). BMI was negatively associated to achievement, aggression, and dominance ($p<0.02$). Larsson et al. (1989) found a negative correlation between WHR and social class ($p<0.009$), and social group ($p<0.03$), and positive correlation with periods and duration of sickness ($p<0.005$) in 792 males after adjusting for BMI. According to Rosato (1986) aerobic exercise had successfully been used as therapy for relieving anxiety, mental depression, drug addiction, and schizophrenia.

Hypotheses 8:

H_A: At the end of the 12-week program subjects will have a lower calorie (cals), fat, and cholesterol intake, and a higher dietary fiber intake (Table 19).

Males and females decreased kcal and fat intake, but the decrease was significant only for kcal intake (332 ± 100 cals; p=0.04), and fat intake (35 ± 9 g; p=0.03) in males. Cholesterol intake was not reduced significantly in any group. Dietary fiber intake was not increased significantly in any group, but it approached significance in females (5 ± 3 g; p=0.09). The number of subjects who returned food records at the end of the study was small (5 females and 3 males). In addition, none of the subjects from the control group returned food records at the end of the program. Therefore, it was not possible to assess the effectiveness of the program for changes in nutrient-food intake by the participants. According to the food records returned at the end of the program, males and females decreased kcal, and fat, and increased dietary fiber. With a larger number of subjects returning food records at the end of the program, significant favorable changes in food intake variables should have occurred.

From the studies previously cited, one (Anderson et al., 1991) obtained a diet history from the participants at the beginning and at the end of the study. Specific results for different nutrients were not reported. However, the investigators stated that obese females decreased energy intake (329 ± 91 kcal; $p<0.05$) with training while leaner females and males did not. Others studies previously cited, (Bouchard et al., 1990; Vansant et al., 1988; Nieman et al.,

1990; Wadden et al., 1988; and Bjorkelund et al., 1991) did not assess changes in nutrient-food intake before and after intervention programs, even when diet was included as part of the programs.

Hypothesis 9:

H_A: The cardiovascular fitness of males and females will improve at the end of the 12-week program as measured by a decrease in the time taken to walk a mile (Table 20).

The time taken to walk a mile was decreased significantly at the end of the 12-week program for males (-1.3 ± 0.3 min; $p=0.002$) and females (-1.7 ± 0.6 min; $p=0.009$) in this dissertation research. A decrease in the time for walking a mile was expected among the participants in the RESHAPE program. From the studies previously cited, no one included the 1-mile test as part of their evaluation.

According to Rosato (1986) there are some beneficial effects that accompany long term aerobic exercise. Some of these effects are: a decrease in heart rate by 10 to 25 beats/minute, an increase in stroke volume since the heart can pump more blood per beat, and an increase in blood flow. Exercise training may improve the aerobic capacity by 15 to 20% in previously untrained healthy young adult. This improvement may be due to a combination of the physiological adaptations previously discussed.

Hypotheses 10:

H_A: Favorable reductions in the SSF are positively correlated with changes in each of the:

a. diabetes risk factors: insulin, glucose, and Hb A_1 (Table 21).

A decrease in glucose and Hb A_1 were not correlated with a decrease in SSF in males or females. A decrease in insulin level was correlated with a decrease in SSF only for males ($r=0.53$; $p=0.04$). For the correlation between changes in insulin and changes in SSF, only 2 of the 12 females included in the analysis increased insulin levels. However, the correlation was not significant because there were females that reduced insulin levels without reducing SSF. In addition, there was one female that reduced about twice in SSF than the next female that reduced more SSF, that reduced the correlation between changes in insulin and changes in SSF. The 12 males included in the analysis decreased insulin levels which contributed to the significant correlation ($p=0.04$). For the correlation between changes in glucose and changes in SSF, only 5 of the 13 females, and 3 of the 14 males included in the analysis increased glucose levels. For the correlation between changes in Hb A_1 and changes in SSF, only 1 of the 13 females, and 3 of the 13 males included in the analysis increased Hb A_1. For this analysis only subjects who reduced 6mm of SSF or more were included. This selection reduced the sample size further

(Table 21). It might be that significant correlations could be obtained with a larger sample size or by including all the subjects in the study since probably subjects who did not reduced SSF could have an increase in the diabetes risk factors. A positive correlation between changes in SSF and changes in the diabetes risk factor variables was expected in this dissertation research. None of the studies previously cited assessed changes in SSF with changes in the diabetes risk factor variables considered in this dissertation research.

Lundgren et al. (1989) studied the correlations between increases in BMI, SSF, waist and hip circumference, and WHR with increases in serum glucose concentration during a 12-year follow up period. The p-values for the correlations found were significant ($p<0.001$) for all anthropometric variables except WHR ($p<0.192$) (correlation values were not given). According to Lonnroth (1988) obesity is often associated with insulin resistance and type II diabetes (NIDDM). The risk for diabetes is increased for overweight Americans when compared to non-overweight Americans as revealed by NHANES II (NRC, 1989). As explained in the review of literature section, hyperinsulinemia accompanies obesity as a marker of the insulin resistance, and fasting plasma insulin levels are correlated with the degree of obesity (Kissebah and Peiris, 1989). Subjects in this study decreased SSF, %BF, and BMI significantly. Both males and

females also reduced insulin and Hb A_1. Females also reduced fasting glucose levels significantly. However, not all the subjects who reduced SSF reduced insulin, glucose or Hb A_1 levels. Thus, the correlation coefficients, although positive for insulin and glucose were nonsignificant. With a larger sample size, significant correlations between changes in SSF and changes in diabetes risk factor variables would probably be observed.

b. Hypertension risk factors: SBP and DBP (Table 21).

A decrease in SBP was not correlated with a decrease in SSF in males or females. Reductions in DBP were significantly correlated with reductions in SSF for males ($r=0.49$; $p=0.03$) and females ($r=0.42$; $p=0.06$). These results suggest that subjects who reduced subcutaneous fat, tended to reduce DBP. Hypertension can usually be controlled with medication, diet, weight loss, and exercise. Therefore, in this dissertation research, a positive correlation between changes in SSF and changes in SBP and DBP was expected. The correlation between changes in DBP and changes in SSF was higher and more significant for males than females probably because males lost more SSF and reduced DBP more than females. None of the studies cited before assessed this specific hypothesis. In the Framingham study (Kannel et al., 1967), the risk of developing hypertension increased with increased BW. In the most obese group, 46% were hypertensive. MacMahon et al. (1987) found

that approximately one-third of the prevalence of hypertension was attributable to obesity in males and females aged 25 to 64 years.

c. CHD risk factor: TC.

Changes in TC were not correlated with changes in SSF. In this dissertation research, a positive correlation between changes in SSF and changes in TC was expected. In the general population, subjects who are more active usually do not have lower cholesterol levels when compared to less active subjects. More active subjects usually have increased HDL_2-C and decreased LDL-C leading to a small net change in TC (Wood & Stefanick, 1990). Both males and females decreased TC and SSF significantly in this dissertation research. However, the decrease in TC was not significantly correlated to the decrease in SSF. For the correlation between changes in TC and changes in SSF, 12 of the 14 females, and 12 of the 16 males included in the analysis decreased TC levels. For this analysis only subjects who reduced 6.0 mm of SSF or more were included. This selection reduced the sample size further (Table 21). It might be that significant correlation would be obtained with a larger sample size.

d. Favorable reductions in the SSF are negatively correlated with changes in each of the CHD risk factors: HDL-C, HDL_2-C, and HDL_3-C (Table 22).

A decrease in SSF was correlated with an increase in HDL_2-C ($r=-0.71$; $p=0.003$) in females, but not in males. A decrease in SSF was not correlated with an increase in HDL-C, or HDL_3-C for males or females. These results are consistent with some investigations. Changes in SSF were significantly correlated ($r=-0.39$; $p<0.001$) with changes in HDL_2-C in males studied by Marti et al. (1990). The correlation was negative (-0.11) for HDL-C but did not approach statistical significance. No significant correlation was found for HDL_3-C. Marti et al. estimated that a decrease in SSF by 18 mm would have raised the HDL_2-C concentration by 0.15 mmol/l. In this dissertation research, for the correlation between changes in HDL-C and changes in SSF, only 5 of the 14 females, and 8 of the 16 males included in the analysis increased HDL-C levels. For the correlation between changes in HDL_2-C and changes in SSF, 10 of the 13 females, and 10 of the 16 males included in the analysis increased HDL_2-C levels. For the correlation between changes in HDL_3-C and changes in SSF, only 2 of the 14 females, and 6 of the 16 males included in the analysis increased HDL_3-C levels. For this analysis only subjects who reduced 6.0mm of SSF or more were included. This selection reduced the sample size further (Table 22). A significant correlation might be obtained with a larger sample size.

Hypotheses 11:

H_A: Favorable reductions in the WHR are positively correlated with changes in each of:

a. diabetes risk factors: insulin, glucose, Hb A_1 (Table 23).

A decrease in WHR was not correlated with a decrease in insulin, glucose, or Hb A_1 in males or females. A positive correlation between changes in WHR and changes in diabetes risk factor variables was expected in this study. The correlations between changes in diabetes risk factor variables and changes in WHR were not significant in this study probably because WHR was not reduced significantly after the 12-week program. In addition, for the correlation between changes in insulin and changes in WHR, 2 of the 7 females increased insulin levels, while the 7 males included in the analysis decreased insulin levels. For the correlation between changes in glucose and changes in WHR, 3 of the 8 females increased glucose levels, while the 9 males included in the analysis decreased glucose levels. For the correlation between changes in Hb A_1 and changes in WHR, the 8 females included in the analysis decreased Hb A_1, while only 1 of the 9 males included in the analysis increased Hb A_1 levels.

Subjects who lost WHR by 0.03 or more were included in this analysis which reduced the sample size further. The magnitude in WHR reduction was small (females: 0.01 ± 0.01

and males: 0.07 ± 0.14) compared with the magnitude in insulin reduction (females: 4.3 ± 0.9 and males: 4.7 ± 1.2uIU/ml), glucose (females: 5.1 ± 2.5 and males: 10.6 ± 3.8 mg/dl), and Hb A_1 (females: 0.09 ± 0.3 and males: 0.9 ± 0.1%) which may affect the value and significance of the correlations. Again, with a larger sample size, significant correlations might be found. None of the previous studies cited addressed this hypothesis. Lundgren et al. (1989) evaluated the correlation between increases in WHR and increases in serum glucose in a group of females during a 12-year follow up study. The correlation found between changes in these two variables was not significant (p=0.192).

b. Hypertension risk factors: SBP and DBP.

Changes in SBP or DBP were not significantly correlated with changes in WHR. A decrease in WHR was expected to correlate with decreases in SBP and DBP in this study. For the correlation between changes in SBP and changes in WHR, 7 of the 9 females decreased SBP, while the 9 males included in the analysis decreased SBP. However, the correlation was not significant in males or females probably because of the reduced sample size and because these subjects reduced SBP without reducing WHR significantly. For the correlation between changes in DBP and changes in WHR, only 4 of the 9 females decreased DBP, while 2 of the 9 males included in the analysis increased DBP. Neither the decrease in DBP or in WHR was significant in females.

c. CHD risk factor: TC.

Decreased WHR was positively correlated with decreased in TC in males ($r=0.68$; $p=0.02$) but not in females. When both males and females were analyzed together, the correlation was positive and significant ($r=0.43$; $p=0.04$) probably because of a higher statistical power. The ranges in WC, HC, and WHR were higher in males than in females which may contribute to the significant correlation in males and the lack of significant correlation in females.

d. Favorable reductions in the WHR are negatively correlated with changes in each of the CHD risk factors: HDL-C, HDL_2-C, and HDL_3-C (Table 24).

A decrease in WHR was not correlated with an increase in HDL-C, HDL_2-C, or HDL_3-C, in males or females. These results are consistent with the study by Marti et al. (1990). Marti et al. found no correlation between changes in WHR and changes in HDL-C, HDL_2-C, and HDL_3-C in males after a 16-week aerobic exercise program. However, changes in WHR were significantly and inversely related to changes in total physical activity ($r=-0.27$; $p<0.05$). In this dissertation research, for the correlation between changes in HDL-C and changes in WHR, 4 of the 8 females decreased HDL-C, while 5 of the 9 males included in the analysis decreased HDL-C. For the correlation between changes in HDL_2-C and changes in WHR, 2 of the 8 females decreased HDL_2-C, while 4 of the 9 males included in the analysis

decreased HDL_2-C. For the correlation between changes in HDL_3-C and changes in WHR, 6 of the 8 females decreased HDL_3-C, while 6 of the 9 males included in the analysis decreased HDL_3-C. The lack of consistency and statistical power influenced the correlation analysis. Measurement error may have contributed to the lack of significant statistical findings. According to Marti et al. (1989) the proportion of total variance due to measurement errors is much larger for change data than for cross sectional data, since measurement error contributes twice to the total variance for change data.

Hypotheses 12:

H_A: Favorable reductions in BW are positively correlated with changes in each of:

a. Diabetes risk factors: insulin, glucose, Hb A_1 (Table 25).

A decrease in BW was not correlated with a decrease in insulin, glucose, or Hb A_1. These hypotheses were not considered in any of the studies previously cited. BW includes not only body fat but also fat free mass and water. Changes in BW are not a good indicator of changes in BF because the measurement do not distinguish between fat mass and fat free mass (McArdle et al., 1986). Lundgren et al. (1989) found a positive and significant correlation ($p<0.001$) between increase in BMI and an increase in glucose levels in females after a 12-year follow up.

b. Hypertension risk factors: SBP and DBP.

A decrease in BW was positively correlated with a decrease in DBP ($r=0.46$; $p=0.06$) in females. Changes in SBP were not correlated with changes in BW in males or females. Since the risk of developing hypertension increases with an increase in BW, positive correlations were expected between changes in BW and changes in SBP and DBP.

c. CHD risk factor: TC,

Decreased BW was correlated with decreased TC ($r=0.73$; $p=0.002$) in females, but not in males. Nieman et al. (1990) found that a decrease in BW accounted for approximately 40% of the change in TC in females. A positive correlation was expected between changes in BW and changes in TC.

d. Favorable reductions in BW are negatively correlated with changes in each of the CHD risk factors: HDL-C, HDL_2-C, and HDL_3-C (Table 26).

Changes in BW were not correlated with changes in HDL-C, HDL_2-C, or HDL_3-C in males or females. These findings are consistent with the study by Marti et al. (1990), who did not find a significant correlation between changes in BMI and changes in HDL-C, HDL_2-C, or HDL_3-C in males after four months of aerobic exercise. Thus, one important factor in evaluating the results of this study is that none of the other investigators calculated correlations between changes in BW and changes in lipoproteins.

General Limitations

1. Use of volunteers: volunteers represent a group of self-motivated and health conscious people. They may not have been representative of the general population of overweight or obese people.

2. Use of free living subjects: because subjects were free living it was difficult to control food intake and physical expenditure on a daily basis. However, subjects were encouraged to walk and to control their food intake as part of their lifestyle, which could also be an advantage.

3. Sample size: at the end of the program 5 of 20 males and 14 of 31 females were not available for final evaluation. The sample size was similar to many other studies, but ideally should have been much larger in order to increase the statistical power.

4. Food records: only 8 subjects returned food records at the end of the program. This lack of compliance made it impossible to generalize about these results for the entire RESHAPE population. A greater number of food records should have indicated if the dietary habits significantly affected the decrease in fasting glucose, insulin, Hb A_1, and lipid levels.

5. Although the subjects served as their own controls. the use of a control group would have strengthened the evaluation of the effectiveness of the intervention program on the variables.

6. Not all the participants were obese. Thus, future studies may want to categorize subjects as "lean", moderately overweight and obese. See the study by Anderson et al. (1991) as an example.

7. Smoking and alcohol intake were not controlled for in this study. However, few subjects smoked and many subjects reported that they seldom or never drank alcoholic beverages. These factors could have affected the blood lipids and blood pressure.

8. No distinction was made regarding the menopausal status of females which could have affected the diabetes and CHD risk factors.

9. WHR measurement: The WHR was calculated from a waist circumference measured at the level of the umbilicus, and a hip circumference measured at the widest part between hip and buttocks. In other studies, different body landmarks have been used to measure the waist and hip circumference. Thus, differences in the findings reported among studies may at least partially reflect differences in the methods used to assess body fat distribution as well as unique anthropometric characteristics of some of the populations that have been studied. For example, significant differences in anthropometric profiles exist among whites, blacks, hispanics, and oriental populations.

Recommendations For Future Research

There are several factors that should be considered when doing research similar to that presented. Future research on body fat distribution should include a large sample size, as well as matching for confounding variables such as age, gender, and SSF. More accurate methods for measuring intra-abdominal fat versus subcutaneous fat such as the CT should be used to evaluate the body fat distribution-disease relationships assuming facilities and costs are not problems. Additionally, the procedures for measuring hip and waist circumferences should be standardized. The development of methods that differentiate between subcutaneous and deep abdominal fat are needed. Such methods should be both practical and cost effective because of the large number of subjects recruited for such investigations. Reference values for measurements like waist, hip, WHR based on age, gender, and ethnic groups are also needed. Repeated measurements of waist and hip circumferences and WHR should be taken several times during the research period to evaluate changes in patterns of fat distribution.

In addition, there are many areas that could be explored regarding body fat distribution-disease relationships. Longitudinal studies should be carried out to evaluate: changes in body fat distribution from childhood to adulthood and the relationship with chronic diseases;

differences in fat distribution among people from different ethnic backgrounds and the relationship with chronic diseases; body fat distribution in chronic users of oral contraceptives since hormonal effects may affect body fat distribution; body fat distribution in postmenopausal females receiving estrogen replacement therapy; the effect of alpha-2 adrenergic receptor antagonists or beta adrenergic receptor agonists on body fat distribution as well as on abdominal versus gluteofemoral fat cell size and number; the effect of "sensible" low calorie, low fat diets with and without aerobic exercise on body fat distribution in different population subgroups such as adolescents, adult females, adult males, and postmenopausal females; the effect of a long term "sensible" low calorie, low fat diet upon diabetes risk factors, hypertension risk factors, and CHD risk factors; and, the effects of reducing WHR or changing body fat topography on the risk of developing NIDDM, since an excess mobilization of free fatty acids from the intra-abdominal fat depots can impair the insulin hepatic extraction.

CHAPTER VI

SUMMARY AND CONCLUSIONS

This dissertation research specifically focused on determining if body fat distribution exhibited a higher correlation with chronic disease risk factors (diabetes, hypertension, and CHD) than overall measures of general obesity such as the SSF and BMI. The specific objectives of this research were directed at the measurement of food intake, %BF, cardiovascular fitness and stress as well as selected risk factors for diabetes, hypertension, and CHD in a group of overweight/obese males and females. The selected nutrient variables of interest were: energy intake (cals), fat, protein and carbohydrate (grams per day, and as a percent of total kcal intake), cholesterol, dietary fiber, zinc and copper. Measures of body fat included body weight, the Quetelet index or BMI, SSF (triceps, biceps, subscapular and suprailiac), estimated %BF, and the WHR. Cardiovascular fitness was measured by the amount of time required to walk one mile. Measures of stress included the Personal Stress Assessment and the State-Trait Anxiety Inventory.

The relative risk of developing CHD was based on the measurement of TC, HDL-C, HDL_2-C, and HDL_3-C. The relative risk of developing hypertension was based on the measurement

of SBP and DBP. The relative risk of developing diabetes was based on measuring fasting glucose, insulin, and Hb A_1.

Twenty male subjects and 35 female subjects were evaluated at baseline for the cross-sectional study. Fifteen male subjects and 21 female subjects were evaluated at week 0 and at week 12 for the longitudinal component of this research. Statistical analyses conducted included descriptive statistics (means and standard errors of the means), Pearson product moment correlation coefficients, multiple regression analyses, paired-difference t-tests, and analysis of covariance.

The following are the results obtained from the cross sectional study. TC was the only dependent variable associated with WHR in males and females after adjusting for age and SSF. TC was not correlated with SSF either in males or females after adjusting for age and WHR. Thus, TC was highly associated with body fat distribution independent of general obesity. Insulin, glucose, SBP, and DBP were correlated with SSF in males and females even after adjusting for age and WHR. These variables were more associated with general obesity independent of body fat distribution. Hb A_1, HDL-C, and HDL_2-C were correlated with SSF independent of WHR and age in females but not in males. These results suggest that Hb A_1, HDL-C, and HDL_2-C were associated with general obesity independent of body fat distribution in females. HDL_3-C was correlated with SSF

after adjusting for age and WHR in males, but not in females. The lack of significant correlations between SSF and lipoproteins in males was probably because males tend to have less subcutaneous fat compared to females at the same degree of obesity.

BMI was significantly correlated with insulin and SBP in males and females, and negatively correlated with HDL-C and HDL_2-C in females but not males. BMI may not adequately reflect variations in body fat (Garn et al., 1986). Height is one of the component of BMI, and BMI may be stature dependent over at least part of the age range. BMI like weight itself may reflect both lean and fat tissue to a comparable degree which may explain the lack of significant correlations between BMI and the diabetes, hypertension, and CHD risk factors in comparison with SSF.

The increase in WHR tertile from low to medium to high was associated with a non statistically significant increase in glucose, Hb A_1, SBP, DBP, and TC in males. The increase in WHR was associated with a non statistically significant decrease in HDL-C and HDL_2-C in males. The reduction in HDL_3-C levels with increments in WHR was significant ($p=0.01$) in males. A larger sample size would increase the statistical power of these analysis. In females, the estimated means for TC in each tertile were significantly different, but there was no dose response effect. Increased WHR tertiles were not associated with increases in any of

the diabetes risk factors, hypertension risk factors or TC, or with decreases in HDL-C or HDL_3-C in females. The increase in WHR was associated with a non statistically significant decrease in HDL_2-C in females. The lack of associations between these variables and the WHR tertiles in females suggests that gender differences in WHR may account for differences in these relationships. There is the possibility that females in this research did not have enough visceral fat accumulation to observe the associations between deep abdominal fat accumulation and alterations in diabetes, hypertension, and CHD risk factors. In addition, exercise and dietary habits, history of weight loss, alcohol intake, cigarette smoking, oral contraceptive use, estrogen replacement in the postmenopausal women, menopausal state, genetic predisposition to hypertension, NIDDM and CHD represent confounding factors not controlled in this research that may have affected the association between WHR and dependent risk factors in females. Alterations in estrogen production may alter the effect of lipoprotein lipase activity on HDL-C, HDL_2-C, and HDL_3-C levels (Tikkanen & Nikkila, 1987). Because WHR was lower in females than males, there may be a threshold effect of WHR below which AO does not elevate risk factors.

The following are the results from the longitudinal study. Body weight, BMI, SSF, %BF, WC, and HC decreased significantly in males and females. Even when the reduction

in waist circumference was larger than the reduction in hip circumference, the decrease in WHR was not significant. Fasting insulin, glucose, Hb A_1, SBP, and TC were reduced significantly in both males and females. DBP decreased significantly in males but not females. In general, HDL-C, HDL_2-C, and HDL_3-C were not altered during the 12-week program in males or females. HDL_2-C increased significantly ($p=0.04$) in males. As noted previously, cigarette smoking, alcohol intake, and dietary habits could have masked the exercise-lipoprotein relationships. Changes in alcohol intake with changes in exercise habits might potentially affect the interpretation of the exercise influence on lipoprotein levels. A diet low in saturated fat may decrease VLDL, LDL-C, and HDL-C. The subjects in the RESHAPE program were encouraged to decrease fat and cholesterol intake, which may explain why HDL-C did not increase. In addition, these subjects walked for an hour from week 0 through week 12, which probably was not long enough to elicit changes (decreased HL activity and or increased LPL activity) in lipoprotein metabolism. WHR was not significantly reduced which probably accounts for the non-increase in lipoproteins. Hormonal effects may have also affected the lack of change in lipoproteins since both HDL_2-C and HL activity are sensitive to sex steroids.

Stress and anxiety improved after the 12-week program. Mean STAI scores decreased while mean CSA scores increased.

The increase in CSA scale was not significant in females.

Fat and calorie intake decreased significantly in males. Dietary fiber intake increased while cholesterol intake decreased in males and females but these changes were not significant. These results cannot be generalized to the RESHAPE population since only eight food records were returned at week 12. Cardiovascular fitness significantly improved as measured by the amount of time required to walk a mile. Changes in SSF were correlated with changes in insulin and DBP in males. Changes in SSF were not associated with changes in glucose, Hb A_1, SBP, TC, HDL-C, HDL_2-C, or HDL_3-C in males. Changes in SSF were associated with changes in HDL_2-C in females.

Changes in WHR were positively correlated with changes in TC in males. However, changes in WHR were not significantly correlated with any of the other dependent variables in males. Changes in WHR were not correlated with changes in any of the dependent variables in females. Changes in body weight were positively correlated with changes in TC in females, but not with any of the other dependent variables in females, or with any dependent variable in males. The lack of correlation between changes in the anthropometric variables and the dependent variables might be explained by the fact that not every subject who reduced SSF, WHR, or body weight, had a decrease in the diabetes risk factors, hypertension risk factors, TC, or an

increase in HDL-C, HDL_2-C, or HDL_3-C. There were large differences among subjects regarding changes in SSF, WHR, and body weight. The differences between responders and "non-responders" probably affected these relationships. Additionally, the sample size was reduced for the last three hypotheses, because only subjects who reduced each anthropometric variable by at least a certain amount were considered. The decrease in statistical power reduced the probability of finding significant results.

Overall, the most important findings from this dissertation research were that the diabetes risk factors, hypertension risk factors, and lipoprotein were more related to the overall degree of obesity than to body fat distribution. TC was associated with body fat distribution measured as the WHR independent of the effects of age and body subcutaneous fat measured as the SSF. BW, %BF, BMI as well as waist and hip circumference were on the average significantly reduced at the end of the 12-week RESHAPE program for both males and females. Cardiovascular fitness increased as measured by the significant decrease in the time taken to walk a mile.

Although more research is needed on the effects of abdominal body fat on chronic disease risk factors, educational and therapeutic guidelines should be directed toward males and females with abdominal fat distribution. Research on adolescents is also needed because obese

children frequently become obese adults. Exercise of long duration and high intensity such as "fast" walking combined with a low fat diet should be encouraged as a therapeutic and a preventive strategy for obesity, hypertension, NIDDM, and CHD.

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APPENDIX A

Relationship Between Abdominal Fat Distribution, Diabetes, Hypertension, and Coronary Heart Disease Risk Factors.

Diagram Explanation

In AO, there is an increase in the size of the adipocytes or fat cells. In females, a normal distribution of adipose tissue includes a specific accumulation of body fat in the gluteo-femoral regions, mediated by stimulation of LPL activity, progesterone and estrogen. In females with irregular ovulations, there is an inadequate production of progesterone, affecting the accumulation of excess fat depot in the gluteo-femoral region. An elevation of free testosterone and a decrease in SHBG is observed in these females, and in females with AO indicating an increase in androgenic activity. In these females, as well as in males who do not have functioning gluteo-femoral adipose tissue, the excess is stored in other regions such as the abdomen. Androgens and corticosteroids probably facilitate fat storage in the abdomen directly.

Steroids with androgenic activity increase HL activity leading to a decrease in HDL_2-C. HL activity has a key role in the degradation of HDL_2 molecules. Estrogens elevate HDL by suppressing HL activity and by increasing Apo A1 synthesis, which is the protein backbone of the HDL molecule. HDL concentration are determined by: 1) synthetic rate of Apo A1, 2) activity of LPL which regulates the lipolytic degradation of TG-rich lipoproteins increasing HDL_2-C, and 3) the activity of HL.

Human adipose tissue is an important site of HDL interaction and metabolism by the binding capacities of HDL to human adipocytes with high affinity and specificity. HDL binding is enhanced with increasing cell size as occurs in AO. These effects may contribute to lower HDL-C in AO.

The intra-abdominal omental fat cells have a higher lipolytic sensitivity presumably due to an increase in the ratio of beta 1 to alpha 2 adrenergic activities and to diminished sensitivity to the action of insulin which is an anti-lipolytic hormone. Insulin is going to have a less pronounced effect on abdominal adipose tissue, perhaps due to a small number of insulin receptors. Due to the above, abdominal adipose tissue is easily mobilized, and when enlarged will cause elevations of FFA in the portal vein. Increased circulating FFA inhibit glucose transport causing hyperinsulinemia or high insulin levels and eventually insulin resistance. FFA from abdominal adipocytes may lead to an increased hepatic VLDL-TG secretion and a subsequent decrease in HDL-C levels triggered by hyperinsulinemia.

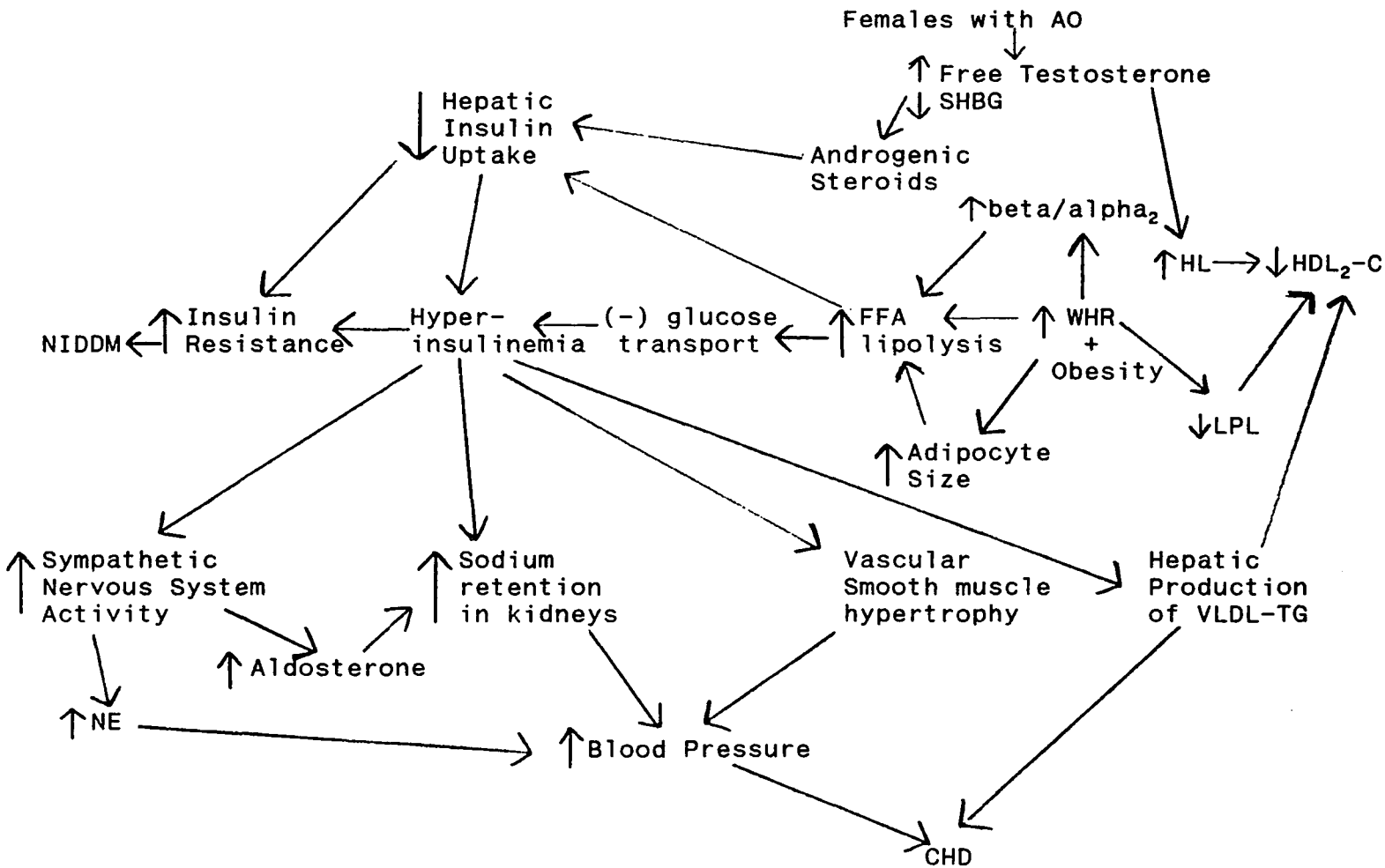
High concentrations of portal FFA may regulate the hepatic insulin uptake and lead to insulin resistance. Pancreatic Beta-cells secrete insulin, insulin passes through the portal circulation, and a major part is normally taken up by the liver. Therefore, a decrease in hepatic insulin uptake contributes to the hyperinsulinemia in AO, and is probably an important cause of the higher insulin

levels and associated complications. FFA could also lead to peripheral insulin insensitivity and decreased hepatic extraction, triggered by androgenic activity. These effects will further enhance hyperinsulinemia resulting in insulin resistance.

Elevated insulin levels are most likely to be the key intermediary factor which connects upper body fat to lipid disturbances, probably enhanced by high FFA levels released from the visceral compartment. Insulin can enhance renal sodium retention directly, through its effect on renal tubules, and indirectly, through stimulation of the sympathetic nervous system and increase of aldosterone secretion. In addition, insulin can increase NE leading to an increase in BP via sympathetic nervous system stimulation.

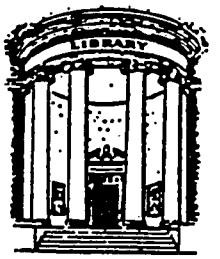
Insulin has a direct effect on the arterial walls that could be atherogenic: inhibition of lipolysis, stimulation of cholesterol, phospholipids, and TG synthesis; and, a mitogenic effect resulting in stimulation of smooth muscle proliferation leading to increased in BP and CHD. A high WHR may also influence levels of circulating clotting factors so as to increase the coagulability of blood in the coronary arteries and cerebral vessels, thus, leading to an increased risk of heart attacks.

Relationship Between Abdominal Obesity, Diabetes, Hypertension, and Coronary Heart Disease Risk Factors.



APPENDIX B

Consent Form



THE UNIVERSITY OF NORTH CAROLINA
AT GREENSBORO

SCHOOL OF HUMAN ENVIRONMENTAL SCIENCES

Department of Food–Nutrition–Food Service Management
(919) 334-5332; 5313

CONSENT FORM

I agree to participate in the study "Nutritional Status, Energy Expenditure and Chronic Disease Risk Factors Among Reshape Participants of Spring 1990 which is being directed by Dr. Terry Bazzarre, and two doctoral students (Rita Sigmon and Lizette Sanchez).

EXPLANATION OF STUDY

I understand that the purpose of this study is to measure food intake, physical activity, stress, blood pressure and the levels of various constituents such as cholesterol, iron, zinc, vitamin C, and immunoglobulins present in the blood. I understand that the above measurements will enable Dr. Bazzarre and his colleagues to study the relationships of diet and physical activity to health and to disease problems such as cardiovascular heart disease, high blood pressure and diabetes. I understand that I will need to complete a questionnaire about my personal and familial medical health in order for Dr. Bazzarre to conduct his study.

METHODS

I understand that a 4-day food record which I will complete at home will be used to estimate my intake of 25 nutrients. I understand that a 4-day activity record that I will complete at home will be used to measure my energy expenditure for physical activity. I understand that questionnaires will be used to collect information about my personal and family medical histories as well as to assess the amount of stress I have experienced in my life during the past year. I understand that these questionnaires will be reviewed and completed at my first visit. The food records and activity records will be explained to me at visit I.

I understand that my blood pressure will be measured using a standard blood pressure cuff. I understand that about 30 ml (5 tablespoons) of blood will be collected to measure the cholesterol, iron, zinc, immunoglobulin, insulin, glucose and vitamin C in my blood. I understand that the risks of having by blood drawn include fainting, bruising, air emboli, puncture of an artery instead of a vein and compression of a nerve. I understand that

Dr. Bazzarre will draw blood following appropriate blood drawing techniques and will make every effort to avoid causing any of the above risks. I understand that my blood pressure will be measured and that the blood sample will be collected at visit II. I understand that I will return the food record and activity record at visit II. I understand that skinfold thickness measurements will be taking at four body sites.

CONFIDENTIALITY

I understand that a code number rather than my name will be used to identify the information I provide to the researchers, and that my name and code number will be linked only on raw data forms. These forms will be kept securely in a file cabinet. I also understand that I may withdraw from the study at any time of my choosing without prejudice form any of the investigators.

EXPLANATION OF BENEFITS

The benefits I may gain form participating in this study include: evaluation of my risk of developing heart disease, hypertension, or nutrition problems; evaluation of my stress levels, resistance to diseases, and measurements of my body fat. I will also receive a written report containing all my measurements upon the completion of the study. I understand that the benefits of participating in this research outweigh the potential risks which are not likely to occur.

I understand that Dr. Bazzarre or his designee will be able to answer any questions I have. They can be reached at 919-334-5332 during the weekdays. All of my immediate questions have been answered.

_____ _____

SIGNATURE (FULL LEGAL NAME) Date

_____

SIGNATURE OF RESHAPE STAFF MEMBER

APPENDIX C

Physician's Clearance Forms

ATTACHMENT I

_____
(Date)

Dr. Terry L. Bazzarre
RESHAPE
School of Home Economics
UNC-Greensboro
Greensboro, NC 27412

Dear Dr. Bazzarre,

I have reviewed the medical records of

_____
(name of RESHAPE participant)

and reached the following opinion.

Check as appropriate:

_____ May participate in the RESHAPE program without any known medical risk

_____ May participate in the RESHAPE program only after the following tests have been satisfactorily completed

(1) _____ exercise stress test scheduled for the following date _____
Month Day Year

(2) _____ Other tests: (please specify)

_____

_____

_____ May not participate in the RESHAPE program because of the following medical problems:

_____

_____

_____

_____

Sincerely,

_____
(Signature)

_____
(Office Telephone Number)

THE UNIVERSITY OF NORTH CAROLINA
AT GREENSBORO

School of Home Economics

Dear _____
(Physician's Name)

_____ is being screened for participation in
(Participant's Name)
the RESHAPE program sponsored by the departments of Nutrition, Physical Education, and Psychology at UNC-Greensboro. Part of our screening procedures require that we individually contact the physician of all participants over 35 years of age, and any participant who has known medical risk factors (e.g. high blood pressure, elevated fasting cholesterol, angina, etc.) before they begin the program.

We would like you to review the medical records of the above participant, conduct any necessary tests, and complete the attached form. Please mail the completed form to:

Dr. Terry L. Bazzarre, Director
RESHAPE
School of Home Economics
UNC-Greensboro
Greensboro, NC 27412

You can contact Dr. Bazzarre or members of the RESHAPE staff by calling 334-5332.

We have also attached, for your information, a letter which briefly explains the RESHAPE program. We have been approved as a service provider for weight reduction by the State Medical Director of Vocational Rehabilitation.

Thank you for your assistance.

Sincerely,

Terry L. Bazzarre, Ph.D.
Associate Professor

TLB:mr

Enclosure:

MEDICAL INFORMATION
Dr. Terry L. Bazzarre

Date _____

RESHAPE

NAME _____ Address _____

_____

R _ _ _ _ _ _ _ _ _ Telephone No(s): Home - _____
1 5 6 7 8 Year Work - _____
I.D. No. Session 1 = Fall 2 = Spring 3 = Summer 4 = Private Client

Sex: _ 1 = Male _ 2 = Female _
9

Race: _ 1 = Black _ 2 = White _ 3 = Other _
10

Physician's Clearance: (PHYSCL) _
If client is over 35 years of age or has CHD, diabetes or hypertension, give the client, the physician's clearance forms. 11

_ 0 = Not approved
_ 1 = Approved
_ 2 = Approved w/ exercise stress test performed
_ 3 = Approved for walking only
_ 4 = Other (Specify): _____
_ 5 = Not Applicable (i.e. client is under 35 years of age with no medical history of CHD, hypertension or diabetes)

_____
Name of physician

Occupation: (OCCU) _ _
12 13

Ask client to describe their current occupation. If retired, ask client to describe their occupation prior to retirement.

_____

_ 01 = Housewife
_ 02 = Student
_ 03 = Health professional (e.g., MD, RN, RD, dentist, psychologist)
_ 04 = Administrator/ Lawyer
_ 05 = Secretary/ Clerical
_ 06 = Blue Collar (e.g., mechanic, gardener)
_ 07 = Sales/ Service (e.g., social worker)
_ 08 = Farmer
_ 09 = Teacher/ Educator
_ 10 = Technical/ Engineer/ Computer Programmer
_ 11 = Other (Specify): _____

Marital Status: (MARITAL) _
14

_ 1 = Married
_ 2 = Single
_ 3 = Divorced/ Separated

AGE: (AGE) years (Ask client for date of birth: _/_/_) _ _
15 16

MEDICAL INFORMATION
Page 2 Date _____

NAME _____ (I.D. NO. R _ _ _ _ _)

Height: (HEIGHT) record in inches
1/4" = .3 in
1/2" = .5 in
3/4" = .8 in
17 _ . _ 20

Goals: (GOALS)
Please ask client to describe his/ her goals:-
(1) _____
(2) _____
(3) _____
(4) _____
_____
_____

1 = Weight loss
2 = Fitness
3 = Diet
4 = Stress Management
5 = Weight loss + Fitness (1 & 2)
6 = Weight loss + Diet (1 & 3)
7 = 1,2 & 3
8 = 1,2,3 & 4
9 = Other (Specify)
21

Goals for Weight Loss: (GLWTLOSS)
If the client plans to lose wt during the program, write the number of pounds s/he plans to lose during the program. If the subject does not plan to lose any weight, write " 000 " in columns 22 - 24.
22 _ _ 24

Children: (CHILDREN) Write down the number of children.
25

Write down the age of the oldest child.
26 _ 27

Write down the age of the youngest child.
28 _ 29

List names, ages and sex of all children.

MEDICAL INFORMATION
Page 3 .

Date _____

NAME _____ (I.D. NO. R _ _ _ _ _)

PERSONAL MEDICAL HISTORY

For each of the following chronic diseases mark: 1 = present
2 = absent
3 = unknown

Coronary Heart Disease (PCHD) _ 30

Hypertension (PHYP) _ 31

Diabetes (PDIA) _ 32

Obesity (POBESITY) _ 33

Ask the client if s/he has any other major medical problems. _ 34
Please list: _____ 0 = None
(POTHER) _____ 1 = Cancer
_____ 2 = Mental Health
_____ (e.g. depression)
3 = Arthritis
4 = Gastro-Intestinal
5 = Endocrine
6 = Respiratory (e.g. asthma, allergies
7 = Dermatological
8 = Other

Smoking History: (SMOKE) 0 = Never
1 = Stopped _ 35
2 = Yes

If the individual stopped smoking, how many years ago did they stop? _ _
(YRSAGO) 36 37

If the individual currently smokes, how many packs/ day does s/he smoke? _
(PKSDAY) 38

If the individual currently smokes, how many years has s/he smoked? _ _
(YRSSMOKED) 39 40

MEDICAL INFORMATION
Page 4

Date _____

NAME _____ (I.D. NO. R _ _ _ _)

Alcohol intake: (ALCOHOL) 0 = Never
1 = Yes _ 41

If yes, describe the amount of the following beverages consumed.

Beer (No. of 12 oz cans/ week) (BEER) _ _ 42 43

Wine (No. of 3 oz glasses/ week) (WINE) _ _ 44 45

Mixed Drinks (No. of 2 oz servings/ week) (MIXED) _ _ 46 47

Note: Use 0 if they never consume any of the above category of alcoholic beverages. Use 1 if s/he consumes the beverage between once/ year and once/ week.

History of Obesity:

Ask client if s/he considers herself or himself overweight? (OVWT)
1 = yes _ 48
2 = no

If s/he considers herself or himself overweight, ask client how many pounds s/he is overweight? AND (XTRAWT) _ _ _ 49 50 51
how many years s/he has been overweight? (YRSOVWT) _ _ 52 53

RESHAPE

NAME: _____ (I.D. NO. R 1 _ _ _ _ 5) Date: _____

INITIAL DATA:

VARIABLE:	WEEK 0		WEEK 12		FOLLOW-UP DATA: 9 (# Wks in program)	
Body Weight (pounds)	54 _ _ ÷ 58		59 _ _ ÷ 63		35 _ 37 — 38 _ _ ÷ 42	(THRWT)
Waist (inches)	_ _ ÷ _ 64 67		_ _ ÷ _ 68 71		_ _ ÷ _ 43 46	(THRWAIST)
Thigh (inches)	_ _ ÷ _ 72 75	1* 79	_ _ ÷ _ 6 9		_ _ ÷ _ 47 50	(THRTHIGH)
Biceps (mm)	_ _ ÷ _ 10 13		_ _ ÷ _ 14 17		_ _ ÷ _ 51 54	(THRBICEP)
Triceps (mm)	_ _ ÷ _ 18 21		_ _ ÷ _ 22 25		_ _ ÷ _ 55 58	(THRTRICP)
Subscapular(mm)	_ _ ÷ _ 26 29		_ _ ÷ _ 30 33		_ _ ÷ _ 59 62	(THRSUBSC)
Suprailiac (mm)	_ _ ÷ _ 34 37		_ _ ÷ _ 38 41		_ _ ÷ _ 63 66	(THRSUPRA)
Sum of 4 Skinfolds	_ _ _ ÷ _ 42 46		_ _ _ ÷ _ 47 51		_ _ _ ÷ _ 67 70	(THRSKIN)
% Body Fat	_ _ ÷ _ 52 55		_ _ ÷ _ 56 59		_ _ ÷ _ 71 74	(THRPBFAT)
Blood Pressure:						
Systolic (mm Hg)	_ _ _ 60 62		_ _ _ 63 65		_ _ _ 75 77	(THRSYSBP)
Diastolic (mm Hg)	_ _ _ 66 68		_ _ _ 69 71		_ _ _ 6 8	(THRDIABP)
Total Cholesterol (mg%)	_ _ _ 72 74		_ _ _ 75 77	2** 79	_ _ _ 9 11	(THRTC)
HDL-Cholesterol (mg%)	_ _ _ 6 8		_ _ _ 9 11		_ _ _ 12 14	(THRHDLC)
Hematocrit (%)	_ _ 12 13		_ _ 14 15		_ _ 15 16	(THRHTC)
Exercise Heart Rate (BPM)	16 17		18 19		17 18	(THRXHR)
Resting Heart Rate (BPM)	20 21		22 23		_ _	(THRRHR)
12 Minute Walk/Run (Miles)	24 ÷ 26		27 ÷ 29		21 ÷ 23	(THRMILES)
Activity Sessions Attended:	30 31	Workshops Attended:	32 33		4	(END LINE 4)

APPENDIX D

Percent Body Fat Table

Table 9. *The equivalent fat content, as a percentage of body-weight, for a range of values for the sum of four skinfolds (biceps, triceps, subscapular and supra-iliac) of males and females of different ages*

Skinfolds (mm)	Males (age in years)				Females (age in years)			
	17–29	30–39	40–49	50+	16–29	30–39	40–49	50+
15	4·8	—	—	—	10·5	—	—	—
20	8·1	12·2	12·2	12·6	14·1	17·0	19·8	21·4
25	10·5	14·2	15·0	15·6	16·8	19·4	22·2	24·0
30	12·9	16·2	17·7	18·6	19·5	21·8	24·5	26·6
35	14·7	17·7	19·6	20·8	21·5	23·7	26·4	28·5
40	16·4	19·2	21·4	22·9	23·4	25·5	28·2	30·3
45	17·7	20·4	23·0	24·7	25·0	26·9	29·6	31·9
50	19·0	21·5	24·6	26·5	26·5	28·2	31·0	33·4
55	20·1	22·5	25·9	27·9	27·8	29·4	32·1	34·6
60	21·2	23·5	27·1	29·2	29·1	30·6	33·2	35·7
65	22·2	24·3	28·2	30·4	30·2	31·6	34·1	36·7
70	23·1	25·1	29·3	31·6	31·2	32·5	35·0	37·7
75	24·0	25·9	30·3	32·7	32·2	33·4	35·9	38·7
80	24·8	26·6	31·2	33·8	33·1	34·3	36·7	39·6
85	25·5	27·2	32·1	34·8	34·0	35·1	37·5	40·4
90	26·2	27·8	33·0	35·8	34·8	35·8	38·3	41·2
95	26·9	28·4	33·7	36·6	35·6	36·5	39·0	41·9
100	27·6	29·0	34·4	37·4	36·4	37·2	39·7	42·6
105	28·2	29·6	35·1	38·2	37·1	37·9	40·4	43·3
110	28·8	30·1	35·8	39·0	37·8	38·6	41·0	43·9
115	29·4	30·6	36·4	39·7	38·4	39·1	41·5	44·5
120	30·0	31·1	37·0	40·4	39·0	39·6	42·0	45·1
125	30·5	31·5	37·6	41·1	39·6	40·1	42·5	45·7
130	31·0	31·9	38·2	41·8	40·2	40·6	43·0	46·2
135	31·5	32·3	38·7	42·4	40·8	41·1	43·5	46·7
140	32·0	32·7	39·2	43·0	41·3	41·6	44·0	47·2
145	32·5	33·1	39·7	43·6	41·8	42·1	44·5	47·7
150	32·9	33·5	40·2	44·1	42·3	42·6	45·0	48·2
155	33·3	33·9	40·7	44·6	42·8	43·1	45·4	48·7
160	33·7	34·3	41·2	45·1	43·3	43·6	45·8	49·2
165	34·1	34·6	41·6	45·6	43·7	44·0	46·2	49·6
170	34·5	34·8	42·0	46·1	44·1	44·4	46·6	50·0
175	34·9	—	—	—	—	44·8	47·0	50·4
180	35·3	—	—	—	—	45·2	47·4	50·8
185	35·6	—	—	—	—	45·6	47·8	51·2
190	35·9	—	—	—	—	45·9	48·2	51·6
195	—	—	—	—	—	46·2	48·5	52·0
200	—	—	—	—	—	46·5	48·8	52·4
205	—	—	—	—	—	—	49·1	52·7
210	—	—	—	—	—	—	49·4	53·0

In two-thirds of the instances the error was within ±3·5% of the body-weight as fat for the women and ±5% for the men.

Reference: Durnin, J. V., & Womersley, J. (1974). Body fat assessed from total body density and its estimation from skinfold thickness: Measurements on 481 men and women aged from 16–72 years. British Journal of Nutrition, 32, 77–96.

APPENDIX E

Instructions For Food Records

INSTRUCTIONS FOR FOOD RECORDS

These instructions will help you in recording the food that you eat. Please read this instructions carefully. Please feel free to call the Department of Food and Nutrition at The University of North Carolina at Greensboro at 919 334-5313.

1. Measure each item using household measurements (1 cup, 1/2 cup, 1/4 cup, tablespoon, teaspoon, 3/4 teaspoon, 1/2 teaspoon, etc.). Abbreviations can be used.

2. For items that are not measured such as fresh fruits or eggs, write the number of items eaten and whether they are large or small.
Examples:
1 large egg
1 small banana
Additional information about the size of the food such as diameter, length, width, thickness or ounces is helpful.
Examples:
3" carrot
1 brownie with walnuts, wedge 2" by 2" by 1" high.
1- 12 oz. can coke
Pizza with mushrooms, green peppers and cheese - 1/8 of 12" pizza
1 apple - 2 1/2" diameter

3. If you do not eat all the food you have served on your plate, try to measure the amount of each item you did not eat and subtract that amount from what was served.
Example: If you are served a peanut butter sandwich with two slices of bread an 2 T peanut butter and you eat 3/4 of the sandwich, you have eaten 1 1/2 slices of bread and 1 1/2 T of peanut butter.

4. Describe the food eaten as exactly as possible.
a. For meat, fish, poultry, and eggs specify the cut or type of meat or fish (chuck or bass), whether you ate or trimmed off the fat, whether you ate the skin (poultry), percent fat (hamburger), and whether the fish was oil pack or water pack (tuna).
b. For breads, cereal, cakes, cookies, etc. state whether the food is made from white flour or whole grain and whether the food was homemade or bought. Specify the brand names whenever possible.
c. For margarine state the brand name, whether the margarine comes as a stick, soft or liquid, whether it is diet or regular, and whether it is whipped or not.
d. For oils and shortening state the brand name, the major oil(s) (if known) and whether the fat is solid fat or oil.

e. For salad dressings specify whether it is homemade, commercial or restaurant, the type of oil or brand name, creamy or clear, and additional ingredients such as cheese or bacon bites.

f. For dairy products indicate the percent fat, the brand name or relative price and whether it is a true dairy product or a nondairy product.

g. For bakery items state whether they are homemade, restaurant or commercial, the brand, the principal fat, toppings or frostings, yeast or cake and type of grain. For pies indicate whether it is a single or double crust.

h. For sauces and gravies indicate the type of fat, the meat fat, and what kind of milk added (if any).

i. For recipes and mixed dishes indicate whether it is homemade, commercial or restaurant, the brand name, cooking method, and all the ingredients used. Submit a recipe if possible.

j. For fruits and juices indicate whether they are fresh, frozen, canned, cooked, or dried; and whether the food is sweetened or unsweetened.

k. For vegetables state whether they are cooked or raw, the kind of fat added if any, sauces added, the method cooked and any seasoning added. Specify how mashed potatoes were prepared.

l. For soups specify whether they are homemade or canned, cream soups or clear soups and the water or kind of milk or stock added.

m. For beverages and cereals, indicate whether they are sweetened or unsweetened, the brand, decaffeinated (coffee or tea), and whether it is cola or not.

n. For crackers, snacks, candy bars indicate the brand, weight, type or size. If you are in doubt as to whether the information is needed or not, include the information.

5. Record accompaniments such as gravies, sauces, salad dressings, mayonnaise, ketchup, mustard, seasonings, garnishes, etc. separately. Do not forget to record sugar, lemon, cream, non-dairy creamers, or flavorings that you may add to drinks such as coffee, tea, or milk. If you drink any liquid other than water, measure the amount in a liquid (pyrex) measuring cup.

6. Describe how the food was prepared, including any additional fat, sugar or condiments that may be added. Example:

sauteed in butter
basted with garlic butter
boiled in water
deep fat fried in peanut oil
simmered in wine

7. Do not forget to record snacks. If you eat a snack away from home carry the wrapping home with you as a reminder.

APPENDIX F

Laboratory Procedures for Cholesterol, HDL-C, Hb A_1, Insulin, and Glucose

Laboratory Procedure for Cholesterol Analysis

The reagents and materials necessary for this analysis were obtained from Sigma Diagnostics. The Cholesterol Reagent obtained from Sigma was Catalog No. 351-20, the cholesterol equilibrator was Catalog No. C 0284, and the Cholesterol Decolorizing Reagent was Catalog No. 350-10. The analyses conducted followed the guidelines for procedure established by Sigma Chemical Company (1986).

Micro Method for Total Cholesterol

1. To a test tube labeled blank, 0.01 ml of water was added. To a test tube labeled standard, 0.01 ml of Cholesterol Calibrator, Catalog No. C 0284 was added. To a test tube labeled test, for the sample plasma to be analyzed, 0.01 ml plasma was added.
2. To each tube, 1.0 ml Cholesterol assay Solution was added. The test tubes were placed on the vortex for several seconds to ensure that the plasma and Cholesterol calibrator was mixed.
3. The test tubes were incubated at 37°C in a waterbath for 10 minutes.
4. Once the solutions were placed in cuvets, the absorbance was read and recorded. The absorbance of the standard and the tests vs the blank as reference at 500 $\pm$ 15 nm were read within 30 minutes.

5. The total cholesterol was calculated as follows:

Total Cholesterol (mg/dl) = (A test/ A standard) * 200

200 is the concentration (mg/dl) of the Cholesterol Calibrator, Catalog No. C 0284.

Micro Method for HDL Cholesterol

1. To a small container (2 ml with top), 0.4 ml plasma and 0.05 ml HDL Precipitating Reagent, Catalog No. 350-3, were placed and mixed throughly by the vortex.

2. Samples were centifuged for 5-10 minutes to obtain clear supernatant.

3. To a test tube labeled blank, 0.05 water was added. To a test tube labeled standard, 0.05 ml Cholesterol Calibrator, Catalog No. C 9908, was added. To a test tube labeled test, 0.05 ml supernatant (HDL fraction) from step 2 was added.

4. To each test tube 1.0 ml Cholesterol Assay Solution was added.

5. The test tubes were incubated at 37°C for 10-minutes.

6. Once the solutions were placed in cuvets, the absorbance was read and recorded. The absorbance of the standard and the tests vs the blank as reference at 500 $\pm$ 15 nm were read within 30 minutes.

7. The HDL cholesterol was calculated as follows:

HDL-C (mg/dl) = (A test/A standard) * 50 * 1.125

Where: 50 = Concentration (mg/dl) of Cholesterol Calibrator, Catalog No. C9908.

1.125 = Factor to correct for the dilution of the plasma during the isolation of the HDL fraction (step 1).

Assay Procedures for Glycohemoglobin (Hb A_1)

This procedure is described in the Sigma Diagnostics Instruction Booklet (Procedure No. 440, Quantitative Column Technique for Whole Blood at 415 nm) P.O. Box 14508, St. Louis, MO 63178, 1989. According to the Sigma procedure, an aliquot of hemolysate, prepared by mixing measured volumes of blood and hemolyzing solution, is introduced onto the resin column. Hb A_1 and other hemoglobins are absorbed onto the ion-exchange material. Subsequent addition of a known volume of eluting solution to the column removes only Hb A_1. Measurement of the absorbance of this eluate and of the original hemolysate (diluted) at 415 nm permits quantitation of the Hb A_1 fraction.

Reagents

Hemolyzing solution	Catalog No. 440-2
Hb A_1 column	Catalog No. 440-4
Eluting solution	Catalog No. 440-3
Gycohemoglobin control-N	Catalog No. G2012

Procedure

1. To one or more test tubes corresponding to the number of samples to be determined, add 0.5 mL Hemilyzing Solution, and 0.1 mL test sample. Mix contents well to obtain hemolyzate.
2. Prepare Hb A_1 Columns by shaking until the resin material above the column plug is resuspended.
3. Place the column upright on the column stand.
a) Remove first the top cap and then the bottom cap.
b) Allow the liquid in the column to completely drain and proceed quickly to the next step.
4. Add to the column carefully so as not to disturb the resin 0.050 ml hemolysate from Step 1.
5. Place a clean test tube marked E beneath the column outlet. Carefully add 5.0 mL volumetric of Eluting Solution to the column using a 5.0-mL pipet. Add slowly with the tip of the pipet against the side of the column so that minimal disturbance of the resin bed occurs.
6. Allow the column to drain completely into the tube marked E and mix tube contents.
7. While the column is draining, mark a second test tube T and add 10.0 mL Eluting Solution, and 0.02 ml hemolysate from Step 1. Mix well.
8. Transfer portions of tubes E and T to cuvets and read absorbance of each at 415 nm vs water as reference.

$$\text{Hb } A_1 \ (\%) = \frac{\text{Absorbance of Tube E} * 20}{\text{Absorbance of Tube T}}$$

Assay Procedure for Insulin Analysis

The reagents and materials necessary for this analysis were obtained from Diagnostic Products Corporation 5700 West 97th St. Los Angeles, CA 90045. The Coat-A-Count Insulin is a solid-phase ^{125}I radioimmunoassay designed for the quantitative measurement of insulin in serum. It is intended strictly for *in vitro* diagnostic use as an aid in clinical diagnosis. In the Coat-A-count Insulin procedure, ^{125}I-labeled insulin competes with insulin in the patient sample for sites on insulin-specific antibody immobilized to the wall of a polypropylene tube. After incubation, isolation of the antibody-bound fraction is achieved by decanting the supernatant. The tube is then counted in a gamma counter, the counts being inversely related to the amount of insulin present in the patient sample. The quantity of insulin in the sample is then determined by comparing the counts to a standard curve.

Reagents:

1. Insulin Antibody-coated tubes
2. Buffered (^{125}I) Insulin
3. Insulin calibrators, the reconstituted calibrators contain respectively 0, 5, 15, 20, 100, 200, and 400 micro-International Units of insulin per milliliter in processed human serum.

Radioimmunoassay Procedure

All components must be at normal temperature before use.

1. Plain tubes: Label four plain (uncoated) 12x75mm polypropylene tubes T (total counts) and NSB (nonspecific binding) in duplicate.
Coated tubes: Label fourteen Insulin Antibody-Coated Tubes A (maximum binding) and B through G in duplicate. Label additional antibody-coated tubes, also in duplicate, for controls and patient samples.
2. Pipet 200 ul of the zero calibrator A into the NSB and A tubes, and 200 ul of each remaining calibrator, control and patient sample into the tubes prepared. Pipet directly to the bottom.
3. Add 1.0 ml of Buffered [^{125}I] Insulin to every tube. Vortex. Samples should not be left in the tubes for extended periods of time. Following step 2 (sample addition), step 3 (tracer addition) should be completed with minimal delay, with no more than 40 minutes elapsing between the addition of the first sample and the completion of tracer addition. Set the T tubes aside for counting (at step 6).
4. Incubate for 18-24 hours at room temperature.
5. Decant thoroughly. Removing all visible moisture will

enhance precision. Using a foam decanting rack, decant the contents of all tubes (except T tubes) and allow them to drain for 2 or 3 minutes. Then strike the tubes sharply on absorbent paper to shake off all residual droplets.
6. Count for 1-minute in a gamma counter.

Calculation of Results:

To calculate insulin concentrations from a logit-log representation of the calibration curve, first calculate for each pair of tubes the average NSB-corrected counts per minute:

Net Counts = Average CPM - Average NSB CPM

Determine the binding of each pair of tubes as a percent of maximum binding (MB), with the NSB-corrected counts of the A tubes taken as 100%:

$$\text{Percent Bound} = \frac{\text{Net Counts}}{\text{Net MB Counts}} * 100$$

Using logit-log graph paper plot Percent Bound on the vertical axis against Concentration on the horizontal axis for each of the calibrators B through G, and draw a straight line approximating the path of these six points. Insulin concentrations for the unknowns may then be estimated from the line by interpolation.

Assay Procedures for Plasma Glucose

This procedure is described in the Sigma Diagnostics Instruction Booklet (Procedure No. 16-UV, Quantitative, Enzymatic [Hexokinase] Determination of glucose in plasma at 340 nm) P.O. Box 14508, St. Louis, MO 63178, 1988. The enzymatic reaction involved in the assay begins when glucose is phosphorylated by adenosine triphosphate (ATP), in the reaction catalyzed by hexokinase (HK). The glucose-6-phosphate (G-6-P) formed is then oxidized to 6-phosphogluconate (6-PG) in the presence of nicotinamide adenine dinucleotide (NAD). This reaction is catalized by glucose-6-phosphate dehydrogenase (G-6-PDH). During this oxidation, an equimolar amount of NAD is reduced to NADH. The consequent increase in absorbance at 340 nm is directly proportional to glucose concentration.

Reagents: The Glucose (HK) reagent, when reconstituted according to the directions, contains approximately the following concentrations of active ingredients:

NAD	1.5 mmol/L
ATP	1.0 mmol/L
Hexokinase(yeast)	1000 units/L
G-6-PDH (L.m.)	1000 units/L
Magnesium ions	2.1 mmol/L
Buffer	pH 7.5 $\pm$ 0.1

Procedure:

1. Prepare Glucose (HK) reagent according to the instructions.
2. Warm reagent to ambient temperature.
3. Add 1.5 ml of Glucose (HK) reagent to a labeled cuvet.
4. Read and record absorbance (A) at 340 nm vs water as reference. This is INITIAL A.
5. Add 0.01 mL (10uL) of sample. Mix by gentle inversion.
6. Incubate cuvets for 5-min. Read and record the absorbance (A) at 340 nm vs water as reference. This is FINAL A. Following completion of reaction, FINAL A remains constant for 60 minutes.
7. Subtract INITIAL A from FINAL A to obtain change in absorbance (change A).
8. To calculate glucose concentration (mg/dL), multiply the change A by factor 437 when sample to reagent ratio is 1:150 and by factor 293 when sample to reagent ratio is 1:100.

Example:

The following absorbance values were obtained using a cuvet with a 1-cm lightpath.

Sample to reagent ratio = 1:150

INITIAL A = 0.106

FINAL A = 0.296

change A = 0.296 - 0.106 = 0.190

Glucose Concentration of sample = 0.190 * 437 = 83 mg/dL

APPENDIX G

Current Self Appraisal Scale

Name _____

I.D. Number F ___ ___ ___ ___ S 1
01 02 03 04 05 06 07

Date: ___ ___/___ ___/___ ___
08 09 10 11 12 13

Current Self Appraisal

Between the following pairs of words select the space that best describes the way you feel today and mark it with an X. For example: If you are feeling very depressed mark the first space.

depressed X ___ ___ ___ ___ joyous

If you are very joyous mark the fifth space. If you are moderately depressed the 2nd space, etc.

Please read each set of words carefully.

	1	2	3	4	5		
rested	____	____	____	____	____	tired	___ 14
rich	____	____	____	____	____	poor	___ 15
well	____	____	____	____	____	ill	___ 16
happy	____	____	____	____	____	sad	___ 17
stressed	____	____	____	____	____	relaxed	___ 18
lonely	____	____	____	____	____	supported	___ 19
angry	____	____	____	____	____	calm	___ 20
blah	____	____	____	____	____	perky	___ 21
accepted (liked by others)	____	____	____	____	____	unaccepted	___ 22

APPENDIX H

State-Trait Anxiety Inventory
Self-Evaluation Questionnaire