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THE EFFECT OF CHANGES IN ACTIVITY LEVEL ON THE BODY FAT DISTRIBUTIONS OF MEN AND WOMEN

By

Heather L. Adam

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Abstract

Recent research has shown the marked association between cardiovascular disease, stroke, and non-insulin dependent diabetes mellitus and obesity localized to the abdominal fat depot compared to the gluteal-femoral region. Research is now being directed towards determining whether body fat located abdominally can be decreased in order to lower the waist-to-hip ratio (WHR) and offset any susceptibility to disease. Physical activity is a modulating factor that could cause a decrease in the WHR.

The purpose of this study was to examine the effect of changes in activity level on the body fat distributions of men and women. The subjects analyzed included healthy men and women (ages 26-71 in 1988) who participated in the 1981 Canada Fitness Survey and the follow-up 1988 Campbell's Survey On Well-Being In Canada who either increased (sedentary to moderately active or sedentary to active) or maintained their activity level. This secondary data analysis involved identifying necessary variables in the surveys that were relevant to this study. Utilizing several programs and data manipulations, the data was transformed from MS-DOS (IBM) to Macintosh, and eventually to a statistical analysis program file (Statview SE + Graphics). The relative changes in the dependent variables body mass, BMI, sum of skinfolds, percent body fat, and WHR were assessed to determine specific changes in body fat distributions with respect to sex, initial body fat distribution, and activity level.

Regression analysis indicated that physical activity level was not a significant predictor of the relative changes in each of the dependent variables. Males and females independent of their level of

activity experienced relative increases in the body composition measurements. Men experienced significantly smaller relative increases in sum of skinfolds ($p<0.0001$) and percent body fat ($p<0.0001$) than women. Women who were on average initially gynoid experienced smaller increases in WHR than the males ($p<0.0001$). Independent of sex, subjects with an initially more android fat distribution experienced smaller relative increases in WHR ($p<0.0001$). Subjects who continued to smoke experienced greater relative increases in WHR, while subjects who quit smoking between testing periods had greater relative increases in body mass, BMI, sum of skinfolds, and percent body fat. Smoking therefore, poses many health risks since upon the cessation of smoking there are increases in the body composition measurements while people who continue to smoke experience a more marked increase in WHR than non-smokers.

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CHAPTER 1
INTRODUCTION

Physical activity is frequently prescribed as part of body mass and body fat reduction programs and the beneficial effects on fitness and lifestyle are overwhelmingly accepted (Fox & Matthews, 1981). Despite the fact that athletics and physical leisure pursuits play a significant role in different sectors of our population, healthy lifestyles are ignored by many. Specifically, obesity has become such an important personal and public health problem (Bray, 1989) that the benefits of physical activity must now be strongly promoted.

Obesity is defined as an excess of body fat and the most widely used criterion to approximate excess body mass is the body mass index (BMI=kgm^{-2}). Overweight is an increase in body mass above a standard defined in relation to height. The Body Mass Index actually estimates the degree of overweight which in turn is used to assess the degree of obesity. The body mass index is used in large population studies to estimate the prevalence of obesity. However, BMI must be utilized in conjunction with other methods used to determine obesity since athletes such as body builders are considered overweight by BMI. The desirable range for BMI increases very slightly with age. Generally, a BMI between 20-30 kgm^{-2} infers a low risk of health complications, whereas a BMI above 40 kgm^{-2} infers a very high susceptibility towards health complications (Bray, 1989).

The association between obesity and morbidity is widely accepted. This correlation is the basis for promoting and convincing the public of the health benefits of body mass control. Researchers have suggested, however, that a major factor in this correlation is not obesity per se, but the anatomical distribution of the adipose tissue. At equal degrees of relative (percentage of body fat) or absolute (mass of body fat) adiposity, individuals with a predominantly central distribution of fat ("android" or "apple") will experience higher rates of atherosclerotic heart disease, stroke, hypertension, hyperlipidemia, and diabetes mellitus than will similarly obese individuals whose adipose tissue distribution is more peripheral ("gynoid" or "pear") (Leibel, Edens & Fried, 1989). Studies of body fat topography have indicated that men generally are characterized by adiposity which is confined to the upper parts of the body (nape of the neck, shoulders, and abdomen). In women, however, adiposity may predominate in the upper body segment or it may affect the lower body segment (buttocks and thighs) (Vague, 1969).

The waist-to-hip ratio (WHR) is considered to be the index of the regional distribution of fat. It has been found to be more effective in predicting the susceptibility to health complications than other more complicated multiple skinfold measurements (Krotkiewski, Björntorp & Sjöstrom, 1983). There is also a higher association of the metabolic profile with abdominal visceral fat than with total body fat. This is not surprising since the WHR correlates highly with the intra-abdominal fat mass (Kissebah, Freedman & Peiris, 1989).

The WHR is influenced by both gains and losses in body mass (Ohlson, Larsson & Svardsudd, 1985) and "weight" cycling (Rodin, Radke-Sharpe, Rebuffe-Scrive & Greenwood, 1990). The WHR increases with a gain in body mass and decreases with body mass loss. Subjects indicating they were weight cyclers showed significantly higher WHRs than non-weight cyclers in a cross-sectional analysis

(Rodin et al., 1990) Weight cycling appeared to promote abdominal obesity and consequently may contribute to health risks later in life (Rodin et al., 1990).

The abdominal adipose tissue has a higher lipolytic activity than the femoral fat region (Rebuffe-Scrive, Andersson, Olbe & Björntorp, 1989). The adipose tissue in this region is therefore highly mobilizable and the flux of free fatty acids can cause insulin resistance which can lead to diabetes and/or hypertension and the production of very low density lipoproteins (VLDL) which can lead to high cholesterol and triglyceride levels and eventual cardiovascular disease.

As a result of the interest in the adverse effects of the distribution of body fat, research is now being directed toward decreasing the upper-body fat region therefore reducing the detrimental affects of the android fat distribution. If body mass reduction is to control the effects of upper-body obesity, it must do so by reducing this adipose tissue region. Specifically, investigators have been studying the effects of the two modulating factors that could alter fat distribution and decrease the WHR. Dietary regimes and physical activity might lead to changes in "fat patterning" under conditions of a negative energy balance, since the rate of lipolysis or fat breakdown has been found to be greater in the abdominal region than in the gluteal-femoral region (Kissebah et al., 1989).

Calorie restricted diets have been successful at reducing body mass and body fat in both females and males. According to Himes (1988) the available data pertaining to alterations in the distribution of body fat with nutritional intervention are concerned with changes in subcutaneous fat thicknesses and to a lesser extent body circumferences. Nutritional intervention studies in the past which monitored changes in body composition did not consider fat distribution. As a result, when skinfold thicknesses were included, they were often reported as sums, making it difficult to evaluate differential site responses.

Studies involving the effect of calorie reduced diets have found significant decreases in the WHR, suggestive of reductions in upper-body obesity (Wadden, Stunkard, Johnston, Wang, Pierson, VanItallie, Costello & Pena, 1988; Vansant, Den Bensten, Westrate & Deurenberg, 1988). In these studies subjects were classified in two groups (android or gynoid) based on their initial body fat distribution. Subjects who initially had greater upper-body obesity tended to achieve greater reductions in the WHR but actually lost less adipose tissue than subjects characterized with lower body obesity (Wadden et al., 1988). Vansant et al., (1988) demonstrated significant reductions in the WHR of both groups however, the initial body fat distribution was not related to the ability to lose body mass. These results agree with the study conducted by Lanska, Lanska, Hartz, Kalkhoff, Ruphry & Rimm (1985) in which the initial distribution of body fat did not affect the amount of body mass loss in females on a calorie restricted diet.

Deprés, Bouchard, Tremblay, Savard & Marcotte (1985) studied the effect of aerobic training in sedentary males and found that the trunk skinfolds were altered more than extremity skinfolds. The subjects were not classified as android or gynoid as the investigators did not consider circumference measurements. Decreases in both the central and peripheral skinfolds were expressed as simply the number of millimeters lost. The decrease in the total sum of seven skinfolds was expressed relative to both percent body fat and total fat mass.

Tremblay, Deprés & Bouchard (1988) also studied the effect of exercise training on body fat distribution in overweight males and also found that the trunk skinfolds were slightly more reduced than the extremity sites. In a high intensity training program significant differences in subcutaneous fat loss were noted with men losing more fat in the trunk than in the extremities whereas such a preferential fat depletion was not observed in the women (Tremblay et al., 1988). The changes in both the sum of trunk skinfolds and sum of extremity skinfolds was expressed as the mean percent difference and the mean percent difference in the ratio of the trunk to extremity skinfolds. Expressing the intervention-related changes in fat thicknesses as percentages, standardizes the changes relative to initial fat thicknesses. The absolute losses are often more desirable than relative losses, if the intent is to reflect the site-specific differences in response to the exercise or caloric restriction intervention. Unfortunately, changes in body fat distribution were not reported in terms of changes in the WHR.

Deprés et al., (1985) explained that very little is known about the effects of aerobic training induced changes on body fat distribution in women. According to these investigators physical activity alone is not successful in reducing body fat unless it is over a very long duration. Therefore most of the literature regarding the effect of physical activity on body fat distribution has concentrated on male subjects.

STATEMENT OF THE PROBLEM

The purpose of this study was to determine the effects of changes in physical activity from an inactive level in 1981 to a moderate or active level in 1988, on the body fat distributions of men and women that participated in the 1981 Canada Fitness Survey (CFS) and the follow-up 1988 Campbell's Survey On Well-Being In Canada (CS).

HYPOTHESES

1. Subjects increasing activity levels from inactive to moderately active or highly active would experience greater reductions in body composition measurements of body mass, BMI, sum of skinfolds, percent body fat, and WHR (measured as relative changes) compared to subjects that have remained at constant activity levels, with the most substantial changes occurring when activity changes from inactive to highly active.

2. Subjects (men and women) with predominantly android fat distributions would lose significantly more body mass and percent body fat, experience greater reductions in BMI, sum of skinfolds, and WHR (measured as relative changes) compared to subjects with predominantly gynoid fat distributions as a result of a change in physical activity from an inactive to a more active level (moderate or active level).

3. Men would lose significantly more body mass and percent body fat, experience greater reductions in BMI, sum of skinfolds, and WHR (measured as relative changes) than similarly active (moderate or active level) women.

IMPORTANCE AND RELEVANCE

This study has both theoretical and practical value. As stated previously, the regional distribution of body fat has effects on mortality and morbidity (Bray & Gray, 1988). Specifically, a robust association of increased abdominal or upper body obesity with overall mortality has been demonstrated. With progressive increases in upper body fat, the relative risk of death due to vascular diseases also increases. Upper body obesity is also associated with an increased risk for hypertension and diabetes. Consequently, decreases in the WHR would require a greater mobilization of abdominal body fat and ultimately a decreased susceptibility toward health complications.

Lower-body obesity, or a gluteal-femoral pattern of fat distribution (gynoid), is relatively benign in terms of impact on morbidity and mortality, unless a significant increase in body fat becomes associated with this body fat distribution. Lower body obesity is associated with varicose veins and due to the excessive mass in this region could contribute to important orthopedic disorders (Bray & Gray, 1988). Hence adipose tissue losses in men and women with either body fat distribution would clearly be beneficial.

This study would also provide information on the changes in body composition in men and women with either predominantly android or gynoid initial fat distributions. The circumference and skinfold measures were utilized in order to arrive at a description of the adipose tissue loss both centrally and peripherally. Based on the findings of this study it was not determined whether appropriate amounts of body mass and body fat lost should be based on the initial fat distribution of the individual. Women, in particular with initial gynoid fat distributions may not be able to reach a desired body mass without drastically increasing the amount of physical activity performed each day.

This study was very cost efficient since a number of research questions independent of the proposed study, could be answered by utilizing this very large data set.

DELIMITATIONS

This study examined a population of men and women, 19 years of age and older in 1981. The number of subjects that participated in the 1988 Campbell's Survey On Well Being In Canada was 3068, 950 of which were eligible for this study because they provided both questionnaire and measurement data and 323 subjects of which were eligible for this analysis based on the change in physical activity. The analyses only included healthy men and women who did not suffered from any illness or injury that significantly prevented participation in physical activity over the last year prior to 1988 testing. The analyses also included individuals who did not indicate a change in activity between 1981 and 1988 (n=627). Specifically, this group included individuals that either remained sedentary, moderately active, or active. The survey excluded institutions, hospitals, school dormitories, prisons, Indian reserves, and collectives as it was a household-based design. Measures of body fat were delimited to skinfolds and circumferences. Measures of percent body fat were delimited to skinfold measurements. Percent body fat was determined by the sum of four skinfolds and the percent body fat formula (Siri equation) described by Jackson, Pollock & Ward, 1980) The equation for body density is found in Appendix C.

$$\% \text{ body fat} = \left(\frac{4.950}{Db} - 4.500\right) \times 100$$

Measures of the distribution of body fat included WHR, and skinfolds and circumferences located both centrally and peripherally. Initial body fat distributions were determined by the WHR (gynoid < 0.80 and android ≥ 0.80, for females, gynoid < 0.90 and android ≥ 0.90, for males) and changes in skinfolds and circumferences were indicators of changes in body fat distribution.

LIMITATIONS

Limitations occur as a result of delimiting the sample according to the previously stated restrictions.

1. The Canada Fitness Survey was biased slightly towards a younger population, under-sampling sedentary older individuals.

2. The investigator could not exclude or control for subjects if they experienced juvenile onset obesity since this information was not available in the survey questionnaire.

3. The investigator could not exclude or control for female subjects that were using or ever used oral contraceptives since this information was not available in the survey questionnaire.

4. The investigator could not control for the specific average daily or weekly caloric consumption of each subject since this information was not provided in the questionnaire.

5. Percent body fat could not be measured directly and therefore was estimated by skinfolds and the Siri equation (Appendix C).

6. The changes in body composition were the result of individually self-selected lifestyle modifications (diet and/or exercise) rather than by a specific experimental intervention.

7. The activity level of the subject was determined by the average daily energy expenditure for all activities in the past year. The investigator was unable to control for the number of years maintained at this level.

8. Observational studies, are much less controlled than designed experiments and therefore conclusions drawn from them must be stated with some caution. Random allocation of subjects provides some protection, without this however, there is no guarantee of inherent comparability. However observational studies have the advantage of taking place in real world settings and consequently the results and conclusions are very relevant and widely generalizable (Hassard, 1991).

9. There was a socio-economic bias of the respondents in 1981 as only 30.7% described themselves as blue collar workers, and as predicted from the influence of socio-economic status on leisure habits, this occupational bias increased the activity level of the sample relative to the national population. Additionally, there was an educational bias as 31.9% of subject 20 years or older claimed to have a university degree, certificate or diploma and this has been found to have a greater influence upon activity patterns and fitness levels of the sample (Shepard, 1986).

10. The results may have been skewed by season upon which recollection was based (ie. winter less active, summer more active) however a three way analysis of variance (sex vs. season vs. area of residence) demonstrated only small, statistically insignificant differences of fitness and selected fitness measures with respect to these variables of the 1981 data (Shepard, 1986).

ASSUMPTIONS

The fundamental assumption of the this study was that the WHR is a valid method by which to assess body fat distribution. The WHR assesses subcutaneous adipose tissue and, in subjects who are predominantly of the android distribution, the waist circumference assesses internal adiposity. Ratios can be very crude since they are uninformative of possible changes that are occurring (Wadden et al., 1988). For example, subjects may undergo a large reduction of the waist and hip circumferences and yet no real change in the WHR. Consequently, the waist and hip circumferences should be considered in absolute terms in addition to the waist-to-hip ratio itself.

Skinfold caliper formulas for the prediction of body fat that are based on densitometry as the method for the validity criterion are doubly indirect. The densitometric model relies on several assumptions as described by Wilmore (1983), include the following:

1. The density of fat and the fat free mass are known values and are given as 0.900 g/ml and 1.1 g/ml, respectively in Siri's equation.

2. The densities of the components are relatively constant between individuals.

3. The densities of mineral, muscle, water, and residual which constitute the fat free mass, are constant within the same individual and among individuals. In addition, these constituents have a constant proportional contribution to the total fat free mass.

The prediction of body fat by skinfolds relies on the above assumptions as well as five additional assumptions as described by (Martin, Ross, Drinkwater & Clarys, 1985).

1. Constant compressibility of the skinfolds.
2. Skin thickness being negligible or a constant fraction of the skinfold.
3. Fixed adipose tissue patterning.
4. Constant fat fractionation of the adipose tissue.
5. Fixed proportion of internal to external fat.

However, skinfold measures are extremely useful for analyzing changes in body composition within an individual (Ross & Marfell-Jones, 1990).

In addition several other assumptions exist with regard to the variables utilized in the fitness survey:

1. The MET (Metabolic Equivalent, where 1 MET= 3.5 ml O_2/kg/min) is a valid indicator of the energy cost/kg/hr for a given activity.

2. Activity Level, based on total energy expenditure in all leisure-time activities was a valid method of classification. (See definition of terms-Activity Level).

3. The fitness survey was a representation of average Canadians in terms of physical activity and body composition.

4. The field personnel were adequately trained with regards to specified procedures and standard definitions and data was collected and properly recorded by both the testers and the participants.

DEFINITION OF TERMS

**Denotes Canada Fitness Survey Definition

Activity Level**

A classification based on the total energy expenditure in all leisure-time activities. This was determined by the survey questionnaire. The total energy expenditure for all activities was calculated by summing the energy expenditure for each activity that an individual reported. This total was divided by 365 to give an indication of the daily average. The total time per activity was restricted to a maximum of 241 minutes.

Active-12 month average of at least 3 kilocalories of energy expenditure daily per kg of body mass per day.

Moderate-1.5-2.9 kcals of energy expenditure per kg of body mass per day.

Inactive-below 1.5 kcals/kg/day.

Activity Level Categories

Activity categories created for this study based on the 1981 and 1988 surveys.

1. Sedentary 1981 and Sedentary 1988-Reference Category
2. Moderate 1981 and Moderate 1988-Dummy Variable A1
3. Active 1981 and Active 1988-Dummy Variable A2
4. Sedentary 1981 and Moderate 1988-Dummy Variable A3
5. Sedentary 1981 and Active 1988-Dummy Variable A4

Adipose Tissue

Tissue in which the main function is to store lipid.

Adiposity

The amount of adipose tissue in an individual relative to his or her own age and stature.

Alcohol Consumption Status

Subjects are categorized according to their alcohol consumption in 1981 and 1988.

1. Non-Drinker (1981 and 1988)-Reference Category
2. Drink the Same Amount and Frequency -Dummy Variable AL1 (< 5 ounces per week)
3. Drink Increase-Dummy Variable AL2
4. Drink Decrease-Dummy Variable AL3

Android

Refers to a distribution of body fat that is located on the trunk region, centrally, or in the upper-body region.

Body Fat**

Skinfolds-sum of biceps,triceps,medial calf, suprailiac, and subscapular skinfolds. These five values are added together and compared to a table representing excess fat by age and gender.

Body Fat Distribution**

The ratio of the waist girth divided by the hip girth. Abdominal girth is considered excessive if the ratio is greater than 0.90 for males and greater than 0.80 for females.

BMI

Body mass index. Body mass (kg) divided by the square of stature (m).

Dummy Variables

Dummy variables are used when a nominal-scale variable is to be inserted into a regression equation. Each category of a nominal variable is treated as a separate variable and zeros and ones are assigned for all cases depending upon their absence (indicated by a zero) or presence (indicated by a one) in each of the categories.

Energy Expenditure**

An estimate of average total leisure-time activity in kilocalories expended per kilogram of body mass over the last 12 months.

Energy Over-Compensation

A counterbalance of energy intake (calorie intake) beyond that produced by the energy deficiency as a result physical activity.

Gynoid

Refers to a body fat distribution that is located peripherally, in the gluteal-femoral region, or lower-body.

Obesity

Excess adiposity or body fatness (>25 percent) (Ross & Marfell-Jones, 1990).

Overweight

Excess body mass (Ross & Marfell-Jones, 1990).

Percent Body Fat

This will be determined by the sum of four skinfolds expressed in logarithmic units to determine body density. Percent body fat is then determined by the Siri equation described by Jackson et al., 1980).

$$\% \text{ body fat} = \left(\frac{4.950}{Db} - 4.500\right) \times 100$$

Where Db= Body density determined by the sum of four skinfolds (Appendix C).

Smoking Status

Subjects were categorized according to their smoking status in 1981 and 1988.

1. Never Smoked-Reference Category
2. Former-Quit before 1981-Dummy Variable SM1
3. Started and Quit since 1981-Dummy Variable SM2
4. Continue to smoke (1981-1988)-Dummy Variable SM3
5. Quit After 1981-Dummy Variable SM4

Skinfold

A double thickness of skin, and underlying adipose tissue. The skinfold caliper is applied at right angles to the pinched fold at all times. The investigator must allow time for the full pressure of the caliper to take effect but not so long that the adipose water becomes compressed out of the skinfold. The reading is expressed in millimeters (mm) (Ross & Marfell-Jones, 1990).

Total Body Fat

Represents the absolute amount of fat and can be considered in terms of its relative contribution to total body mass (Ross & Marfell-Jones, 1990).

Waist-to-Hip Ratio (WHR)

The waist girth is the circumference at the level of the noticeable waist narrowing and is located approximately halfway between the costal border and the iliac crest. The hip girth is the circumference at the level of the greatest posterior protuberance, approximately at the symphysion pubis level anteriorly (Ross & Marfell-Jones, 1990). The WHR is simply the waist girth divided by the hip girth; this index is a dimensionless number.

CHAPTER TWO
REVIEW OF LITERATURE

It is commonly recognized that excess body fat or obesity is a risk factor associated with an increased susceptibility to a variety of disorders (Simopoulos & Van Itallie, 1984). However a growing body of data suggests that body fat distribution, more specifically upper body obesity, is by itself a risk factor and may be a factor independent of obesity (Norgan, 1985). Excess truncal or abdominal fat is accompanied by a higher incidence of blood lipid disorders, diabetes, and hypertension, and increased mortality rate.

This chapter will review in detail those aspects of body fat distribution that are important to our understanding of this area of research as well as to the testing of the research hypotheses. The concept of body fat distribution and its quantification will be addressed. Specifically the WHR has become the most commonly used index to predict fat patterning. The physiological significance of body fat distribution in terms of its impact on health complications and disease will also be emphasized. The regulation of lipolysis and lipogenesis in human fat cells will be reviewed, including the regional differences in fat metabolism. The understanding of fat cell metabolism in the different regions, abdominal versus gluteal-femoral, is essential since this will illustrate those mechanisms that will either hinder or promote changes in body fat distribution.

A comprehensive literature review of the two modulating factors that could decrease body mass and alter body fat distribution (physical activity or caloric restriction) will be examined. The review analyzes studies in which the subjects have undergone either a specific physical activity treatment or a calorie restricted diet to determine the subsequent changes in body fat distribution.

The intentions of this review are therefore to consider the physiological implications of body fat distribution and to determine the relative changes in body mass and body fat distribution due to physical activity or caloric restricted diets.

BODY FAT DISTRIBUTION AND THE WAIST-TO-HIP RATIO

A number of techniques have been developed in order to measure adipose tissue distribution. Groddeck (1899) was one of the first to have measured circumferences at different parts of the body. He observed that during reductions in body mass, the waist circumference changed more than the femoral circumference. Sheldon (1950) developed the relationship between body build and traits and introduced a scoring system to describe an individual's degree of endo-, meso-, and ectomorphism.

Several researchers used radiographic techniques to measure subcutaneous adipose tissue thickness in the 1940s and 1950s and specifically Garn in 1956. In addition, ultrasonic techniques were introduced for measurements of human adipose tissue. Ultrasound was used to describe the adipose tissue distribution in young (Sjöstrom, Smith, Krotkiewski & Björntorp, 1972) and in middle aged women (Krotkiewski, Sjöstrom, Björntorp & Smith, 1975). It is possible to calculate adipocyte number by measuring the subcutaneous thickness with ultrasound, by sizing the cells in biopsies from the same region and by taking the non-fat cell volume at different adipocyte sites into account (Sjöstrom et al., 1972).

Skinfold measurements on a large scale started in the 1950s (Keys & Brozek, 1953; Garn, 1956) however the technique was introduced in 1890 by Richer. Although, skinfold calipers were once rare and expensive instruments, they are now being mass-produced (Martin et al., 1985). Subcutaneous adipose tissue is easily accessible and since it contains a large fraction of the body's total fat content, the utilization of skinfold calipers appears to be the most reasonable indirect, non-invasive method (Martin et al., 1985). However, there are several underlying assumptions that have been brought under scrutiny such as constant compressibility, skin thickness as being negligible, fixed adipose tissue patterning, constant fat fraction, and a fixed proportion of internal to external fat. Compressibility, of all of the factors considered, probably presents the major problem since within the same individual this is both large and difficult to predict. Skinfold thicknesses can be used to monitor change with growth, exercise, diet, disease, and debilitating conditions. As well, experienced measurers, using repeated measures at several anatomical locations can provide reliable data which can then be related to norms for both age and sex (Ross & Marfell-Jones, 1990).

By combining skinfold and circumference measurements valuable information about the relation between adipose and lean tissues have been obtained. Vague (1947,1969) introduced this combination and the trans-sectional area of adipose tissue and muscle from circumferences and skinfolds in the brachial and femoral regions was calculated. Vague arrived at a adipo-muscular ratio which is larger in females than males in both regions and at all ages except during childhood. Specifically, Vague (1969) suggested that the relative amount of upper (android) versus lower (gynoid) obesity was important and could be quantified by an average of two ratios: 1) fat at the nape of the neck with that at the sacrum, and 2) the ratio of fat to muscle area in the arm with that in the thigh.

Computed tomography (CT) is an ideal technique to describe regional adipose tissue distributions, however, using CT to quantify adipose tissue distribution is expensive and is of substantial risk to the patient with longitudinal studies. Therefore research should be directed toward constructing equations which accurately predict the visceral adipose tissue from anthropometric measurements (Sjöstrom, 1988).

Several indices have been identified to quantify body fat distribution however the most common one is the waist-to-hip ratio. The WHR strongly predicts susceptibility to health related complications in both cross-sectional (Krotkiewski et al., 1983) and longitudinal (Larsson, Svardsudd, Wilhelmsen, Björntorp & Tibblin, 1984) studies. Since relationships between health risks and visceral/total adipose tissue area ratios in abdominal CT scans have been demonstrated, the circumferences therefore indicate that the visceral adipose tissue is related to cardiovascular risks (Sjöstrom, 1988). Kissebah et al., (1989) made the following conclusions which were based on several studies that examined the relationship of body fat distribution to the metabolic profile in both male and female subjects:

1. The WHR strongly predicts susceptibility to health complications such as non-insulin dependent diabetes mellitus and cardiovascular disease, as indicated by abnormalities in the metabolic profile.

2. The association of WHR with metabolic abnormalities is independent to the effects of the degree of overweight, however the association is additive to the effects of the degree of overweight.

3. The correlative power of the WHR is the result of its prediction of the abdominal visceral mass.

As a result of these findings the WHR is the most commonly used index to predict fat patterning. Researchers will also use other girths and skinfolds in association with this ratio.

According to Garn, Sullivan & Hawthorne (1988) defining fat distribution poses two methodological problems. Fat distribution independent of the total amount of fat is a problem since the relative thickness of outer fat varies with the total amount of fat. Skinfold and skinfold ratios reflect this, and are therefore dependent on the degree of fatness. Ratios, particularly the WHR derived from circumferences poses a second problem since either the waist or the hip or both circumferences may change with fluctuations or differences in body mass. Consequently it is important to acknowledge those factors that may affect fat distribution.

FACTORS AFFECTING THE WAIST-TO-HIP RATIO

The WHR is influenced by both losses and gains in body mass in men (Ohlson et al., 1985) and women (Wadden et al., 1988). With an increase in overall adiposity, WHR increases as it has been well documented that increments in subcutaneous fat thicknesses on trunk sites are more highly correlated with body mass increments than fat thicknesses measured on the extremities (Borkan & Norris, 1977). To further emphasize this point, Weststrate, Dekker, Stoel, Begheijn, Deurenberg & Hautvast (1990) studied a group of obese otherwise healthy premenopausal women and classified the subjects into three groups based on WHR (WHR$\leq$ 0.79, 0.79< WHR < 0.85, WHR > 0.85) and compared these groups along with a group of non obese women. The data illustrated that when studying subjects of varying degrees of total adiposity, WHR increased with increasing fat mass (kg) and fat percentage (%). This does not mean that two subjects with identical amounts of total adiposity could not have two distinct body fat distribution patterns. Instead these results emphasized that in the general population, as total adiposity increases, so does the WHR. Therefore, the interaction between total body fat and measurements of regional fat distribution is important. In a cross-sectional and longitudinal analysis of body mass changes in men and women, WHR correlated directly with changes in mass in both sexes (Shimokata, Andres, Coon, Elahi, Muller & Tobin, 1989). Figure 2-1 demonstrates the cross-sectional effects of age, sex and body mass index (BMI) on waist-to-hip ratio (Shimokata et al., 1989). Consequently, when comparing android and gynoid obese subjects, total adiposity must be considered and adjusted if differences exist.

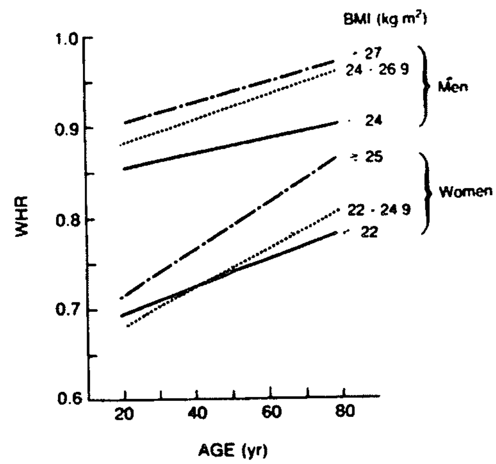

Figure 2-1. Cross- sectional effects of age, sex, and body mass index on WHR. Linear regression lines of WHR on age are shown by BMI tertiles in men and women (Shimokata et al., 1989).

Other factors that may influence body fat distribution are smoking, oral contraceptive use, alcohol consumption, and parity. It has been well documented that smoking is associated with android adiposity as described by a high WHR, however the exact mechanisms that cause this shift are not known (Tonkelaar, Seidell, Van Noord, Baanders-Van Halewijn, Jacojus & Bruning, 1989). It does not appear from the literature that oral contraceptive use displays any significant relationship with WHR in premenopausal women. However, a slight effect or increase in WHR may be associated with parity (Tonkelaar et al., 1989). Rodin, Radke-Sharpe, Rebuffe-Scrive & Greenwood (1990) found that the number of pregnancies was associated with a higher WHR. Further research is needed in the area of oral contraceptive use and regional adiposity. Alcohol, however, has been determined as a contributing factor in the tendency towards a high WHR (>0.80) or an android fat distribution (Cox, 1989; Björntorp et al., 1989).

Another factor that has been found to influence WHR is "weight" or more appropriately termed "mass" cycling. Rodin et al., (1990) were interested in whether mass variability, produced by repeated cycles of body mass gain and loss, influenced fat distribution toward a more abdominal pattern in premenopausal women. In this study WHR was significantly associated with a higher degree of "weight" cycling, while controlling for age and parity. Subjects who were classified as weight cyclers showed a significant association between BMI and WHR. This study suggests that repeated bouts of mass loss and body mass regain promotes abdominal obesity and consequently, may contribute to health risks later in life. Consequently, these factors must be controlled for when quantifying regional adipose tissue distribution.

HEALTH RISKS AND BODY FAT DISTRIBUTION

The role of body fat distribution in the understanding of the health risks associated with being overweight has become the most significant realizations in obesity research. The higher ratio of abdominal-to-gluteal circumferences (WHR) has been suggested to increase the risks for diabetes and cardiovascular disease. For example, Vague (1956) studied the degree of masculine differentiation of obesities to determine predisposition to disease. In this study, diabetes, atherosclerosis, gout, and uric calulous were found to be associated with upper body obesity whereas gynoid obesity was found to be associated with such factors as locomotor difficulty, slowing of venous and lymphatic circulations, and a limitation of respiratory motion. Lapidus, Bengtsson, Larsson, Pennert, Rybo & Sjöstrom (1984) in a 12 year follow up of premenopausal women demonstrated that the WHR is an independent risk factor for cardiovascular morbidity and mortality. Specifically, the WHR was a significant predictor of myocardial infarction, stroke, and death independent of age or BMI. Among the 10 percent of the women with the lowest ratio, not one developed myocardial infarction or stroke. The WHR, as well as other methods such as skinfolds and skinfold ratios, were used to assess body fat distribution in these studies. The android fat distribution, as indicated by a high WHR was found to be a greater risk factor than BMI and therefore WHR was validated as a risk factor, independent of BMI (Bray & Gray, 1988).

In several cross-sectional studies abdominal fat predominance was found to be associated with glucose intolerance, hyperinsulinemia, and hyperlipidemia (Krotkiewski, Sjöstrom & Björntorp G, 1977; Deprés, Tremblay & Bouchard, 1988). Gillum (1987) stated that a greater waist girth relative to the hip was independently associated with an increased prevalence of definite hypertension, definite hypertensive heart disease and diabetes mellitus, as well as higher blood pressure and post-load serum glucose concentration. Peiris, Sothmann, Hennes, Lee, Wilson, Gustafson & Kissebah (1989) confirmed that indices of central fat distribution are closely related with hyperinsulinemia and hyperlipidemia, and that indices of intra-abdominal fat are correlated better with the blood pressure profile. Body fat distribution within the abdomen was assessed by computed tomography. The anthropometric measures of WHR and subscapular and triceps skinfolds were used to assess body fat distribution. Figure 2-2 shows the percentiles for fat distribution of the abdominal circumference to the gluteal circumference (WHR) for men and women by age groups and disease risk.

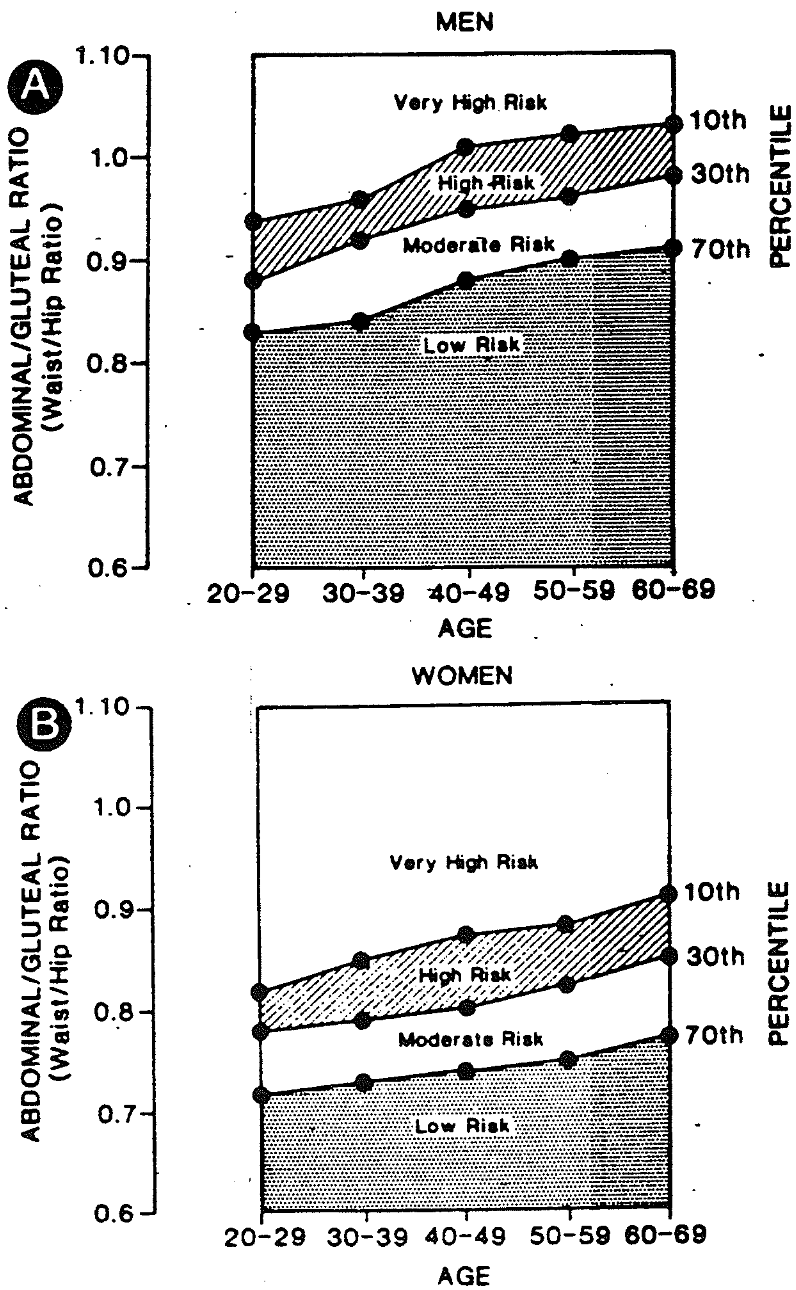

Figure 2-2. Percentiles for fat distribution (WHR) at different ages for men and women and risk for disease.

Adapted from: Bray, G.A. (1989). Obesity: basic considerations and clinical approaches. Disease-a-Month. 35(7). 449-537.

THE PHYSIOLOGICAL SIGNIFICANCE OF BODY FAT DISTRIBUTION

The prevailing view is that body fat distribution and the accompanying metabolic abnormalities are linked via a deviation in normal androgenic-to-estrogenic activity. Sensitivity to the androgenic environment is induced or exacerbated by a genetic and/or early developmental aberration occurring at the time of sexual dimorphism (Kissebah et al., 1989).

In healthy premenopausal women without history of amenorrhea or clinical evidence of endocrine disorders, no significant relationship between body fat distribution and plasma level of total testosterone, androstenedione, dihydroepiandrosterone sulfate, or estradiol exists. However, there is a significant trend toward a decrease in sex hormone binding globulin (SHBG) and an increase in percent-free testosterone (%FT) as WHR values increase.

Since plasma SHBG levels in female humans are determined largely by the androgen to estrogen balance, the decrease in SHBG and the increase in percent-FT, therefore indicates a relative increase in androgenic activity (Kissebah et al., 1989).

Body fat distribution may be an indication of the increased exposure of the body to unbound androgens, as suggested by the strong correlation between the increases in androgenic activity (SHBG and %-FT) with increased adipocyte volumes in the abdomen, but not the thigh. This suggests that the abdominal adipocyte hypertrophy in the upper body obese (android) may be the result of hyper-androgenicity (Gillum, 1987). Upper abdominal obese women and men are similar since fat is preferentially deposited intra-abdominally (Kissebah, Evans, Peiris & Wilson, 1985).

Additionally, there is a regional specification of the adipose depots. The gluteal-femoral region is primarily a storage organ for the purposes of pregnancy and lactation, and the abdominal region is primarily for the storage of energy reserves that are easily mobilizable. The differences in adipocyte metabolism of the two different regions will be examined in a subsequent section.

The degree of androgenic activity correlates significantly with the deviations in plasma glucose and insulin levels in premenopausal women (Gillum, 1987). Evans, Hoffmann, Kalkoff & Kissebah (1983) reported a significant negative correlation for SHBG and insulin resistance, as determine by steady-state plasma glucose levels during simultaneous infusion of glucose, insulin, and somatostatin. The subjects' steady state plasma glucose (SSPG) levels with similar steady-state plasma insulin (SSPI) levels and identical rates of glucose infusion, reflect the ability of insulin to dispose of a glucose load. Therefore, the higher the steady-state plasma glucose level, the greater the insulin resistance. Champaigne (1990) concluded that these results suggest that the degree of central adiposity is associated with specific hormone levels and that these hormone levels reflect the degree of insulin resistance as well as associated fat distribution.

Kissebah et al., (1989) summarized several observations which suggested that androgenic activity may influence glucose-insulin homeostasis by two mechanisms (Figure 2-3). First, by influencing the deposition of adipocytes abdominally that are different morphologically and metabolically from those deposited in the gluteal-femoral region, androgen activity could result in greater plasma free fatty acid flux (FFA), exposing hepatic and extra-hepatic tissues to free fatty acids.

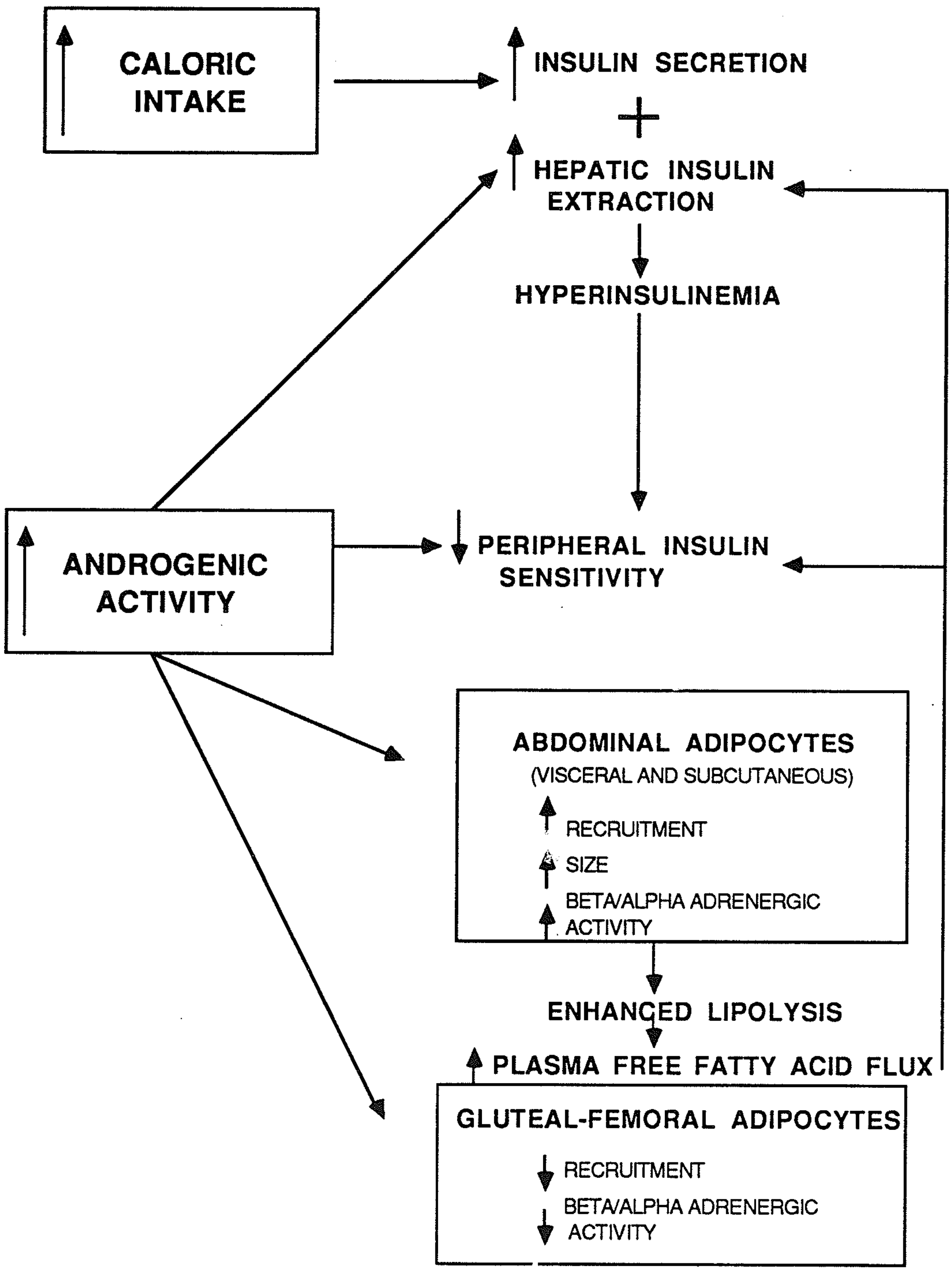

Figure 2-3. Mechanisms associating body fat distribution and obesity to abnormalities in insulin and glucose homeostasis (Kissebah et al., 1989).

This mechanism was suggested because of several observations which included the fact that upper body adipocytes are large and exhibit high rates of basal and catecholamine-stimulated lipolysis, presumably the result of increased beta-to-alpha-adrenergic activities (Kissebah, Vydelingum, Murray, Evan, Hartz, Kalkhoff & Adams, 1982). As well, Kissebah et al., (1985) determined that upper body obese women demonstrate higher nocturnal levels of plasma free fatty acids, despite higher insulin levels. Another observation was the increase in portal vein plasma FFA levels and hepatic triglyceride contents in rats that were fed a high fat diet.

Secondly, androgenic activity might be directly responsible for the abnormalities in insulin dynamics and in hepatic and extra-hepatic insulin actions. This mechanism was suggested because it was observed that insulin-mediated glucose disposal, measured during a euglycemic clamp, is 45 percent lower in healthy men relative to women of similar age and body mass, when expressed per kg of lean body mass (Yki Jarvinen, 1984). Additionally, the administration of testosterone derivatives to women results in impaired glucose tolerance and hyperinsulinemia (Landon, Wynn & Samolos, 1963). Hyperandrogenism and insulin resistance in women are associated with polycystic ovary disease and may decrease with estrogen therapy (Mandour, Kissebah & Wynn, 1977).

Björntorp (1988) also proposed three alternative interpretations of the WHR and its association to disease (Figure 2-4). Free fatty acid overproduction and adrenal hyperactivity are two of the interpretations which are similar to those described by (Kissebah et al., 1989). The third alternative is a neuro-endocrine dysregulation due to hypothalamic arousal which can cause several endocrine axes to be disturbed, and are produced by stress. Björntorp et al., (1988) cited a study by (Larsson, Svardsudd, Wilhelmsen, Björntorp & Tibblin, 1987) which stated that women with elevated WHR had symptoms which made them more susceptible to environmental stress. It was thought that these women might suffer from stress with neuro-endocrine consequences known to occur in laboratory animals. This includes the sympatho-adrenal axis (causing hypertension and elevated FFAs, the pituitary-adrenal axis (causing increased secretion of adrenal steroids), and the pituitary-ovarian axis (causing anovulation, lack of progesterone and abdominally distributed adipose tissue). Therefore, risk factors develop in this way for stroke, CHD, non insulin dependent diabetes mellitus, and possibly associated female cancers. Björntorp(1988) stated that the metabolic disorders are be exaggerated by the additional presence of obesity.

It is clear that there is a relationship between sex hormone balance, body fat distribution, and metabolic abnormalities, however the relationship may be exacerbated by genetics and/or early development (Kissebah et al., 1989). For example, when the effects of SHBG and percent FT are adjusted for, the association between body fat distribution and disturbances in hepatic insulin extraction or peripheral insulin sensitivity are markedly reduced, although are still detectable which suggests that the androgenic balance is not the sole determinant of these relationships (Peiris et al., 1989).

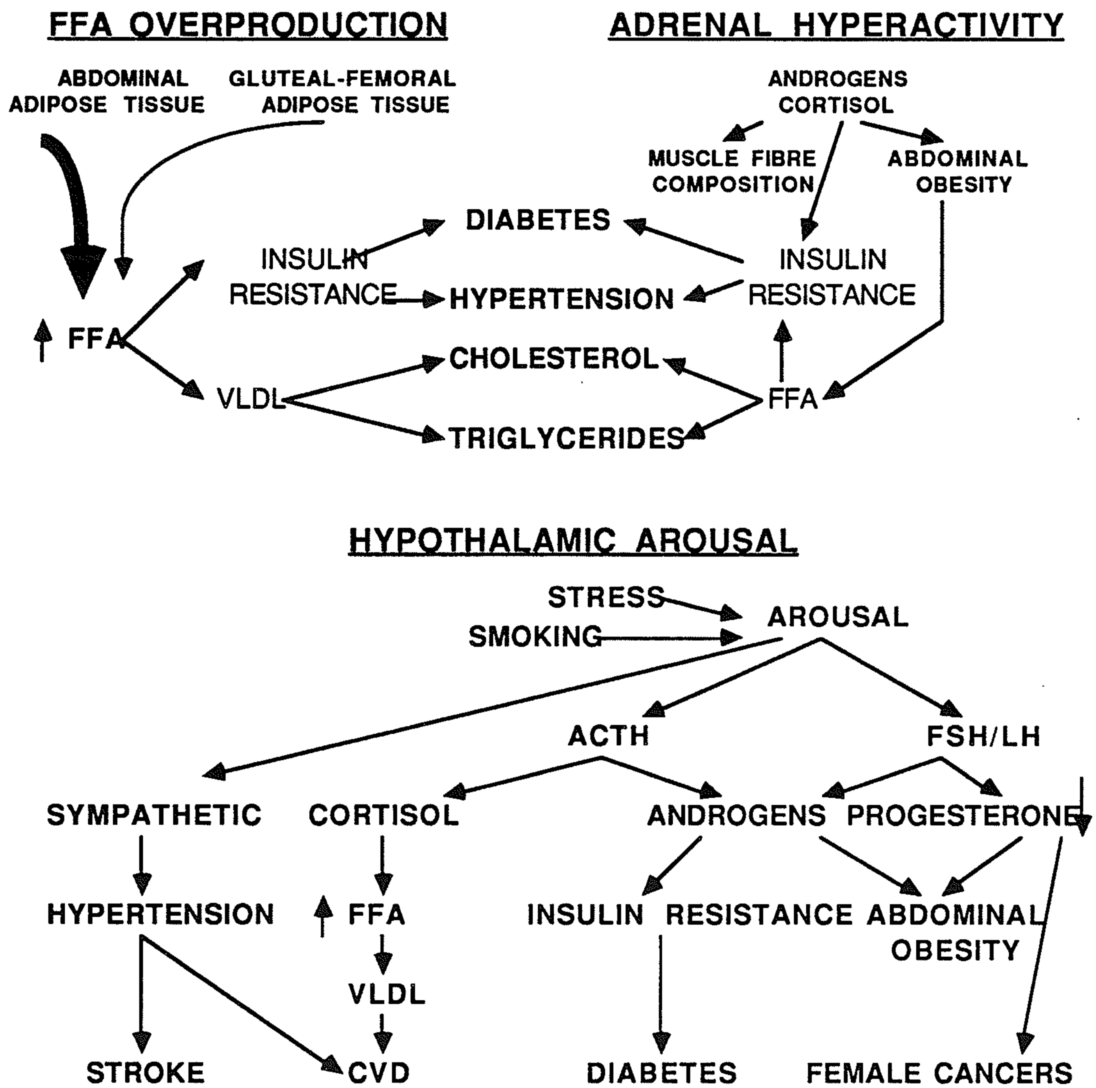

Figure 2-4. Hypothetical associations between fatty acid overproduction, adrenal cortical hyperactivity, and hypothalamic arousal syndrome and the probable causes of disease (Björntorp, 1988).

HUMAN ADIPOSE TISSUE

Over ninety percent of the body energy is stored as triglyceride in adipose tissue (Björntorp, 1971). Protein and glycogen provide much smaller quantities of energy in comparison, however glycogen is important in providing a critical source of glucose during exercise or short term fasting.

There are two principle functions of adipose tissue: (1) the synthesis and storage of fatty acids in triacylglcerols and (2) the release of fatty acids as a source of metabolic fuel. The storage of fat in the first months of life occurs primarily by an increase in the size of already existing fat cells. After the first year of life, fat cell size has nearly doubled, with little change in the number of fat cells, either in children who become obese or in those who do not (Knittle, Timmers & Ginsbeg-Fellner, 1979).

Children who are lean have revealed that the size of the fat cells decreases after the first year of life whereas obese children retain throughout childhood the large fat cells that developed during the first year of life. The fat cells multiply in number throughout the growing years in a process that usually terminates in adolescence. The number of fat cells increases more rapidly in obese children than in lean children and reaches adult level by age 10-12 years (Knittle et al., 1979).

Sjöstrom (1981) provided evidence that suggested that after puberty acute changes in the stores of body fat primarily occur by increasing the size of adipocytes that already exist with little or no change in the total number. The total number of cells may change during adult life, with a chronic increase in body fat leading to an increase in the number of fat cells however this has been demonstrated in individuals who are 75% above their desirable body mass (Sjöstrom,1981). Consequently, juvenile onset obesity or hypercellular obesity as compared to adult onset obesity or hypertrophic obesity is characterized with a duration of body mass loss that follows successful dietary treatment as being shorter, and the rate at which the body mass is regained is more rapid (Krotkiewski et al., 1977).

According to Bray (1989) hypertrophic obesity involves the enlargement of adipose tissue cells with lipid, and this type of obesity correlates with android or truncal fat distribution.

ADIPOCYTE METABOLISM

Hirsch, Fried, Edens & Leibel, (1989) referred to the active cycle of free or unesterfied fatty acid uptake and esterfication within the adipocyte and simultaneous lipolysis and release of free fatty acid. The glycerol that is released from lipolyzed triglyceride cannot be re-utilized immediately for esterfication. Alpha-glycerophosphate which is synthesized from glucose within the adipocyte, is used as a substrate for free fatty acid re-esterfication. Very little energy is consumed in the cycle of lipolytic release of free fatty acid and immediate re-esterfication. This cycle assures that abundant supply of free fatty acid is readily available as a metabolic fuel. Hirsch et al., (1989) provided a schematic representation of lipolysis and lipogenesis in Figures 2-5 and 2-6.

Regulation of Lipolysis in Human Fat Cells

Mobilization of triglyceride stores in the fat cell is catalyzed by the enzyme hormone sensitive lipase (HSL), which like lipoprotein lipase (LPL), hydrolyzes triglycerides to FFA and glycerol. The rate of lipolysis is dependent upon what Hirsch et al., (1989) refers to as a metabolic cascade that eventually results in the phosphorylation and activation of HSL. Initiation of this cascade occurs because of the binding of hormones and regulatory metabolites to specific receptors on the surface of the cell. A signal is initiated by the receptors that is transduced by specific G proteins which either stimulate (Gs) or inhibit (Gi) adenylate cyclase. Adenylate cyclase catalyzes the formation of cAMP from ATP which activates kinases which phosphorylate HSL. Catecholamines are activators of lipolysis and therefore stimulate the lipolytic cascade via beta adrenergic receptors coupled by Gs, while the inhibitors such as adenosine or $alpha_2$-agonists inhibit lipolysis via Gi. Norepinephrine and epinephrine are "mixed" agonists, and simultaneously activate both beta (lipolytic) and $alpha_2$ (antilipolytic) receptors. A potent antilipolytic agent is insulin, however the mechanism by which insulin inhibits lipolysis is uncertain but may involve phosphodiesterase activity that breaks down cAMP and activation of a phosphatase that dephosphorylates HSL. Adenosine inhibits lipolysis via G protein-linked receptors.

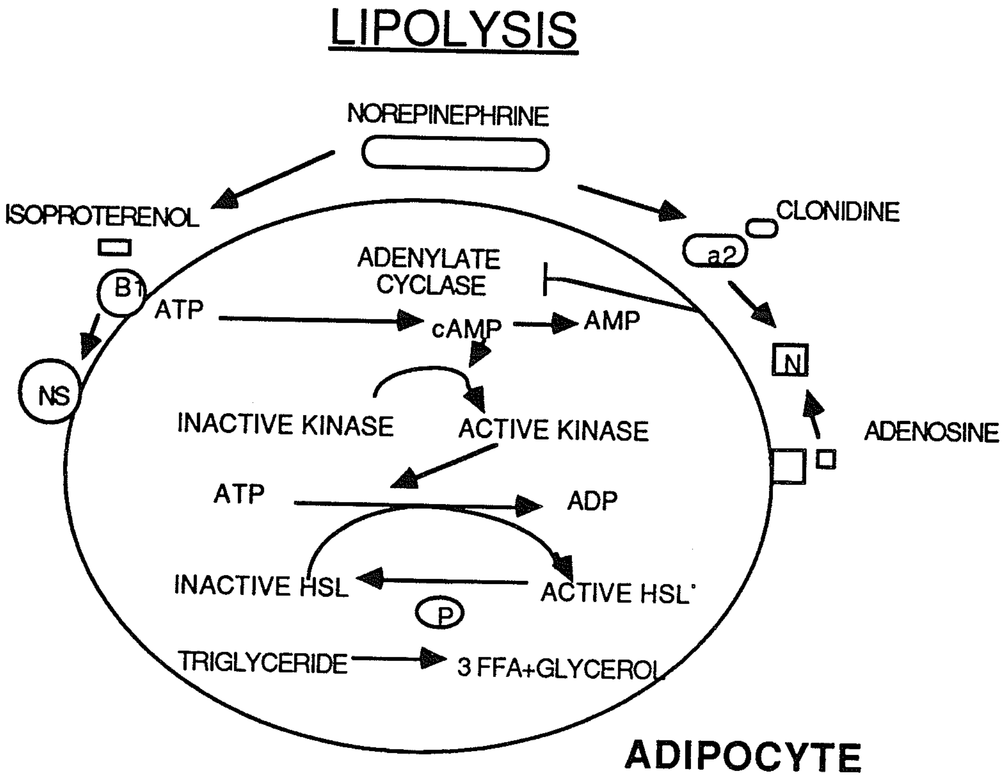

Figure 2-5. Regulation of lipolysis in human fat cells.
(Hirsch et al., 1989)

Regulation of Lipogenesis in Human Fat Cells

Circulating triglycerides (TG) derived from dietary fats as well as fats that are synthesized in the liver are transported in the blood and are packaged into lipoprotein chylomicrons and very low density lipoproteins (VLDL). The uptake of triglyceride fatty acids is mediated by an enzyme called lipoprotein lipase (LPL). LPL is synthesized within fat cells and then is secreted to the capillary endothelium where it hydrolyzes the triglyceride to free fatty acids and glycerol. Most free fatty acids are taken up into other fat cells and are esterfied to glycerol-phosphate synthesized from glucose to form TG. These triglycerides are then stored in the adipocytes' large lipid storage droplet (Hirsch et al., 1989).

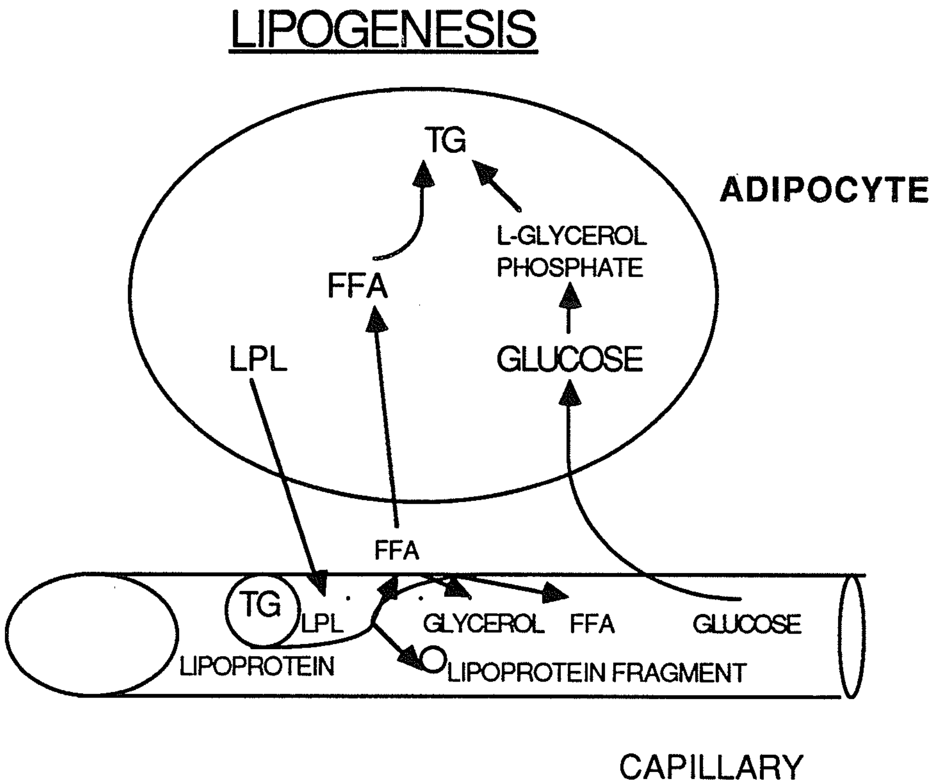

Figure 2-6. Regulation of lipogenesis in human fat cells (Hirsch et al., 1989)

Lipolysis and lipogenesis occur simultaneously, resulting in a cycle of free-fatty acid (FFA) release and re-esterfication that is extremely sensitive to hormonal control. The free fatty acids released by lipolysis may be re-esterfied, or released into the circulation (as albumin bound FFA) for utilization by other tissues. The availability of glucose (for glyceride-glycerol synthesis) as well as local factors such as blood flow both affect the relative rates of re-esterfication and FFA release into the circulation (Hirsch et al., 1989).

Role of Blood Flow in the Regulation of Adipose Tissue Metabolism

As summarized by Leibel, Edens & Fried (1989), sympathetic nerve stimulation causes a decrease in adipose tissue blood flow as norepinephrine acts at the the alpha receptors to increase vasoconstriction and to reduce blood flow. Free-fatty acids are released as a result of lipolysis, accumulating in the tissue as stimulation is prolonged. The FFA and adenosine (origin unclear) exert feedback inhibition on lipolysis. The adenosine present is a vasodilator allowing vasodilatory escape despite continued neural stimulation. Blood flow will rebound above pre-stimulatory levels.

Insulin has a very potent effect on adipose tissue as it can inhibit free fatty acid efflux. Insulin therefore, has the ability to modulate the concentration of circulating FFA and influences the supply of lipid available for oxidation or hepatic re-esterfication. Two mechanisms exist whereby insulin exerts its action: (1) hormone sensitive lipase inhibition, the enzyme that catalyzes the hydrolysis of fatty acids from triglycerides stored in adipose tissue and, (2) promotion of re-esterfication of newly hydrolyzed fatty acids (Hirsch et al., 1989).

Fasting results in a decrease in plasma insulin as well as an increased entry of both glycerol and fatty acids into the circulation as the rate of triglyceride hydrolysis increases. Since the decrease in plasma insulin is one of the major causes of the increased rate of TG hydrolysis, infusion of glucose and insulin might be expected to inhibit lipolysis. Recent studies have found that fatty acid re-esterfication increases more quickly than lipolysis is inhibited, by the infusion of glucose into fasting subjects (Hirsch et al., 1989). Quaade, Lassen & Levin-Nelson, (1967) found that after the ingestion or slow infusion of

400 kcal of glucose in humans that adipose tissue blood flow decreased. The simultaneous infusion of glucose and insulin into fasting subjects might increase fatty acids re-esterfication by reducing the blood flow to adipose tissue, which would limit the entry of fatty acid into the circulation, and promote their re-esterfication within the tissue, by increasing their opportunity to be taken up by the adipocytes (Hirsch et al., 1989).

REGIONAL DIFFERENCES IN ADIPOSE TISSUE METABOLISM : POSSIBLE MECHANISMS BY WHICH BODY FAT DISTRIBUTION IS ALTERED

Hirsch et al., (1989) explained a simple method for measuring rates of lipolysis from adipose tissue fragments that were obtained from different anatomical sites and this method was employed in some of his previous research (Leibel, Hirsch & Berry, 1984). Tissue fragments are incubated with two isotopes: ^{14}C-glucose and ^{3}H-palmitate. Generally, an increase in lipolysis is accompanied by no change in the uptake of ^{14}C into newly synthesized triglycerides, however the level of ^{3}H-palmitate declines because of dilution with newly released fatty acids, which are also available for uptake and re-esterfication. Hence, this ratio of $^{14}C/^{3}H$ in adipose triglyceride correlates with lipolysis. Leibel et al. (1984) examined the effect of various agonists such as isoproterenol and norepinephrine, as well as beta and alpha$_2$-blockers, and demonstrated that human adipose tissue contains vast quantities of alpha and beta adrenoreceptors.

The binding of agonists to the β_1-receptors enhances lipolysis, whereas binding of agonists to alpha-receptors inhibits lipolysis. The alpha effect is very prominent in humans and in both genders and the lipolytic response to norepinephrine (which activates $beta_1$ and $alpha_2$ receptors) is more pronounced in the abdominal tissue than in the gluteal-femoral tissues. Upon further analysis of the different responses of the tissues in the different regions in both men and women, it was suggested that an android fat distribution, may reflect greater α_2 activity in the abdominal tissue.

There are two naturally occurring catecholamines- norepinephrine (NE) and epinephrine (EPI), which are capable of activating both of these receptors ("mixed agonists"), although EPI's affinity for the alpha-$_2$ receptor is somewhat greater than that of NE. Most of the norepinephrine is released from nerve terminals abutting the vasculature and epinephrine derives mainly from the adrenal medulla (Leibel et al., 1989).

Leibel and Hirsch (1986) also found as enhanced alpha-$_2$ receptor activity in the abdominal subcutaneous adipocytes of men, as compared with women, suggesting also that this situation might contribute to the greater tendency of men to accumulate fat in this region. Leibel et al. (1989) cited a study by Richelsen (1986) in which a greater alpha-$_2$ receptor number and response was found in the gluteal adipocytes of women compared to men. Both of these findings are consistent with the sex-related differences in adipose tissue distribution (Leibel et al., 1989).

The enzyme, lipoprotein lipase (LPL) has been reported to have a controlling affect in the regional deposition of fat. The genders differ in LPL activity and in the regional deposition of fat and this seems to parallel the variations in fat cell size.

During the years when a women is fertile, fat tends to be accumulated (LPL high), preferentially in the femoral region compared to the abdominal region, which is difficult to mobilize (noradrenaline stimulated lipolysis is low), and women therefore have enlarged fat cells in this region. During pregnancy these factors are even more pronounced while during lactation, exogenous triglycerides are not preferentially taken up in the femoral region (femoral LPL activity is not higher than in the abdominal region). At the same time, lipids are now as easy to mobilize as in the abdominal region (high lipolysis in both regions). This research conducted by Rebuffe-Scrive, Enk, Crona, Lonnroth, Ambrahmasson, Smith & Björntorp (1985), particularly the changes in metabolism during lactation has culminated in the hypothesis that the typical female fat region or femoral fat has a specific female function, as a reserve of energy which can be utilized as a supply of energy during lactation.

When the ovarian production of sex hormones has decreased considerably or even ceased during post-menopausal years, the typical LPL activity in the femoral region disappears, and there are no regional differences between the abdominal and femoral fat depots in terms of LPL activity. In women who receive estrogen and progestagen therapy, LPL activity increases in the femoral region. Postmenopausal women have reduced abdominal lipolysis which is not much different from the femoral region. In postmenopausal women, there is a lack of regional difference in fat cell size between abdominal and femoral adipocytes due to the combination of low abdominal lipolysis and a low femoral LPL activity. In menopause, fat may accumulate without regional preferences (Rebuffe-Scrive, 1988).

A study on the regional differences in adipose tissue LPL activity in relation to body fat distribution and menopausal status conducted by Raison, Basdevant, Sitt & Guy-Grand, (1988), contradicts the research of Rebuffe-Scrive (1988). Regional differences of the same magnitude were demonstrated in pre- and post-menopausal women with femoral obesity but not in women with abdominal obesity. Menopausal status did not seem to be a sufficient and necessary condition to abolish the typical female regional differences in adipose tissue from obese women. However, the post-menopausal women were only 53 $\pm$ 1.5 years of age and therefore are considered to be in early post-menopausal years. Despite the fact that the post-menopausal women did have low estrogen plasma levels, the regional differences in LPL activity varied in the two regions. The possibility exists that the changes in regional LPL activity towards no difference in this enzyme between the two regions may only occur after a more prolonged exposure to low estrogen plasma levels. The investigators could possibly have demonstrated no significant differences in regional LPL activity in post-menopausal women if these subjects were approximately age 55-60, instead of women that were only in their early fifties. Figure 2-7 demonstrates that the abdominal/femoral ratio of LPL activity was positively correlated to waist-to-hip ratio independent of age, body mass index, fat cell size ratio and menopausal status.

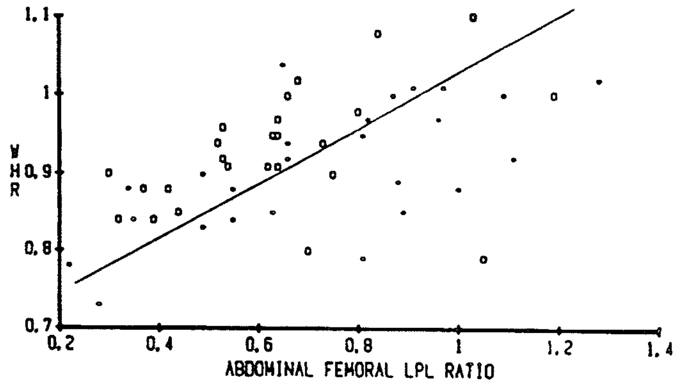

Figure 2-7. The relationship between the ratio of LPL activity from the abdominal to the femoral region and WHR in premenopausal and postmenopausal women (Raison et al., 1988).

In men, there is no increased LPL activity in the femoral region like premenopausal women and the LPL activity is even lower than in postmenopausal women. Testosterone may play an inhibitory role on femoral LPL activity (Rebuffe-Scrive, Lonnroth, Wesslau, Björntorp & Smith, 1987). The abdominal adipocytes compared to the gluteal femoral adipocytes show a higher lipolytic response to noradrenaline, however this decreases with age. It is not known whether this is due to age and or the decreased levels of testosterone. In young men, the lack of difference in the size of adipocytes in the different regions can probably be explained by the high abdominal lipolysis and low femoral LPL activity. Rebuffe-Scrive (1988) posed a tentative conclusion that testosterone inhibits LPL activity and stimulates lipolysis, producing lean young men.

Hirsch et al., (1989) stated that the mechanisms regulating LPL activity are not completely understood. However, it was also stated that it is not unreasonable to assume that the fat patterns of males and females are at least in part related to the effects of sex hormones on both LPL, which makes fatty acids available for storage, and the response of the tissue to catecholamines and other lipolysis regulators. It has been shown in rat adipose tissue that regional variations in receptors for glucocorticoids (Rebuffe-Scrive et al., 1985) or sex steroids (Gray & Wade, 1980) may play a role in the regional differences in LPL activity.

Insulin is also partially responsible for the synthesis of LPL, and the addition of glucocorticoids in vitro with insulin enhance the activity of LPL (Cigolini & Smith, 1979). Men who have similar amounts of body fat to women consistently show higher insulin levels, and insulin levels increase with increases in body fat (Krotkiewski et al., 1983). Higher insulin levels were not due to higher glucose levels in the males. During a oral glucose tolerance test, the insulin/glucose ratio was calculated to give an index of the peripheral insulin sensitivity, and showed higher levels in the males. This suggested that a greater cellular resistance to the action of insulin occurs in the males. With this in mind it is not surprising that Krotkiewski et al., (1983) found that hyperinsulinemia was present twice as often in males than in pre-menopausal females.

CHANGES IN BODY FAT DISTRIBUTION

According to Lapidus et al., (1984) and Larsson et al., (1984), the waist-to-hip ratio (WHR), the index of fat patterning, is now regarded as an important predictor of the susceptibility to cardiovascular disease. As a result of this, there has been considerable interest as to whether this ratio can be altered or reduced.

In a study conducted by Krotkiewski & Björntorp (1986) it was demonstrated that android and gynoid fat patterns are associated with specific morphological patterns of muscle fibre distribution. As a consequence of the transformation that occurs from a more android muscle fibre distribution pattern (high percentage of FTb fibres) to a more gynoid one (FTa fibres), a parallel is drawn and the question arises as to whether or not corresponding differences in changes of body fat distribution would occur with body mass loss. According to (Garn, 1955) however,"the relative fat pattern is an individual characteristic, having some permanence and resistance to change under nutritional stress." The two modulating factors that could alter fat distribution are the quantity and quality of food intake and physical activity. Since the rate of lipolysis has been found to differ between the abdominal region and the gluteal-femoral region, these factors might lead to changes in fat patterning under conditions of negative energy balance. The following review examines studies in which male and female subjects have undergone either physical activity or a calorie restricted diet to determine the subsequent changes in regional fat distribution. The literature concerning caloric restriction focuses mainly on premenopausal women, whereas for physical activity the emphasis is on obese and non-obese males.

CHANGES IN BODY FAT DISTRIBUTION AS A RESULT OF PHYSICAL ACTIVITY

As cited by Hagan, Upton, Wong & Whittam (1986), body mass reduction can be stimulated by an exercise regime conducted a minimum of three days per week for 20 minutes in duration and of a sufficient intensity to expend at least 300 kcal per exercise session (Medicine and Science, 1976, 1978). Exercise is also considered to spare the loss of fat free mass during body fat loss. Hagan, Upton, Wong & Whittam (1986) emphasized that body mass loss due to exercise alone will be minimal compared to that associated with caloric restriction, and caloric restriction combined with exercise. However, the following review will deal specifically with the effect of physical activity on body fat distribution.

Deprés et al., (1985) explained that very little is known about the effects of aerobic training induced changes on the distribution of fat. Exercise training induced changes in body fat distribution have not been studied to any great extent in females due to the lack of success in reducing fat mass by exercise in this particular subject group. In order to ascertain this concept, Tremblay et al., (1988) studied the effect of high intensity exercise in young adult males (n=7) and females (n=7). The exercise program consisted of continuous and intermittent cycle ergometer exercise sessions for a duration of 15 weeks. Gender differences were noted in body fat changes with the men significantly decreasing percent body fat, sum of seven skinfolds, and suprailiac fat cell diameter, whereas in the women these variables were not significantly modified. The men also lost more fat in the trunk than in the extremities, whereas such a preferential fat depletion was not noted in the women. The investigators hypothesized that the short term exercise caloric compensation may be higher in the females than in the males. While this speculation may be true, the investigators failed to control for the caloric intake of the subjects and as a result the findings of this study do not provide convincing information on the changes in body fat distribution between males and females.

The effect of exercise training on body composition and metabolism in both men and women (age 34-40) was studied by Andersson, Xu, Rebuffe-Scrive, Terning, Krotkiewski & Björntorp (1991). The exercise training was the same for all individuals and included jogging and light gymnastics, and more strenuous aerobic work at 80% of maximal working capacity. The sessions were one hour in duration, 3 times per week for 3 months. Amongst men and women that participated at the same relative working intensity, the men lost body fat while women with comparable body fat mass in absolute terms did not. Once again the investigators attributed this to a possible compensatory energy intake in women, since the subjects were not asked to follow a specific diet. This statement is once again, only speculative, since the investigators did not appear to have data pertaining to the energy intake of the subjects. Consequently, the results are misleading, because even though the subjects worked at the same relative physical intensity, the relative caloric intake for each subject was not considered. The total group of women (lean and obese) showed essentially the same changes in waist and hip circumferences with a 0.01 $\pm$ .01 decrease in WHR, as well as decreases in body fat (2.6 kg). All of the subjects experienced 1.9 kg increases in lean body mass (LBM). There were no differences between the two groups of women, except that the obese women increased LBM significantly more than the leaner women. This study demonstrated the maintenance of lean body mass through physical activity, despite an energy deficit.

The previously mentioned studies Tremblay et al., (1988) & Andersson et al., (1991) are prime examples of failing to control for confounding variables such as dietary intake. If the investigators are truly interested in real differences in men and women in terms of the effect of activity on body fat distribution, then it only seems reasonable to direct attention to those factors that could have confounding effects on the results.

Deprés et al., (1985) studied males alone (age 24.3 $\pm$ 4.9 SD) on a 20 week aerobic exercise program consisting of cycling 4-5 times per week for 40-45 minutes , starting at 60% of heart rate reserve and working up to 85% of heart rate reserve. At weeks 5,11,16,18 the subjects performed interval training 3 times a day for 10 minutes at 80% of heart rate reserve. The effect of this program was studied in 13 sedentary non obese men and found reductions in fat mass and subcutaneous fat. Body mass significantly decreased by 2.5 kg. Trunk skinfolds were reduced (12.3 mm for 22%) to a greater extent than the reduction in extremity skinfolds (4.8 mm for 12.5%), which suggests a preferential mobilization of trunk fat. Dietary intake of the subjects was again not considered in this investigation. However, the reductions in skinfolds were expressed in both relative decreases millimeters (mm) per kilogram (kg) of fat mass and decreases (mm) per percent fat, since larger reductions in skinfolds may be associated with a larger initial fat mass.

A group of 5 young males (25 ± 3 years) were also studied to determine the effects of a long-term negative energy balance while maintaining a constant energy intake for 100 days. According to the investigators, (Bouchard, Tremblay, Nadeau, Dussault, Deprés, Theriault, Lupien, Serresse, Boulay & Fournier, 1990), the results were not very clear in terms of the changes in regional fat distribution. Subcutaneous fat significantly decreased but the WHR was unaffected by the body mass and fat loss. Subjects lost an average of 8 kg (range 3-12 kg) and approximately 82% of the mass loss was fat loss. The skinfold data however revealed that slightly more fat was lost on the trunk than on the extremities, although the trend was not statistically significant, except for the decrease in abdominal and suprailiac skinfolds was highly significant.

The changes in skinfolds were analyzed in absolute terms (mm) over the 4 testing periods. These results are not very supportive of site variation in the rate and amount of fat lost under conditions of a negative energy balance. Very few studies have addressed the fact that significant changes in fat distribution will only be detected with substantial fat loss, which is probably essential to detect regional variations in fat depletion. It appears that activity programs of longer duration are required in order to detect real changes in regional fat distribution. The investigators did however, control for diet by ensuring that the subjects maintained a constant energy intake throughout the exercise treatment period. The reductions in the sums of skinfolds were expressed as the average absolute decreases in millimeters when in fact the average relative decreases should also be reported (taking total adiposity into account), especially when initial fat mass and percent body fat for the group was extremely variable (17.0 ± 9.7 kg and 18.7 ± 6.9 kg, respectively).

The effects of aerobic exercise performance at 60% of maximal oxygen consumption, 2 hours per day, 6 days a week for a period of 100 days was studied in 5 moderately obese men (Tremblay et al., 1988). Fat mass and body mass were reduced by 6.8 and 8.6 kg, respectively, as a result of this exercise training program. There was also a trend for a greater mobilization of subcutaneous fat in the trunk compared to the extremities, and the reduction in fat mass was greater (39%) than the reduction in subcutaneous fat (29%), suggesting that some mobilization of deep fat occurred. The decreases in the sums of trunk, extremity, and 7 overall skinfolds were expressed in both absolute and relative decreases. The investigators acknowledged the importance of initial adiposity when considering the amount of fat lost.

Krotkiewski & Björntorp (1986) studied muscle tissue in obesity with different distributions of adipose tissue and the subsequent effects of physical activity in both men and women. The activity consisted of sessions three times per week, 50 minutes each session, for 3 months. The program involved interval work at different intensities, as well as less intense walking or calisthenics. The body fat changes during physical training were different among the 4 groups(1. obese men-android 2.obese women-mixed 3. women-gynoid 4. women- android). Men reduced body fat with physical activity training. This was not the case with women who were categorized as being in between an android or gynoid fat distribution, or women who were strictly considered gynoid. The men and women who were android obese adjusted to a leaner body composition with physical training and experienced decreases in the WHR. Obese women, particularly of the gynoid distribution tend, occasionally to gain mass to become more obese (Krotkiewski & Björntorp, 1986). The training programs were identical between the groups in duration and intensity, and the response in cardiovascular variables were similar. It is unlikely that the differences in energy output were due solely to adaptations to body composition but rather the investigators speculated that possibly the gynoid obese women actually increased energy intake and therefore, the result was a positive energy balance (Krotkiewski et al., 1986). In an animal study (Oscai, Mole & Holloszy, 1971) female rats increased their food intake as a response to physical activity. This model, which can only be applied to rats, implies that energy over-compensation, as a result of physical activity should be investigated in humans. Specifically, these differences must be examined in more detail in women to elucidate whether women in general regulate energy intake differently than men after physical activity due to the implications such factors have on obesity therapy and prevention. As stated previously, the investigators must be aware of confounding factors such as dietary intake and therefore monitor this factor very closely.

More recently, Tremblay, Deprés, Leblanc, Craig, Ferris, Stephens & Bouchard (1990) evaluated the effect of intensity of physical activity on body fatness and fat distribution. Subjects of both genders that participated in the 1981 Canada Fitness Survey were analyzed. Subjects were categorized into four groups on the basis of their participation in leisure activities of various intensities. Subjects who participated in vigorous activities on a regular basis had lower subcutaneous skinfold thicknesses and WHRs than those not performing these activities. After an analysis of covariance was used to remove the effect of total energy expenditure of the activities on subcutaneous fat and fat distribution, the differences remained statistically significant. In addition, the WHR remained significantly lower in subjects performing high intensity activity after the effect of subcutaneous fat on fat distribution was adjusted for. High intensity activity therefore seems to be associated with a preferential mobilization of abdominal fat.

The study by Tremblay et al., (1990) provides new insight on the effect of intensity of physical activity on body fatness and fat distribution. The goal of the study was to review the morphological characteristics of subjects performing or not performing different physical activities at different intensities. However, two major concerns have arisen as a result of reviewing this study. The study is of a cross-sectional nature and therefore warrants further investigations utilizing a true experimental longitudinal analysis. In addition, this particular study design does not exactly give a true indication of the effect of intensity of physical activity on body fat distribution. For example, we do not know if subjects lost body mass and experienced a decrease in WHR as a result of high intensity activity. The results may have occurred because people with lower waist-to-hip ratios (WHRs) and low overall adiposity are more likely to engage in higher intensity activities because their body type predisposes them to this situation. In general, the large subject group in this study, does however give some convincing evidence that the characteristics of subjects performing higher intensity activities are lower adiposity and WHRs.

With reference to the previously mentioned study of Krotkiewski et al., (1986) and the study by Tremblay et al., (1990), it appears that the intensity of the physical activity seems to be an important factor in terms of overall energy balance. Exercise prescription of low intensity aerobic activity is advised due to the high proportion of lipid oxidized compared to that during high intensity activity (Astrand & Rodahl, 1978). However, vigorous activity appears to have a greater impact on the elevation of post-exercise metabolic rate (Lennon, Naigle, Stratman, Shargo & Dennis, 1985) and hence post-exercise energy expenditure.Table 2-1 summarizes the effects of physical activity on body fat distribution.

During exercise there is increased hepatic glucose production, triglycerol breakdown and free fatty acid utilization which is similar to that seen in a person on a calorie restricted diet. The hormone controls are the same in both situations. There is a fall or decrease in insulin secretion, a rise in glucagon secretion, and increased activity of the sympathetic nervous system (Vander, Sherman & Luciano, 1985).

The changes in glucagon and insulin are signaled by a decrease in plasma glucose during prolonged exercise and a calorie reduced diet. During less prolonged activity the sympathetic nervous system supplying the pancreatic islets results in the stimulation of glucagon release by the alpha cells and inhibition of insulin release by the beta cells (circulating epinephrine exerts similar effects on those cells). During exercise the increased sympathetic nervous system activity not only contributes directly to fuel mobilization but contributes indirectly by inhibiting the release of insulin and stimulates the release of glucagon (Vander et al., 1985).

Table 2-1. Summary of results regarding the effects of physical activity on body fat distribution.

STUDY	SUBJECTS	PHYSICAL ACTIVITY	BODY MASS LOSS	SIGNIFICANT DECREASE IN WHR
TREMBLAY ET AL.,1988	YOUNG ADULT MALES (n=7) & FEMALES (n=7)	CYCLE ERGOM. 15 WEEKS	MALES 0% CHANGE FEMALES +1%	MALES-YES FEMALES-NO
ANDERSSON ET AL., 1991	AGE 25-40 MEN & WOMEN BMI-24-27	JOGGING 80% MAX WORKING CAPACITY-1 HR 3 TIMES/WEEK 3 MONTHS	MALES-2.9 KG BODY FAT FEMALES-2.6 KG BODY FAT	NO NO
DEPRES AL,1985	13 SEDENTARY NON OBESE MEN	AEROBIC EXERCISE (20 WEEKS)	2.5 KG	YES
BOUCHARD ET AL., 1989	5 HEALTHY MALES (AGE 25±3)	CYCLING 55%V02 MAX 6 DAYS A WEEK ENERGY DEFICIT-4.2MJ	8 KG	NO
TREMBLAY ET AL., 1988	5 OBESE MALES	60 % VO2 MAX 2 HRS/DAY 6 DAYS/WEEK (100 DAYS)	6.8 KG (FAT MASS)	YES
KROTKIEWSKI MALE AL, 1986	M (W/H-O.8) W (W/H-0.8) W (W/H>0.82) W (W/H<0.82)	3 TIMES/WK 50 MINUTES INTERVALS WALKING CALISTHENICS	-4KG FAT MASS +3KG FAT MASS +3KG FAT MASS +3KG FAT MASS	YES
TREMBLAY ET AL., 1990	MEN n=1257 WOMEN n=1366	VARYING INTENSITIES OF PHYSICAL ACTIVITY		YES

CHANGES IN FAT DISTRIBUTION AS A RESULT OF CALORIC RESTRICTION

The changes in body fat distribution as a result of caloric restriction are presently of considerable interest. Nonetheless researchers such as Garn were studying this area in the mid-sixties. Garn (1956) examined the fat changes during body mass loss in 13 healthy young white males. The diet treatment consisted of approximately 1000 kcal/day for a period of 24 days. Soft tissue teleoroentgenograms were taken at 6 anatomical sites to arrive at 9 specific measures of fat (deltoid "pocket", iliac crest, trochanteric region, lateral arm, medial arm, lateral leg, anterior leg, medial leg, and posterior leg). The median body mass loss was 8.3 kg or 12% of the original value. Each centrally located skinfold decreased by an average of 4-5 mm and each peripherally located skinfold decreased by an average of 1-2 mm. In this study the losses in subcutaneous fat were related to the initial thicknesses. Those individuals with greater amounts of fat to start with sustained greater losses of body fat. However, Garn (1956) failed to report the average relative changes in fat loss and this is important as previously stated, since the subjects were all initially of varying adiposity levels. Also considered was the efficacy of an average body mass loss of 8.8 kg in 24 days, as this could present serious health risks.

The changes in body mass and body dimensions was also studied by Brozek, Grande, Taylor, Anderson, Buskirk & Keys (1957) in men while on a low calorie diet. There were two separate treatment groups with group 1 (n=6) on a 580 kcal/day diet for 12 days and group 2 (n=13) on a 1010 kcal/day diet for 24 days. Both experimental groups walked for 1 hour on the treadmill at 3.5 miles per hour, with a 10% grade. Experimental group 1 walked 4.5 miles/day outdoors while group 2 walked 5.3 mile/day outdoors. In this study group 2 lost 7.6 kg while group 1 lost 5.9 kg. Both of the groups decreased both peripherally (forearm and calf) and centrally (waist, abdominal midpoint, abdomen-navel, below scapula) located circumferences, with decreases occurring more significantly in the central region. The changes in lean body mass (LBM) were not reported, however it could be predicted that LBM was probably maintained due to the incorporation of physical activity into the body fat reduction program, however the caloric intake of 580 kcal/day was probably not sufficient to even maintain muscle mass.

Krotkiewski (1988) also examined a very short term (4 weeks), low calorie diet (544 kcal/day) on body fat distribution of 21 premenopausal women (105.6 kg). The body mass decrease was 3.9 $\pm$ 1.2 kg after the first week and 3.5 $\pm$ 0.8 kg after the second week, for a total mass loss of approximately 7.4 kg, and an average new mass for the group of 98.2 kg. Once again, a very low calorie diet was utilized for a short time in order to create significant body mass and fat loss. Fat cell mass decreased in the gluteal region by 5% and by 8% in the abdominal region. Additionally, the waist girth decreased by 8% and the hip girth by only 4%, and subsequently the WHR decreased by 3%. In the following two weeks, fat cell mass reached a 7% decrease for the gluteal region and 14% decrease for the abdominal region. The decrease in circumferences was higher for the waist (10%) than for the hip (5%) and therefore the WHR decreased even more, for a total decrease of 6%. In this study the changes in circumferences and WHR were determined in a group of women with an average initial WHR of 0.86, which indicates that a majority of the women were initially android (> 0.80) obese. The major fault of this study was that the women were not separated into 2 groups based of their initial fat distribution. Hence, general changes in body composition of a group of women are reported rather than specific changes that are presumably dependent on the initial fat distribution of the subject.

Consequently, Krotkiewski (1988) examined the effects of a longer term body mass reduction program (1000 kcal/day) in sixteen pairs of obese women (16 gynoid and 16 android obese matched by age and body mass, 101.8 kg). Despite the similarity in body mass and composition, the gynoid obese subjects revealed smaller and more numerous fat cells. After the one year body mass reduction program there was a significant decrease in WHR, the difference being significantly greater in the android obese group. In this same study, the regional emptying of fat cells was also compared separately in a larger group (n=46) of premenopausal women on the same diet after a body mass decrease of greater than and less than 10 kg. In the gluteal region, fat cell mass was significantly lower, especially at the lower level of body mass decrease (<10 kg). After a body mass loss of more than 10 kg the gluteal region contributed to fat mobilization in the android group, however in the gynoid group mobilization was unchanged. In the android group the WHR decreased significantly more than in the gynoid group, both in the group with less than 10 kg of body mass loss and in the group with greater than 10 kg of body mass loss. The decrease in body mass (9.2 kg) was found to be positively correlated to the decrease in WHR after the 12 month treatment and only became positive 6 months after the treatment. This study was carefully planned and executed, and the results, based on the physiology of the fat regions of the body, were expected. However, the study would have been more convincing if the subjects lost a greater amount of body fat such that the subjects would no longer be considered obese and at risk for disease.

On the contrary, Andersen, Astrup & Quaade (1989) studied a group of obese patients (37 females and 5 males) that were treated with a 388 kcal formula plus supplements of energy up to 1000 kcal per day for 6 months with either d-fenfluramine or a placebo. The medication was found to not influence the changes in WHR. The type of obesity (android or gynoid) in this study did not influence the total amount of body mass loss or changes in WHR. The median amount of overweight in the subjects of this study was 39 kg. The investigators stated that a 15 kg body mass loss may not have been enough to demonstrate a significant difference without a larger subject group. It has been suggested (Wadden et al., 1988) that if true differences are to be detected in the ability of androids and gynoids to lose body mass and differences in the changes of the WHR then the subjects must be followed to an ideal body mass for that subject. Wadden et al., (1988) acknowledged the need for future investigations to follow subjects to an ideal body mass, since a study that his research group conducted also failed to follow subjects over a longer term to a normal level of fatness.

Wadden et al., (1988) examined the changes in body fat distribution in 68 women who were randomly assigned to three treatment conditions (1.very low calorie diet-400-500 kcal/day for 2 months, 1000 kcal/day for 2 months 2. behavior therapy (BT) 3. VLCD and BT. These women lost an average of 12.3 kg from an initial body mass of 103.6 kg. This body mass loss was accompanied by a small but statistically significant reduction of 1.2% in the WHR, which suggests a reduction in upper-body obesity. The subjects who initially had greater upper-body obesity tended to achieve greater reductions in the waist-to-hip ratio. The changes in five circumference measures were highly correlated with losses of fat and showed that subjects with lower body obesity tended to lose substantial amounts of adipose tissue from both upper and lower fat depots while subjects with upper-body obesity lost fat primarily from their upper body. As well, women with lower body fat lost more total body fat than women with upper body fat. These results contradicted the results of the study conducted by Krotkiewski (1988), since the women in both studies were approximately the same degree of overweight initially and lost approximately the same amount of body mass and body fat. These conflicting results emphasize the necessity to follow severely obese women to a body mass loss greater than 15 kg, preferably to a goal body mass or ideal body mass.

Vansant et al., (1988) also examined the changes in body fat distribution which accompanied body mass reduction in 17 premenopausal obese women. The intervention of an energy reduced 4.2 MJ/day (1000 kcal/day) for 8 weeks resulted in a mean body mass reduction of 10.2 $\pm$ 3.3 kg in the abdominally obese and 9.6 $\pm$ 2.4 kg in the gluteal-femoral obese women. The body fat distribution became more intermediate in the abdominal obese women. In addition, the initial body fat distribution was not related to the ability to lose body mass. In this study fat mobilization from the abdominal fat depot was slightly greater than from the gluteal-femoral region. The android obese women had significantly greater waist circumferences than the gynoid obese women, both before and after the dietary treatment. No significant differences were found in circumference reductions between the groups as a result of the diet. However, the waist circumference decreases were slightly greater in the abdominal obese group than in the gluteal femoral group, specifically 9.1 ± 1.9 cm versus 7.3 ± 2.3 cm ($p<0.10$). This data agrees with a study conducted by Lanska et al., (1985) in that the initial distribution of body fat does not affect the degree of body mass loss in females on a caloric restricted diet. However these conclusions are quite premature. For example, in the study conducted by Vansant et al., (1988) the mean percentage of body fat before the diet intervention was 45.6 percent and 41.6 percent following the rather short term diet. After the diet the women on average were still obese. Therefore it is not possible to conclude that fat patterning types lose body mass equally since we do not follow the subjects to an ideal or goal body mass. Based on the physiology of the two fat depot regions, it is possible that subjects with a gluteal-femoral fat distribution would experience more difficulty in reaching a desired body mass or level of fatness. The results of calorie restricted diets on body fat distributions are provided in table 2-2.

There does not appear to be a significant difference in the effect of exercise versus diet on the two different fat pattern types ability however, men are generally the subjects chosen to participate in studies utilizing physical activity whereas obese women, are generally chosen as the subjects to participate in studies involving calorie restricted diets. Consequently it is difficult to compare the changes that occur as a result of body mass loss on body fat distribution in different studies since the subjects are all of varying initial degrees of total adiposity, which affects the ability to lose body mass and in turn affects the ability to change body fat distribution (WHR). For example, physical activity was found to not significantly change WHR in those subjects that either did not lose more than 3 kg and in those subjects that are already lean or at a normal level of fatness. On the contrary, it appears that with body mass losses of greater than 6 kg results in significant decreases in the WHR, specifically in women.

Table 2-2. Summary of results of the effects of caloric restriction on body fat distribution.

STUDY	CALORIC INTAKE	DURATION	BODY MASS LOSS(kg)	SIGNIFICANT DECREASE IN WHR
GARN, 1956	LOW CALORIE DIET 1000 KCAL *13 YOUNG MALES	24 DAYS	8.3 KG	YES
BROZEK, 1957	GR 1) 580 KCAL *n=6 MEN	12 DAYS	5.9 KG	YES
	GR 2) 1010 KCAL *n=13 MEN	24 DAYS	7.6 KG	YES
KROTKIEWSKI 1985	544 KCAL/DAY	4 WEEKS	10.9 KG	YES
KROTKIEWSKI 1985	1000 KCAL/DAY	1 YEAR	13.7 KG (ANDROID) 12.6 KG (GYNOID)	YES YES
ANDERSEN ET AL , 1989	1000 KCAL/DAY *37 FEMALES *6 MALES MEDIAN AGE-29	6 MONTHS	12.0 KG (ANDROID) 16.5 KG (GYNOID)	YES
WADDEN ET AL., 1988	GRP 1 (400-500/ 1000 KCAL/DAY)	2 MONTHS 2 MONTHS	N1=22, 10.4±4.1	YES
	GRP 2 (BEHAV THERAPY)	6 MONTHS	N2=22, 10.8±6.3	YES
	GRP 3 (400-500/ 1000 KCAL/DAY) *68 PREMENO. WOMEN	2 MONTHS 4 MONTHS	N3= 24, 15.2±7.6	YES
VANSANT ET AL., 1988	4.2 MJ/DAY (1000 KCAL/DAY)	8 WEEKS	10.2±3.3 (ANDROID) 9.6±2.4 (GYNOID)	YES

SUMMARY OF THE MECHANISMS BY WHICH BODY FAT DISTRIBUTION IS ALTERED

In light of the differences in regional adipocyte metabolism described earlier, Krotkiewski (1988) summarizes five mechanisms or combinations as to why there tends to be a significant decrease in WHR in the abdominally obese (android) and obese gynoid (also have upper body fat initially) subjects upon caloric restriction or physical activity:

1) Higher lipolytic activity in the abdominal region compared to the gluteal-femoral depot.

2) Higher lipoprotein lipase activity in the gluteal-femoral region.

3) A higher local fat cell number in the abdominal region in comparison to the gluteal-femoral region.

4) The additive effect of the mobilization of fat from the intra-abdominal fat region, on the decrease in waist girth.

As mentioned previously, fat utilization during exercise is probably associated with the selectively higher mobilization of fat from the intra- and extra-abdominal region in comparison to the gluteal region, which results in a redistribution of adipose tissue. During exercise, the main flux of liberated FFA can be redirected from the portal circulation and the liver to be used in muscle, resulting in improvement of metabolic variables, even in the absence of body fat reduction observed after physical activity in obese men and women (Krotkiewski et al., 1986).

LITERATURE REVIEW SUMMARY AND RECOMMENDATIONS FOR FUTURE RESEARCH

The distribution of body fat is an independent predictor of metabolic aberrations including the risk of developing cardiovascular disease. Abdominal fat is associated with hyperinsulinemia and hypertension. Several indices have been used to quantify body fat distribution the most common one being the waist-to-hip ratio (WHR). The WHR strongly predicts susceptibility to these health related complications. As a result, the focus of attention had been directed to the question of whether fat distribution can be changed or modified to offset the detrimental metabolic consequences of an android fat distribution. Summarizing the results of studies which analyzed the effect of physical activity and caloric restriction on body fat distribution, the reduction of the WHR is often small but significant however both the decrease of energy intake and increase in energy expenditure by exercise, are of value in diminishing any risk factors for the previously mentioned diseases.

As a result of this review, several questions remain to be answered and hence, suggestions for future research arise. The following is a list of possible future studies, with suggestion number two closely approximating the proposed study.

1) Repeated measurements of the waist-to-hip circumferences during body mass reduction to provide important information about the patterns of fat mobilization (Wadden et al., 1988).

2) Long term studies are needed to determine if subjects with lower and upper abdominal obesity differ in their ability to attain a goal body mass or some approximation of it (Wadden et al., 1988; Vansant et al., 1988)

3) To determine whether the initial fat distribution of an individual can predict the ability to maintain body mass losses achieved during treatment (Wadden et al., 1988).

4) To determine whether changes from an abdominal type of body fat distribution to an intermediate distribution are indeed related to changes in blood lipids and blood glucose (Vansant et al., 1988).

CHAPTER 3

METHODS AND PROCEDURES

The 1981 Canada Fitness Survey and the 1988 Campbell's Survey Methodology

Background

Canadians' interest in their fitness and health has become an established trend (Shepard, 1986). In order for government, industry and private organizations to promote programs aimed at increasing the fitness level of Canadians, reliable information on fitness and the factors that influence it must be available.

Consequently, the 1981 Canada Fitness Survey (CFS) was initiated by Fitness Canada in order to describe the physical recreation habits, physical fitness, and health status of the Canadian population. The results from that survey have been published in considerable detail and utilized to plan and evaluate physical recreation programs (Shepard, 1986).

The 1988 Campbell's Survey was designed to provide an update of the 1981 information, examine the contribution of exercise to health, and to investigate adherence to regular exercise over time.

Sample Design and Selection

The objective of the sample design in 1981 was to produce reliable baseline and trend estimates and in 1988 to produce reliable longitudinal information, for fitness and lifestyle factors for Canadians at the national and regional levels.

The choice of the Canadian household as the basic sampling unit immediately excluded approximately 3% of individual who were institutionalized (university students in residences, servicemen, prisoners and hospital patients, and others living in 'collective' households (Household Survey Micro-Data Tape Documentation).

The survey was spread over a six month period encompassing three seasons (winter, spring, and summer) from February to July, 1981, since participation in activity may vary seasonally. Additionally, participation in activity and the relationship between other factors and fitness may also vary from one type of area to another. To account for this the sample design was stratified by the type of area (urban, suburban, and rural) (Shepard, 1986).

The sample design for the household survey was a stratified, multistage cluster design. Stratified, multi-stage, cluster sampling was used to achieve a representative sample of Canadians. Stratification refers to the splitting of a population into a number of subpopulations or strata. Multi-stage sampling is used when the sampling units can be defined in a hierarchical manner (for example a household within a dwelling that is found in a segment of a geographic area within a province). The final sample is selected in a corresponding series of steps (a number of dwellings are selected at random, from a number of selected segments). The cluster sampling procedure is often used when sampling units naturally form themselves into groups or clusters. A number of such clusters are randomly selected from a list of clusters, and all the sampling units in each selected cluster are entered into the final sample (Hassard, 1991). Specifically, the selection procedure involved "area sampling", whereby the survey sample was chosen by Statistics Canada, from several geographically distinct areas. Each province was divided into separate geographical areas (major city; urban; rural). Each of these areas was then broken down into smaller areas called segments. A sample of these was selected and all of the dwellings contained within the segments were listed. A number of dwellings were chosen from each segment identifying the sample households, and information was collected on the members of these sample households (Shepard, 1986).

Respondents of the 1981 Canada Fitness Survey involved 11,884 randomly selected households in 80 urban and rural communities in Canada's ten provinces from the 13,440 households that were initially selected. Of the 34,363 persons that were initially selected to participate in the survey, 23,400 responded. From this group of 23,400 people, 14,365 (61%) provided both measurement and questionnaire data.

Families that were selected for the 1981 CFS served as clusters in the 1988 follow-up sample. All family members age 7 and older in 1988 were included. As regional level estimates were not an objective for the 1988 Campbell's Survey, the 80 geographic clusters were subsampled with a probability proportional to their CFS sample weights. This subsampling of the various clusters assisted in both equalizing the weights in the follow-up survey and in avoiding any inflation in variance of survey estimates caused by the variability in the weights. Approximately one-fifth (4200 individuals) of the 1981 sample were contacted to participate in the follow-up in 1988. The Campbell's Survey is based on 3068 individuals that participated in both surveys. Individuals were traced using telephone listings, city directories, registered mail, records of drivers' licences, and local searches by field personnel.

Instrumentation

The Canadian Standardized Test of Fitness used in both the 1981 Canada Fitness Survey and the 1988 Campbell's Survey, is a comprehensive field test which assesses the main elements of physical fitness: cardiovascular endurance (the step test), flexibility (trunk forward flexion), muscular strength (handgrip), muscular endurance (push-ups and sit-ups), and body size (height, body mass, skinfolds, girths, bone diameters).

The health, fitness, and lifestyle questionnaire was self completed and was used to collect detailed information on: physical activity (including the type, frequency, intensity, and duration), health habits such as diet and smoking, motives, values and obstacles affecting activity patterns. Characteristics of each individual are given including age, gender, marital status, occupation, education, and income. The final 1981 questionnaire appears in Appendix A and the final 1988 questionnaire appears in Appendix B.

The health screening of adults in 1981 and 1988 was based on a simple, self-completed 7-item Physical Activity Readiness Questionnaire (PAR-Q) (Chisholm, Collis, Kulak, Davenport & Gruber 1975).

Prior to the administration of the 1981 CFS there was no pilot testing of the questionnaire and the anthropometric and activity measures. Consequently there is no information regarding the intertester reliability of the survey team with respect to the anthropometric instrumentation.

In the 1988 Campbell's Survey, some of the questions were revised and some were added to collect more detail for investigative purposes. A pilot study was conducted on the 1988 questionnaire to ensure comprehension and to obtain estimates of test-retest reliability. Questionnaires were administered twice within an interval of 3 weeks to 200 individuals, using the same procedures of the main survey. A sample of 59 individuals were then selected and debriefed on the comprehension and ease of the questionnaire. Recommendations were made and implemented to increase understanding of the questionnaire. The pilot test showed good levels of test-retest reliability over three weeks for survey data items of major interest with percentage agreement ranging from 73 to 83 and Kramer's phi values ranging from 0.53 to 0.86 (Stephens & Craig, 1990).

Pilot testing was not done prior to testing in 1988 to determine intertester reliability of the survey team with the instruments for testing. However, the reliability of measurements such as height, body mass, skinfolds, and circumferences have been reported for anthropometric protocols similar to that of the 1981 CFS and the 1988 CS using the same instrumentation. For example, the intertester differences for the measurement of height have been reported for large samples in the Fels Longitudinal Study (M=2.3 mm SD=2.4 at 15 to 20 years) (Chumlea & Roche, 1979 cited by Lohman, Roche & Martonell, 1988). The intertester differences were also reported for the weights of adults (M=1.5 g SD=3.6 g) (Chumlea & Roche, 1979 cited by Lohman et al., 1988). Circumference measures have been reported to have an intratester technical error of 0.1 to 0.4 mm and an intermeasurer error of 0.3 mm (Brown, 1984 cited by Lohman et al., 1988). With respect to skinfolds, intermeasurer correlations are generally above 0.9 for most skinfold sites, however the standard error of the mean (SEM) may be 3 to 4 mm with inexperienced measurers or when the sites have not been standardized (Lohman, Pollock, Slaughter, Brandon & Boileau 1984, cited by Lohman et al., 1988). The survey teams "checked" the scales and tape measurers regularly against known weights and lengths respectively to achieve greater reliability of the instrument.

Many equations and methods for estimating percent body fat have proliferated, and not one of the methods has ever been validated in humans (Martin & Drinkwater, 1991). Validation of a method requires a comparison of percentage fat, estimated by that method (skinfolds), with the true value. The inability to validate the methods of fat estimation means that it is impossible to assess the accuracy of fat estimates. Usually two indirect methods are compared with each other, however this does not constitute validation. Furthermore, several underlying assumptions are associated with these indirect methods of percent body fat estimates (Martin & Drinkwater, 1991).

The WHR is regarded as a valid index of fat patterning due to its ability to predict abdominal visceral fat mass as well as the susceptibility to health complications. Regional fat distribution assessed by the WHR correlates highly with computed tomography (Kissebah, 1989).

The following modifications were made to the test battery in 1988:

-height was modified to a two-person procedure based on gentle traction.

-the aerobic test was modified by implementing a Sport Tester 3000 (to obtain heart rate readings during exercise instead of a stethoscope used for measuring the post-exercise heart rate).

The body composition of each individual participating in the 1981 CFS and 1988 CS was assessed by measuring height, body mass, skinfolds, and girths. Height was measured by a metric carpenter's tape and set square and body mass was measured using a platform scale (Seca 'Accuweigh'). Skinfolds were assessed using Harpenden calipers with a pressure of 10 g/mm^2 over a face area of 35 mm^2. Girths were taken with a steel anthropometric tape.

Survey Procedures

Anthropometric Protocol

The survey team usually was comprised of one individual of each gender, in order to maximize the cooperation of both male and female subjects. The procedures for the anthropometric measures of the Standardized Test of Fitness were based on the Durnin & Womersley (1974) approach to estimating body fatness from skinfolds. These procedures consisted of biceps, triceps, subscapular, and suprailiac sites, and for the CS, the medial calf skinfold was added. Height and body mass were also measured or estimated if necessary. The diameter of the humerus and femur, and girth of the upper arm, thigh, and calf were added to the original anthropometric battery of chest, abdomen, and hip girth for the CFS in 1981. Bone breadths were not included in the 1988 CS.

Site selection, instrument placement, and readings were exercised with care. Every measurement was taken by one tester with the site locations verified by the second. The measurements were read out loud, repeated by the second tester, and recorded. The skinfold measurements were taken twice and recorded, with a third measurement taken if the difference between the first two measurements was greater than 4 millimeters, and the mean of the two closest measurements was used as the datum. The anthropometric procedures are described in greater detail in Table 3 (Stephens & Craig, 1985).

Activity Measurement

The section of the questionnaire (1981 and 1988) regarding physical recreation activity contains information on the type, frequency, intensity and duration of a number of physical activities undertaken over a typical day and typical week. Subjects were asked to include only items performed regularly during the preceding year. For the purposes of analyzing intensity and calculating daily energy expenditures, attention was directed to the previous month in 1981 and the previous 3 months in 1988. This period of time was considered adequate to ensure a training response as well as accurate recall of information by the subject (Shepard, 1986).

Table 3-1. Anthropometric Procedures

Parameter	Tolerance	Remarks
Body mass	0.1 kg	Light clothing, no shoes
Height (standing)	0.1 cm	Stretch with gentle traction
Triceps skinfold	0.2 mm	Midpoint, right side, arm relaxed after site location
Subscapular skinfold	0.2 mm	Lateral to inferior angle of right scapula .
Biceps skinfold	0.2 mm	Same landmark as for triceps
Suprailiac skinfold	0.2 mm	Subject holds breath, site 3-5 mm above the crest of the right ilium at midline of the body, fold angles slightly downwards .
Calf skinfold	0.2 mm	Right foot on step, vertical fold on inside of calf just above point of maximum girth
Upper Arm girth	0.1 cm	Arm relaxed, same landmark as for biceps and triceps
Chest girth	0.1 cm	At mesosternale, arms relaxed, at the end of expiration
Waist girth	0.1 cm	At level of noticeable narrowing or at lateral level of 12th or lower floating rib
Hip girth	0.1 cm	At level of greatest gluteal protuberance
Thigh girth	0.1 cm	1 cm below gluteal line, right side
Calf girth	0.1 cm	At maximum girth, right side

The frequency of activities was expressed per month for the past 12 month period. Also indicated was the average time spent per occasion to the nearest minute of any physical recreation activities performed in the participants spare time. Intensity of each activity performed prior to 1981 was rated in terms of the amount of perspiration that occurred as a result of exercising (light, medium, or heavy. In 1988 activity intensity was rated according to the change in heart rate from rest (faster than normal, a lot faster but talking possible, so fast that talking not possible, no change). The energy expenditure (per hour) for a particular activity was calculated by referring to a table of energy costs for the most commonly reported activities and multiplying the average time per occasion by the number of occasions and by the METS value for the activity. The total yearly energy expenditure for all activities was calculated by summing the energy expenditure for each activity that an individual reported. The average daily energy expenditure in hours was calculated for leisure time activities and for all daily activities, including leisure time activities. The level of activity was determined using the total time and total number of months for all reported leisure activities. The level of activity to potentially benefit the individual's cardiovascular health was calculated based on the total yearly energy expenditure in hours for all activities and the average daily energy expenditure in hours for leisure activities. According to these values the individual was then classified as sedentary (if energy expenditure less than 1.5 kcal/kg/day), minimally active (moderate) (if energy expenditure less than 3.0 kcal/kg/day and greater than 1.5 kcal/kg/day), or sufficiently active (active) if energy expenditure greater than 3.0 kcal/kg/day).

Data Entry

After the information was edited and coded it was captured onto computer tape using a system incorporating some simple range and correlation edits, and a 100 percent verification of entries. Data miskeys were identified by extensive editing, as well as possible recording errors. Fields for which a data item was missing were recorded to unknown values for use in data analysis. Some complex variables and indices were calculated for data analysis.

Research Methodology

Subjects

From the sample of 3068 males and females that participated in both the 1981 CFS and the 1988 CS, 323 subjects (males (n=177) and females (n=146)) were sedentary in 1981 and in 1988 were classified as minimally active (moderately active) or sufficiently active (active) in 1988 and completed both the questionnaire and the physical assessment sections of each survey. In addition, all of these subjects were. Specifically, 83 males and 84 females (age 26 and older in 1988) changed their activity level from sedentary to moderately active and 94 males and 62 females (age 26 and older in 1988) changed their activity level from sedentary to active. Subjects that have reported no change in activity level from 1981 to 1988 will also be included in the analyses (sedentary (females n=253 and males n=154), moderately active (females n=51 and males n=31) , active (females n=49 and males n=89)).

Of the subjects that changed from a previously sedentary activity level to a moderate or active level, 70 males had a reported initial

WHR in 1981 greater or equal to 0.90 and 106 males had a reported initial WHR less than 0.90. In 1981, 35 females had a reported WHR greater or equal to 0.80 and 108 females had a WHR less than 0.80.

A Chi Squared analyses was performed in order to determine if the sample of (n=950) to be used in this study was representative of all of those individuals that participated in the 1981 and 1988 surveys (n=4345), in terms of education, sex, income, age, and region.

There was a significant difference in terms of the subjects that participated in both surveys and the subsample of subjects that provided both questionnaire and measurement data in education level, region, income, and age. The subjects in the present study (n=950) were observed to be more highly educated and had on average higher incomes. More subjects in this subsample were from western provinces and there were more middle aged subjects (36-55 years) observed than expected (See Appendix F for Chi Square results).

Instrumentation

1. Apple File Exchange Program (data transformation program)
2. Microsoft Word 3.0
3. Filemaker II Pro (database management program)
4. External Hard Drive
5. Excel 3.0
6. Statview Statistical Package (StatView tm SE + Graphics)

Procedures

Construction of Data Set

1) The raw data was obtained from the Canadian Fitness and Lifestyle Research Institute on 13 - 3 1/2 inch floppy disks formatted in MS-DOS (IBM). These data files were subsequently transformed into Macintosh format using Apple File Exchange (transformation program).

2) The data files were then linked together manually in Microsoft Word 3.0. The data was set up such that individual data records were organized in a consecutive string fashion (both pre and post test scores).

3) The variables of interest were then imported into FileMaker II.Pro (database management program). A frequency distribution analysis was performed on a number of randomly selected variables and then compared to the values specified in the record layout which was provided with the raw data set. The results of this analysis showed that the initial transformation of data and input of data into FileMaker were successful.

4) The data was then exported into a spreadsheet in Microsoft Excel 3.0 for further organization and manipulation. Another frequency distribution analysis was performed. Again, the results showed that the data transfer was a success. Subjects were eliminated if they did not complete the questionnaire or participate in the anthropometry of the survey. Subjects were also eliminated if several key variables were not included such as body mass, height, skinfolds, and circumferences. Subjects were eliminated if they were 25 or younger in 1988. Questionnaire variables were also

utilized to delimit the sample to individuals that indicated that their physical activity regime was not affected for more than one month by any temporary illness or injury. Additional body composition variables were added in columns for each individual, utilizing information provided from reported anthropometric variables. These additional variables included body density, percent body fat, relative changes in body mass, BMI, sum of skinfolds, percent body fat, and WHR. In addition, dummy variables (See Definitions of Terms) were created since nominal variables (activity level, smoking status, and alcohol consumption) were inserted into the regression equation. Since the numbers assigned to categories of a nominal scale are not assumed to have an order and unit of measurement they cannot be treated as "scores" as they would be in conventional regression analysis.

5) Finally, the data was transferred into a statistical analysis program file (StatView SE + Graphics). Once again, a frequency distribution analysis was performed to confirm the success of the data transfer.

Research Design and Statistical Analyses

The proposed research question was formulated retrospectively, in order to interpret some of the results of a major prospective study (1981 CFS and 1988 CS). Consequently the proposed research involves secondary data analyses of longitudinal data. In typical prospective studies, a group or cohort of individuals is followed over a period of years, during which individuals select themselves into various subgroups (ie. level of physical activity) either by choice or by circumstance. Prospective studies are also called follow-up studies, cohort studies, or incidence studies.

Mean relative changes and standard deviations were determined for all of the body composition variables (body mass, BMI, sum of skinfolds, percent body fat, and WHR) according to sex and activity level

Percent body fat was estimated using the Siri equation described by Jackson et al., (1980) (Appendix C). Additionally, skinfold changes were calculated according to relative changes in the sum of skinfolds.

Initially, a multiple regression analysis was utilized to describe and test the relationship of each of the dependent variables (relative change in: body mass, BMI, sum of skinfolds, percent body fat, and WHR) in separate analysis with the combination of independent variables which were emphasized in the three major hypotheses: (1) sex (2) initial body fat distribution pattern in (android or gynoid) and (3) activity level (sedentary-sedentary, moderate-moderate, active-active, sedentary-moderate, sedentary-active). Additionally, other explanatory variables were included such as dummy variables created for smoking and alcohol consumption categories, age, initial body mass, and initial percent body fat.

The second process included a stepwise multiple regression analyses applied to analyze the relationship of each of the outcome variables in separate analysis (relative change in: body mass, BMI, percent body fat, and WHR) and a considerable number of potential explanatory variables (gender, initial fat distribution (android or gynoid), activity level, age, alcohol consumption, smoking, initial body mass, and initial percent body fat).

According to Hassard (1991) stepwise multiple regression is considered a "compact" multiple regression equation built up in a series of steps. Each individual explanatory variable is first separately regressed on the outcome variable. The explanatory variable that can explain the largest proportion of the outcome variation is then selected as the first variable to enter the regression equation. Each remaining explanatory variable (independent variable) then is regressed on the outcome variable jointly with the first variable. The explanatory variable that provides the largest gain in explanatory power (in addition to that explained by the first variable on its own) is then added in as the second variable in the multiple regression equation. In the third step, each remaining variable is tried in combination with these two selected variables to see which provides the maximum gain in variation explained (maximum explanatory power after controlling for the variables already selected) and so on. Hassard (1991) explains that the maximum gain in variation explained at each step, is tested against the variation still unexplained at that stage, as stated previously. When this gain is not significantly greater than pure random variation, the stepwise selection process is terminated. The resulting regression equation is the most compact and incorporates all real explanatory relationships.

CHAPTER 4

RESULTS

Introduction

The results of the investigation of the effect of physical activity on the changes in body fat distribution of men and women are presented under the following headings.

1. **Physical Characteristics of the Subjects.** Mean values and standard deviations for body composition variables measured in 1981, 1988, and for the relative changes of these measurements are presented in separate tables for males and females, dependent on their level of activity (tables 4-1 - 4-10).

2. **Checking For Problems Associated With Regression Research.** The following three areas will be addressed concerning problems involved with regression analysis.

i) Multicollinearity, refers to the correlation of some of the regressors (table 4-11).

ii) Autocorrelation, refers to the correlation of the error terms for different observations.

iii) Heteroskedasticity, refers to the lack of equality in the degrees of dispersion in the error term due to changes inherent in cross-sectional data (figures 4-1 - 4-5).

3. **Multiple and Stepwise Regression Analyses.** All sixteen independent variables were entered into a multiple regression analysis and a stepwise regression analysis to determine the variables that have a significant effect on the relative change of each of the dependent variables. Initial anthropometric measurements (body mass, percent body fat, WHR), age, and dummy variables created for alcohol and

smoking status, activity level, and sex were entered as predictor variables of the relative changes in each of the dependent variables. The results of each multiple and stepwise regression analysis are presented for each of the dependent variables (relative change in body mass (table 4-12 and 4-13), percent body fat (table 4-14 and 4-15), sum of skinfolds (table 4-16 and 4-17), body mass index (table 4-18 and 4-19), and WHR (table 4-20 and 4-21)).

1. Physical Characteristics of the Subjects

Table 4-1 Physical Characteristics of Female Subjects
Activity Level : Sedentary 1981 and Sedentary 1988 (n=253)

Variable	Mean 1981	S.D.	Mean 1988	S.D.	Mean Relative Change	S.D.
Age			44.35	11.31		
Mass (kg)	60.80	11.00	64.41	12.25	+0.063	0.101
Sum of Skinfolds (mm)	77.68	27.86	88.69	29.65	+0.193	0.312
Percent Body Fat	28.45	5.69	30.62	5.46	+0.096	0.160
BMI	23.54	4.15	25.07	4.87	+0.066	0.102
WHR	0.769	0.067	0.776	0.064	+0.012	0.061

Table 4-2 Physical Characteristics of Female Subjects
Activity Level : Moderate 1981 and Moderate 1988(n=51)

Variable	Mean 1981	S.D.	Mean 1988	S.D.	Mean Relative Change	S.D.
Age			42.25	11.12		
Mass (kg)	62.29	11.74	65.25	13.76	+0.047	0.073
Sum of Skinfolds (mm)	72.72	29.18	80.83	27.39	+0.150	0.260
Percent Body Fat	27.53	5.53	29.04	5.31	+0.071	0.146
BMI	23.33	3.91	24.47	4.81	+0.047	0.074
WHR	0.749	0.057	0.754	0.055	+0.006	0.050

Table 4-3 Physical Characteristics of Female Subjects
Activity Level : Active 1981 and Active 1988 (n=49)

Variable	Mean 1981	S.D.	Mean 1988	S.D.	Mean Relative Change	S.D.
Age			42.14	12.50		
Mass (kg)	62.22	8.97	65.31	8.44	+0.054	0.080
Sum of Skinfolds (mm)	67.42	26.51	79.02	25.49	+0.219	0.319
Percent Body Fat	26.34	5.24	28.89	5.17	+0.110	0.158
BMI	22.92	3.23	24.14	3.19	+0.057	0.085
WHR	0.734	0.051	0.747	0.058	+0.018	0.057

Table 4-4 Physical Characteristics of Female Subjects
Activity Level : Sedentary 1981 and Moderate 1988 (n=84)

Variable	Mean 1981	S.D.	Mean 1988	S.D.	Mean Relative Change	S.D.
Age			45.31	11.54		
Mass (kg)	60.81	10.53	64.80	11.48	+0.067	0.073
Sum of Skinfolds (mm)	71.10	24.84	83.35	25.60	+0.232	0.273
Percent Body Fat	27.30	5.19	29.88	4.78	+0.113	0.138
BMI	22.81	4.06	24.91	4.25	+0.070	0.077
WHR	0.768	0.060	0.771	0.060	+0.005	0.060

Table 4-5 Physical Characteristics of Female Subjects
Activity Level : Sedentary 1981 and Active 1988 (n=62)

Variable	Mean 1981	S.D.	Mean 1988	S.D.	Mean Relative Change	S.D.
Age			44.52	11.10		
Mass (kg)	59.72	8.79	62.37	10.51	+0.046	0.100
Sum of Skinfolds (mm)	70.06	22.37	79.46	29.41	+0.162	0.295
Percent Body Fat	27.10	4.96	28.93	5.76	+0.075	0.165
BMI	22.64	3.26	23.81	3.79	+0.053	0.098
WHR	0.757	0.059	0.766	0.063	+0.011	0.069

Physical Characteristics of the Female Subjects

Tables 4-1 through 4-5 present the physical characteristics of the females for each of the activity categories. There was a diverse range in age 26-75 years with a mean age of 43.54 years. Sum of skinfolds indicates the sum of the triceps, biceps, suprailiac, and subscapular skinfolds. Percent body fat was derived for each subject using these skinfold values (Jackson et al., 1980).

The mean body mass for the females in 1981 was 61.17 kg and in 1988 the mean was 64.43 kg with a mean increase in body mass of 5.5 percent (+0.055). Females indicating an increase in activity level from a sedentary in an active level showed the least mean relative change in body mass with a 4.6 percent increase, and a S.D. of 0.1. All other groups showed mean relative increases in body mass ranging from 4.7-6.7 percent, with no specific trend with respect to activity level.

The mean Body Mass Index (BMI) in 1981 was 23.05 and in 1988 was 24.48, with a mean relative change of a 5.9 percent increase. The range of relative increase in BMI was 4.7-7.0 percent with no trend according to activity level.

The mean sum of skinfolds for the females in 1981 was 71.80 millimeters (mm) and in 1988 the mean was 82.27 mm with a mean relative increase of 19.12 percent. The range of the mean relative increases (15.0-23.2) of the females showed no specific trend according to activity level.

The mean percent body fat of the females in 1981 was 27.34 and in 1988 was 29.47, and the mean relative change was an increase of 9.30 percent. The range of relative increase in percent body fat was

7.1-11.3 percent, with no specific trend according to activity level.

The mean waist-to-hip ratio for the females was 0.75 in 1981 and in 1988 the mean was 0.76, with a very small mean relative increase of 1.0 percent ranging from 0.5 to 1.8 percent increases.

Tables 4-6-4-10 illustrate the physical characteristics of the male subjects.

Table 4-6 Physical Characteristics of Male Subjects
Activity Level : Sedentary 1981 and Sedentary 1988 (n=154)

Variable	Mean 1981	S.D.	Mean 1988	S.D.	Mean Relative Change	S.D.
Age			43.81	11.03		
Mass (kg)	75.76	12.47	79.06	12.71	+0.046	0.072
Sum of Skinfolds (mm)	57.43	22.07	64.72	22.07	+0.181	0.329
Percent Body Fat	17.55	4.70	19.35	4.39	+0.137	0.251
BMI	24.99	3.50	26.04	3.63	+0.047	0.070
WHR	0.889	0.086	0.903	0.060	+0.019	0.066

Table 4-7 Physical Characteristics of Male Subjects
Activity Level : Moderate 1981 and Moderate 1988 (n=31)

Variable	Mean 1981	S.D.	Mean 1988	S.D.	Mean Relative Change	S.D.
Age			41.00	10.76		
Mass (kg)	76.48	9.88	81.44	10.70	+0.067	0.070
Sum of Skinfolds (mm)	57.88	19.25	69.15	19.31	+0.260	0.373
Percent Body Fat	17.81	4.36	20.12	3.80	+0.171	0.267
BMI	24.20	2.65	25.78	2.95	+0.066	0.060
WHR	0.868	0.044	0.892	0.048	+0.029	0.043

Table 4-8 Physical Characteristics of Male Subjects
Activity Level : Active 1981 and Active 1988 (n=89)

Variable	Mean 1981	S.D.	Mean 1988	S.D.	Mean Relative Change	S.D.
Age			42.63	13.30		
Mass (kg)	77.12	11.65	80.51	10.76	+0.048	0.071
Sum of Skinfolds (mm)	49.39	19.15	58.17	20.74	+0.231	0.396
Percent Body Fat	15.75	4.50	18.06	4.40	+0.187	0.326
BMI	24.84	9.27	25.44	3.19	+0.045	0.108
WHR	0.865	0.057	0.880	0.062	+0.014	0.045

Table 4-9 Physical Characteristics of Male Subjects
Activity Level : Sedentary 1981 and Moderate 1988 (n=83)

Variable	Mean 1981	S.D.	Mean 1988	S.D.	Mean Relative Change	S.D.
Age			44.51	10.80		
Mass (kg)	74.43	10.75	77.30	10.99	+0.041	0.059
Sum of Skinfolds (mm)	55.41	18.19	63.67	22.29	+0.172	0.285
Percent Body Fat	17.48	4.21	19.14	4.26	+0.117	0.213
BMI	24.50	3.19	25.60	3.32	+0.047	0.062
WHR	0.889	0.056	0.906	0.059	+0.020	0.044

Table 4-10 Physical Characteristics of Male Subjects
Activity Level : Sedentary 1981 and Active 1988 (n=94)

Variable	Mean 1981	S.D.	Mean 1988	S.D.	Mean Relative Change	S.D.
Age			45.51	11.24		
Mass (kg)	76.20	11.94	80.01	12.77	+0.052	0.073
Sum of Skinfolds (mm)	53.44	19.98	62.71	22.05	+0.233	0.339
Percent Body Fat	16.81	4.95	18.94	4.62	+0.187	0.290
BMI	24.78	3.47	26.16	3.74	+0.057	0.078
WHR	0.884	0.055	0.895	0.056	+0.015	0.041

Physical Characteristics of the Male Subjects

The mean body mass for the males in 1981 was 76.00 kilograms (kg) and in 1988 the mean body mass was 79.66 kg. The mean relative change in body mass was an increase of 5.0 percent with a range of 4.1-6.7 percent increase with no trend according to activity level.

The mean BMI for the males in 1981 was 24.66 and in 1988 was 25.80. The mean relative change was an increase of 5.2 percent ranging from 4.5-6.6 percent for the activity categories.

The mean sum of skinfolds fro the males in 1981 was 54.71 mm and in 1988 was 63.68, with a mean relative increase of 21.55 percent. Again, changes in sum of skinfolds for each activity group were similar with no apparent trends according to activity level.

The mean percent body fat for the males in 1981 was 17.08 percent and in 1988 the mean was 19.12, with a 15.98 percent mean increase for all activity groups.

The mean WHR for the males in 1981 was 0.88 and in 1988 was 0.90, and the mean relative increase was 1.9 percent, with a range of 1.4-2.9 percent for the activity categories.

2. **Checking For Problems Associated With Regression Research**

i) Multicollinearity

Multicollinearity refers to a high degree of correlation between some of the regressors and can be detected if a simple correlation coefficient of two independent variables is greater than the R value, determined from the regression analysis (Cassidy, 1981). The R values obtained from the five multiple regression analysis ranged from .235 to .546. Hence any simple correlation coefficient greater than .235

would indicate a significant relationship among the variables. Table 4.11 illustrates a correlation matrix of the sixteen independent variables and the five dependent variables. The coefficients in bold type indicate that the two variables are intercorrelated or interrelated. Significant relationships between the variables are highlighted under the following headings: initial body mass, initial percent body fat, initial WHR, relative change in body mass, relative change in Body Mass Index, and relative change in sum of skinfolds.

Correlation of the Independent Variables

Table 4-11

Intercorrelations of the Sixteen Independent Variables and the Five Dependent Variables

	WGT1	% BF1	WHR1	AGE	SEX	A1	A2	A3
WGT1	1							
% BF	.191	1						
WHR1	**.608**	-.066	1					
AGE	.169	.193	.234	1				
SEX	**-.586**	**.448**	**-.678**	-.001	1			
A1	-.008	.085	-.074	-.066	.047	1		
A2	.134	-.027	.005	-.043	-.137	-.128	1	
A3	-.027	-.177	.037	.024	-.030	-.137	-.187	1
A4	.039	-.267	.070	.043	-.100	-.136	-.187	-.200
AL1	.035	-.114	.099	.042	-.148	-.013	.009	.051
AL2	-.085	-.073	-.058	-.171	-.023	.007	-.054	-.027
AL3	.080	.021	.002	-.025	.014	.015	.064	-.027
SM1	.111	.022	.096	.216	-.072	.003	.042	.032
SM2	-.027	.022	.009	.036	.022	-.014	.007	-.036
SM3	-.035	-.089	.088	-.099	-.049	-.027	-.076	.027
SM4	.032	-.076	.044	-.014	-.061	.039	-.006	.001

Correlation of the Independent Variables

Table 4-11 Continued

Intercorrelations of the Sixteen Independent Variables and the Five Dependent Variables

	WGT1	%BF1	WHR1	AGE	SEX	A1	A2	A3
WGTC	.225	.087	.135	.155	-.059	-.002	.004	.010
BMIC	.187	.083	.116	.112	-.061	.014	.005	-.003
SOSC	.206	**.337**	.100	.087	.015	.012	-.038	4.6^{E-5}
WHRC	-.056	-.004	**.279**	-.026	.071	-.001	-.019	-.002
%BFC	**.334**	**.342**	**.238**	.100	-.158	.096	.08	-.232

	A4	AL1	AL2	AL3	SM1	SM2	SM3	SM4
A4	1							
AL1	.034	1						
AL2	.035	-.240	1					
AL3	-.006	-.558	-.259	1				
SM1	.018	.038	-.040	.015	1			
SM2	.047	-.007	-.002	.004	-.090	1		
SM3	-.046	.065	.020	-.003	-.295	-.119	1	
SM4	.037	.003	-.005	.047	-.193	-.078	-.253	1

	A4	AL1	AL2	AL3	SM1	SM2	SM3	SM4
WGTC	.027	.004	-.050	.034	.025	.021	.053	-.110
BMIC	.016	.007	-.036	.022	.020	.018	.058	-.095
SOSC	-.005	-.026	-.048	.026	.006	.017	.050	-.112
WHRC	.016	.055	-.031	-.017	.040	-.001	.008	-.018
%BFC	-.269	-.009	-.049	.050	.030	.003	.047	-.103

Correlation of the Independent Variables

Table 4-11 Continued

Intercorrelations of the Sixteen Independent Variables and the Five Dependent Variables

	WGTC	BMIC	SOSC	WHRC	%BFC
WGTC	1				
BMIC	**.945**	1			
SOSC	**.624**	**.626**	1		
WHRC	**.313**	**.303**	.186	1	
%BFC	**.401**	**.411**	**.711**	.076	1

C-indicates, relative change

A1-A4, AL1-AL3, and SM1-SM4 are the dummy variables created for activity level, alcohol consumption, and smoking status, respectively. (See Definition of Terms, Chapter One).

Initial Body Mass

Initial WHR, sex, and the relative change in percent body fat were highly correlated with initial body mass. Higher initial body masses are generally associated with high waist-to-hip ratios. Males tend to have a higher initial body mass than females. Greater relative changes in percent body fat were associated with higher initial body masses.

Initial Percent Body Fat

Sex, the relative change in sum of skinfolds, and the relative change in percent body fat were highly correlated with initial percent body fat. Females tend to have a higher initial percent body fat than males. Greater relative changes in sum of skinfolds and percent body fat are associated with higher initial percent body fat levels.

Initial WHR

Sex, the relative change in WHR, and the relative change in percent body fat were highly correlated with initial WHR. Males tended to show higher waist-to-hip ratios than females. There also was a slight association of greater relative changes in WHR and percent body fat with higher initial WHRs.

Relative Change in Body Mass

The relative changes in BMI, sum of skinfolds, WHR, and percent body fat were correlated with relative changes in body mass. Substantial changes (increase or decrease) in BMI, sum of skinfolds, WHR, and percent body fat are reflected in large changes (increase or decrease) in body mass.

Relative Change in BMI

The relative changes in sum of skinfolds, WHR, and percent body fat are correlated with the relative changes in BMI. Increases or decreases in sum of skinfolds, WHR, and percent body fat are associated with respective increases or decreases in BMI.

Relative Change in Sum of Skinfolds

The relative change in percent body fat is highly correlated with the relative change in sum of skinfolds. Significant changes (increase or decrease) in percent body fat are reflected by significant changes (increase or decrease) in sum of skinfolds.

We are presented with the problem of multicollinearity in that some of the independent variables are interrelated. As stated previously, initial body mass is highly related to initial WHR. In addition, sex is also associated with certain body composition characteristics. Males tend to have higher initial body masses and WHRs, and less body fat than females. Cassidy (1981) suggested that eliminating a regressor is sometimes useful, however in doing this, a certain amount of bias is introduced.

ii) Autocorrelation

Autocorrelation is described as a problem with time series data, and it occurs when the error term of time (t) is correlated with the error term of time plus one (t+1)(the error terms for different observations are correlated) (Cassidy, 1981). The systematic correlation of error terms violates a major assumption of regression research in that a shock or extreme value in another time affecting the error term for time (t) when such a shock should not affect the error terms of subsequent time periods (Cassidy, 1981). Such a shock could occur for example if 1981 was a year when participaction was highly promoted, thus affecting the data of this time period. The Durbin-Watson (DW) statistic is a test used to determine the extent of autocorrelation. Cassidy (1981) states that a DW of approximately two indicates that the data are sound and that autocorrelation was not a problem. The Durbin-Watson statistics are presented in tables 4-12 - 4-21 for each multiple and stepwise regression model. The DW statistics ranged from 1.86 to 2.14, indicating that autocorrelation was not a problem in this investigation.

iii) Heteroskedasticity

Heteroskedasticity refers to a lack of equality in the degrees of dispersion in the error term due to changes inherent in cross-sectional data (the variance of the error term is not constant for all observations). Heteroskedasticity can be detected by examining the spread or contraction of the residuals plotted against the independent variables. A non-random dispersion indicates that heteroskedasticity was a problem. The following graphs (Figures 4-1 - 4-5) of the residuals versus the independent variable, age, for each of the five multiple regression analysis demonstrates random dispersion, and therefore heteroskedasticity was not a confounding factor in this study.

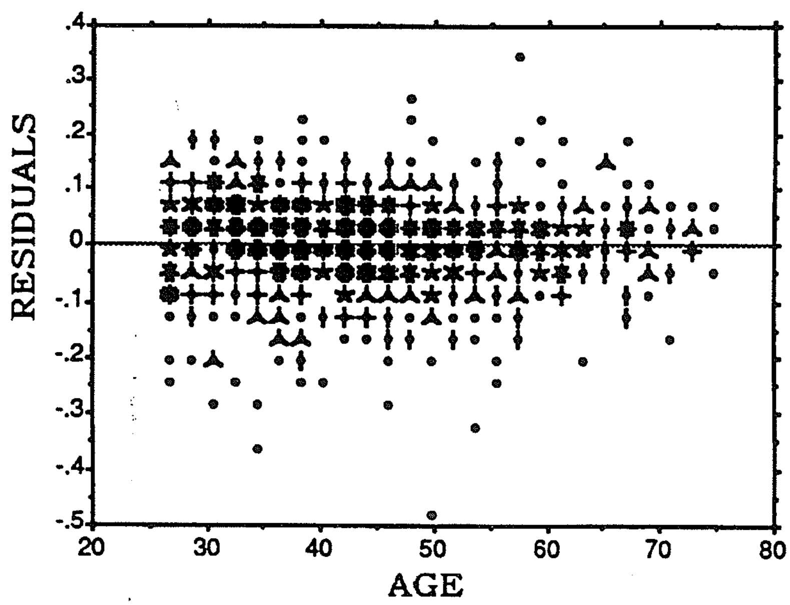

Figure 4-1 Residuals Versus The Regressor Age, From the Multiple Regression Analysis of the Dependent Variable: Relative Change in Body Mass

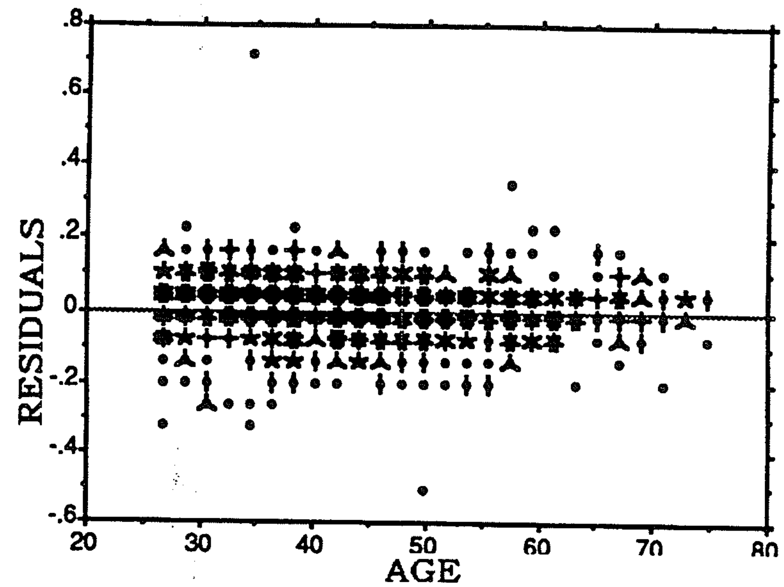

Figure 4-2 Residuals Versus The Regressor, Age, From The Multiple Regression Analysis of the Dependent Variable: Relative Change In BMI

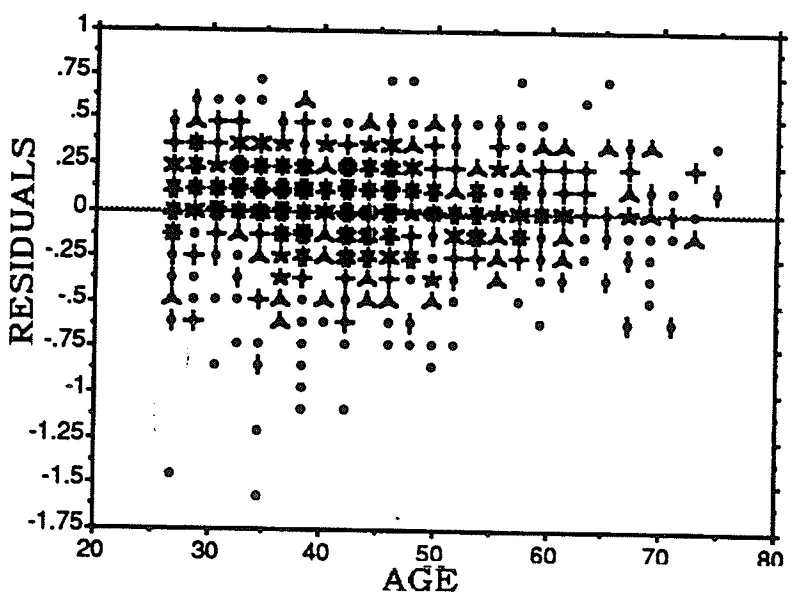

Figure 4-3 Residuals Versus the Regressor, Age From the Multiple Regression Analysis of the Dependent Variable: Relative Change in Sum of Skinfolds

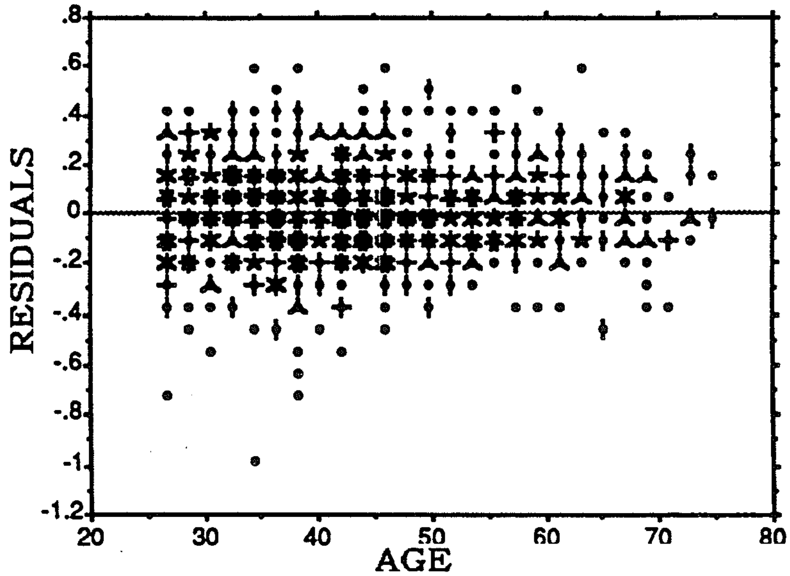

Figure 4-4 Residuals Versus the Regressor Age, From the Multiple Regression Analysis of the Dependent Variable: Relative Change In Percent Body Fat

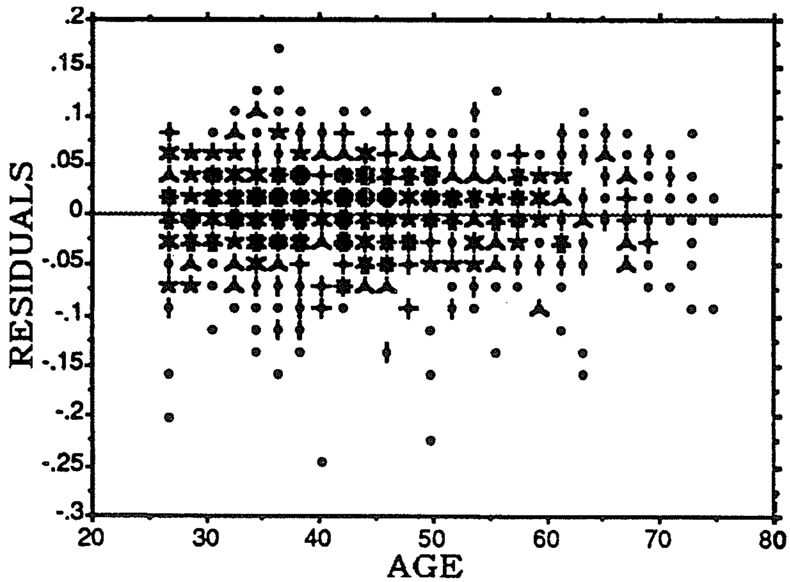

Figure 4-5 Residuals Versus the Regressor, Age From the Multiple Regression Analysis of the Dependent Variable: Relative Change in Waist-to-Hip Ratio

3. Multiple and Stepwise Regression Analyses

To reiterate, regression analysis is applied in order to explain the changes in the dependent variable, as a function of the movements in a set of variables called the predictors or independent variables.

Multiple and stepwise regression analysis were utilized to describe the relation of each of the dependent variables (relative change in; body mass, body mass index, sum of skinfolds, percent body fat, and WHR) in separate analysis with the combination of independent variables which include activity level, sex, age initial body fat distribution (WHR), initial body mass, initial percent body fat, alcohol consumption, and smoking status. The following section is an illustration and report of the results of each of the regression analysis.

Results of the Estimated Multiple Regression Model of the Outcome Variable: Relative Change in Body Mass

The coefficient of determination, R^2, is simply the ratio of the explained portion to the total sum of squares. The R^2 computed in this analysis was .082 which reveals a poor overall fit of the estimated regression equation.

The R^2 is a heuristic measure of the overall degree of fit, whereas the F ratio is a modified statistical test of the overall degree of fit of the estimated equation. Based on the F-ratio, the estimated equation can be accepted or rejected, based on its ability to explain the total sum of squares. The F-ratio is the ratio of the explained to the unexplained portions of the total sum of squares, adjusted for the number of regressors and the number of observations. The F-ratio of this analysis was 5.076 ($p < .0001$), therefore declaring the overall fit of the equation to be statistically significant.

Analysis of the Independent Variables

The multiple Regression technique was used to determine those variables that assist in explaining the changes that occur in the body composition measurement of body mass (relative change).

Sex

The dummy variable, sex, in this regression analysis revealed a beta coefficient of -.022 and was significant at the $p<.043$ level. This result indicated that for females, the relative change in body mass, holding all other variables constant, was 2.2 percent less than for males.

Activity Level

Dummy variables were created to represent the activity level categories. Activity level did not show any significant effect on the relative change in body mass from 1981 to 1988.

Alcohol Consumption

Dummy variables were also created to represent the alcohol consumption categories. In this analysis, alcohol consumption did not have any significant effect on the relative change in body mass of the subjects, holding all other variables constant.

Smoking Status

Dummy variables were created for each of the smoking categories. In this analysis, smokers that quit after 1981 were indicated to experience a 2.8 percent greater increase in body mass. The beta coefficient was .028 and was significant at the $p<.0009$ level.

Age

Age, was indicated to be a significant factor in the relative change in body mass, with a beta coefficient of -.001 ($p < .0003$). This indicated that the older a person was in 1981, the relative change in body mass over the period of years would be a smaller increase than for a younger person over this time period. A person, one year older in 1981, would experience a .1 percent smaller relative increase in body mass than a person one year younger.

Initial Body Mass

Initial body mass was indicated as a significant predictor of the relative change in body mass. the beta coefficient was found to be -.002 and was significant at the $p < .0001$ level. The heavier a person was in 1981, the less the relative increase in body mass over the seven years. A person with a one kilogram greater mass would experience a .2 percent smaller relative increase in body mass.

Initial Percent Body Fat

The body composition measurement of initial percent body fat was not a significant predictor of the relative change in body mass.

Initial WHR

The body composition measurement of initial WHR was not a significant predictor of the relative change in body mass.

Table 4-12 The Multiple Regression and Analysis of Variance Results of the Independent Variables on the Dependent Variable: Relative Change in Body Mass.

Degrees of Freedom	Durbin Watson	R and R^2
920	1.97	.287 .082

Analysis of Variance

Source	D of F	Sum Squares	F-test
Regression	16	.523	5.076
Residual	904	5.822	p<.0001
Total	920	6.345	

Beta Coefficients

Variable	B Coefficient	t Value	Probability
Intercept	.233		
Sex	-.022	2.027	.043
A1	-.004	.368	.713
A2	-.003	.399	.690
A3	-.002	.252	.801
A4	-.003	.360	.719
AL1	-.007	.860	.390
AL2	-.006	.516	.606
AL3	-.007	.901	.368
SM1	.005	.609	.542
SM2	-.006	.416	.678
SM3	-.008	1.096	.273
SM4	.028	3.324	.0009
Age	-.001	3.620	.0003
Body Mass1	-.002	4.766	.001
% Body Fat1	.001	1.066	.287
WHR1	-.037	.783	.434

Results of the Estimated Stepwise Regression Model of the Outcome Variable: Relative Change in Body Mass

Table 4-13 illustrates the stepwise regression to predict or account for the relative change in body mass with the independent variables. This analysis was done to identify which variables influenced the relative change in body mass in this study sample and to determine the extent of the effect. The most moderate solution with the smallest number of independent variables is computed using stepwise regression. As each variable was entered into the equation the procedure selected as the next variable, the one with the highest partial correlation with the dependent variable. The correlation between the independent and dependent variable is the partial correlation, with the effects of the other independent variables partiality out.

The first step identified the initial body mass as the single best predictor of the relative change in body mass in this sample, explaining only 4.3 percent of the variation. The second variable indicated was age, accounting for an additional 1.5 percent of the variation. Subjects indicating that they quit smoking after 1981, were indicated as a predictor of the relative change in body mass, accounting for an additional 1.6 percent of the variation. Overall these variables only account for 7.4 percent of the variation in the dependent variable. Sex was not indicated in the compact regression equation as a significant predictor of the relative change in body mass.

In the stepwise regression model of the outcome variable, relative change in body mass, 7.4 percent of the total explained variance was less than the total explained variance of 8.2 percent from the direct entry (multiple regression) model. This occurs because stepwise regression identifies the major influences on the outcome variable. The stepwise process terminates when the gain in variation explained is not significantly greater than pure random variation. Consequently, the resulting regression equation is the most compact, incorporating all real explanatory relationships.

Summary

Based on the results of this study, initial body mass, age, and smokers who eventually quit had the most significant effect on the body composition measurement; relative change in body mass.

Table 4-13 The Stepwise Regression Results of the Sixteen Independent Variables on the Dependent Variable: Relative Change in Body Mass.

Durbin Watson
2.01

Step No. 1 Variable Entered: Initial Body Mass (kg)

R	R-Squared	Adj. R-Sq.	RMS Res.	F-test
.207	.043	.042	.081	40.951

Step No.2 Variable Entered: Age

R	R-Squared	Adj. R-Sq.	RMS Res.	F-test
.242	.058	.056	.081	28.487

Step No.3 Variable Entered: Smoking Status-Quit After 1981

R	R-Squared	Adj. R-Sq.	RMS Res.	F-test
.271	.074	.071	.080	24.278

Variables In Equation

Variable	Coefficient	Std. Error	Std. Coeffic.	F to Remove
Intercept	.172			
SM4	.029	.007	.123	14.993
Age	-.001	2.348E-4	-.126	15.197
Body Mass1	-.001	2.054E-4	-.188	33.999

Results of the Estimated Multiple Regression Model of the Outcome Variable: Relative Change in Body Mass Index

The computed R^2, coefficient of determination, for this analysis was .055, indicating a poor overall fit of the estimated regression equation. Only 5.5 percent of the total variation in the dependent variable has been successfully explained by the regression.

The F-ratio of 3.281 ($p<.0001$) indicates that the overall fit of the equation, however, is statistically significant.

Analysis of the Independent Variables

The independent variables: sex,activity level, alcohol consumption, initial percent body fat, and initial WHR were not significant predictors of the relative change in BMI. The following is an explanation of those independent variables that were significant predictors of the relative change in BMI.

Smoking Status

Subjects who were smokers in 1981 and quit after 1981, were indicated as a significant predictor of the relative change in BMI. In this analysis, thc dummy variable created for this smoking category indicated a beta coefficient of .024 and was significant at the $p<.006$ level. Subjects that quit smoking after 1981 were more likely to experience a 2.4 percent greater increase in BMI, holding all other variables constant.

Age

Age was indicated as a significant factor in the relative change in BMI, with a beta coefficient of -.001 ($p<.012$). This indicated that the older a person was in 1981, the less the relative increase in BMI would be over this seven year period until 1988. An individual, one year older than another person, would experience a .1 percent smaller relative increase in BMI over the seven year period.

Initial Body Mass

Initial body mass was indicated as a significant predictor of the relative change in BMI. The beta coefficient was found to be -.001 and was significant at the $p<.001$ level. This revealed that the heavier a person was initially, there would be a smaller relative increase in BMI experienced over the seven years. An individual with a one kilogram greater mass would experience a 0.1 percent smaller relative increase in BMI.

Table 4-14 The Multiple Regression and Analysis of Variance Results of the Sixteen Independent Variables on the Dependent Variable : Relative Change in Body Mass Index.

Degrees of Freedom	Durbin Watson	R and R^2
913	1.96	.235 .055

Analysis of Variance

Source	D of F	Sum Squares	F-test
Regression	16	.356	3.281
Residual	897	6.078	p<.0001
Total	913	6.434	

Beta Coefficients

Variable	B Coefficient	t Value	Probability
Intercept	.195		
Sex	-.010	.874	.383
A1	-.007	.637	.524
A2	-.003	.388	.698
A3	-.002	.260	.795
A4	-.004	.404	.636
AL1	-.006	.796	.426
AL2	-.005	.440	.660
AL3	-.006	.709	.479
SM1	.003	.328	.743
SM2	-.006	.417	.676
SM3	-.010	1.376	.169
SM4	.024	2.755	.006
Age	-.001	2.512	.0122
Body Mass1	-.001	3.288	.001
% Body Fat1	1.85E-5	.027	.978
WHR1	-.024	.499	.618

Results of the Estimated Stepwise Regression Model of the Outcome Variable: Relative Change in Body Mass Index

Table 4-15 illustrates the stepwise regression to predict and account for the relative change in BMI with the 16 independent variables.

In this analysis the same three independent variables were identified as significant predictors as in the multiple regression analysis. The first step indicated initial body mass as the single best predictor of the relative change in BMI, accounting for only three percent of the variation. Age was selected as the second best predictor with smokers that quit after 1981, identified as the third and final predictor of the relative change in BMI. Only five percent of the total variation was accounted for by these three independent variables.

Summary

Based on the results of this study, it can be concluded that initial body mass, smokers who eventually quit, and age have the most significant effect on the body composition measurement; relative change in body mass.

Table 4-15 The Stepwise Regression Results of the Sixteen Independent Variables on the Dependent Variable: Relative Change in Body Mass Index.

Durbin Watson
2.14

Step No. 1 Variable Entered: Initial Body Mass (kg)

R	R-Squared	Adj. R-Sq.	RMS Res.	F-test
.172	.03	.028	.083	27.773

Step No.2 Variable Entered: Smoking Status-Quit After 1981

R	R-Squared	Adj. R-Sq.	RMS Res.	F-test
.205	.042	.040	.082	20.048

Step No.3 Variable Entered: Age

R	R-Squared	Adj. R-Sq.	RMS Res.	F-test
.223	.050	.047	.082	15.855

Variables In Equation

Variable	Coefficient	Std. Error	Std. Coeffic.	F to Remove
Intercept	.152			
Age	-.001	2.413E-4	-.088	7.197
Smoking	.027	.008	.111	11.776
Body Mass1	-.001	2.104E-4	-.160	23.735

Results of the Estimated Multiple Regression Model of the Outcome Variable: Relative Change in Sum of Skinfolds

The computed R^2, coefficient of determination for this analysis was .181, indicating a modest overall fit of the estimated regression equation. Approximately, 18.1 percent of the total variation in the dependent variable has been successfully explained by the regression.

The F-ratio of 12.228 ($p<.0001$) indicated, however, that the overall fit of the equation was statistically significant.

Analysis of the Independent Variables

The following independent variables: activity levels , alcohol consumption, smoking categories (except those subjects that quit smoking after 1981), initial body mass, and initial WHR, were not indicated as significant predictors of the relative change in sum of skinfolds. The following is an explanation of those independent variables that were significant predictors of the relative change in sum of skinfolds.

Sex

The dummy variable created for sex in this regression analysis indicated a beta coefficient of .282 and was significant at the $p<.0001$ level. This result revealed that for females, the relative change in sum of skinfolds, holding all other variables constant was 28.2 percent greater than for males.

Smoking Status

Subjects who were smokers in 1981 and quit after 1981, were indicated as a significant predictor of the relative change in sum of skinfolds. The dummy variable created for this smoking category indicated a beta coefficient of .064 and was significant at the $p<.038$

level. subjects who quit smoking were more likely to experience a 6.4 percent greater relative increase in sum of skinfolds than all other subjects.

Initial Percent Body Fat

Initial percent body fat was found to be a significant predictor of the relative change in sum of skinfolds, with a beta coefficient of -.027 and was significant at the $p<.0001$ level. Subjects with a higher initial percent body fat experienced a smaller relative increase in the sum of skinfolds from 1981 to 1988. For every one percent increase in initial percent body fat, there was a 2.7 percent smaller relative increase in the sum of skinfolds.

Table 4-16 The Multiple Regression and Analysis of Variance Results of the Sixteen Independent Variables on the Dependent Variable : Relative Change in Sum of Skinfolds

Degrees of Freedom	Durbin Watson	R and R^2
900	1.88	.426 .181

Analysis of Variance

Source	D of F	Sum Squares	F-test
Regression	16	16.752	12.228
Residual	884	75.688	p<.0001
Total	900	92.440	

Beta Coefficients

Variable	B Coefficient	t Value	Probability
Intercept	.610		
Sex	.282	5.252	.0001
A1	-.005	.139	.889
A2	-.020	.630	.529
A3	-.014	.500	.617
A4	-.030	1.054	.292
AL1	-3.510E-4	.012	.990
AL2	.018	.446	.656
AL3	-.009	.329	.742
SM1	.008	.268	.788
SM2	-.006	.101	.919
SM3	-.047	1.851	.064
SM4	.064	2.079	.038
Age	2.637E-4	.278	.781
Body Mass1	8.268E-5	.064	.949
% Body Fat1	-.027	9.723	.0001
WHR1	.060	.345	.730

Results of the Estimated Stepwise Regression Model of the Outcome Variable: Relative Change in Sum of Skinfolds

Table 4-17 illustrates the stepwise regression to predict and account for the relative change in sum of skinfolds with the 16 predictor variables.

In this analysis four variables were identified as significant predictors of the relative change in sum of skinfolds. The first step indicated initial percent body fat as the single best predictor, accounting for 8.7 percent of the relative change in sum of skinfolds variance. The correlation between the fitted relative change in sum of skinfolds, predicted from initial percent body fat, and the observed relative change in sum of skinfolds was .294. The second step identified sex as the best predictor to be used with the relative change in sum of skinfolds to define a two variable multiple regression equation. The multiple correlation between the observed dependent variable and the fitted scores was .410. The fitted scores were determined, predicted using initial percent body fat and sex as the independent variables in the multiple regression equation. The proportion of the relative change in sum of skinfolds variance that can be predicted by this new two variable multiple regression equation is .168 or 16.8 percent. The third and fourth steps indicated smoking levels ((SM4) quit after 1981 and (SM3) continue to smoke 1981 through 1988) as significant predictors of the relative change in sum of skinfolds. The multiple correlation between the observed and the fitted scores is .423, predicted from the all six independent variables. The proportion of variance that was predicted from this six variable multiple regression equation was .179 or 17.9 percent.

Summary

Based on the results of this study, it can be concluded that initial percent body fat, sex, smokers who quit after 1981, and current smokers (1981-1988), have the most significant effect on the body composition measurement; relative change in sum of skinfolds.

4-17 The Stepwise Regression Results of the Sixteen Independent Variables on the Dependent Variable: Relative Change in Sum of Skinfolds.

Durbin Watson
1.91

Step No. 1 Variable Entered: Initial Percent Body Fat

R	R-Squared	Adj. R-Sq.	RMS Res.	F-test
.294	.087	.086	.306	85.326

Step No.2 Variable Entered: Sex

R	R-Squared	Adj. R-Sq.	RMS Res.	F-test
.410	.168	.166	.293	90.690

Step No.3 Variable Entered: Smoking: (SM4) Quit After 1981

R	R-Squared	Adj. R-Sq.	RMS Res.	F-test
.419	.175	.172	.292	63.530

Step No.4 Variable Entered: Smoking: (SM3) Smoker1981-1988

R	R-Squared	Adj. R-Sq.	RMS Res.	F-test
.423	.179	.175	.291	48.880

Variables In Equation

Variable	Coefficient	Std. Error	Std. Coeffic.	F to Remove
Intercept	.654			
Initial %BFat	-.026	.002	-.601	183.629
Sex	.269	.028	.420	90.534
SM4	.062	.029	.068	4.682
SM3	-.047	.023	-.065	4.234

Results of the Estimated Multiple Regression Model For the Outcome Variable: Relative Change in Percent Body Fat

The computed R^2, coefficient of determination for this analysis was 0.278, indicating a satisfactory overall fit of the estimated regression equation. Only 27.8 percent of the total variation in the dependent variable was successfully explained by the regression.

The F-ratio of 21.259 indicated the overall fit to be statistically significant at the $p<.0001$ level.

Analysis of the Independent Variables

The independent variables of activity levels, alcohol consumption, and all of the smoking categories except for those who quit smoking after 1981, age, initial body mass, and initial WHR were not considered to be significant predictors of the relative change in percent body fat. The following, explains those independent variables that were significant predictor variables.

Sex

The independent variable, sex, revealed a beta coefficient of .194 and was significant at the $p<.0001$ level. This result indicated that for females, the relative change in percent body fat, holding all other variables constant, was 19.4 percent greater than for males.

Smoking Status

Subjects who were smokers in 1981 an quit after 1981, were predictors of the relative change in percent body fat. The dummy variable created for this smoking category indicated a beta coefficient of .054 ($p<.0078$). Subjects that quit smoking after 1981 were more likely to experience a 5.4 percent greater relative increase in percent body fat than other subjects, holding all other variables constant.

Initial Percent Body Fat

Initial percent body fat, was found to be a significant predictor of the relative change in percent body fat, with a beta coefficient of -.023 ($p<0.0001$). Subjects with a higher initial percent body fat experienced less of a relative increase in percent body fat from 1981 to 1988. For every one percent increase in initial percent body fat, there was a 2.3 percent smaller relative increase.

Table 4-18 The Multiple Regression and Analysis of Variance Results of the Sixteen Independent Variables on the Dependent Variable : Relative Change in Percent Body Fat

Degrees of Freedom	Durbin Watson	R and R^2
900	1.90	.527 .278

Analysis of Variance

Source	D of F	Sum Squares	F-test
Regression	16	12.251	21.259
Residual	884	31.839	p<.0001
Total	900	44.090	

Beta Coefficients

Variable	B Coefficient	t Value	Probability
Intercept	.489		
Sex	.194	5.637	.0001
A1	-.014	.565	.572
A2	-.011	.572	.567
A3	-.017	.939	.348
A4	-.011	.584	.559
AL1	-.018	.923	.356
AL2	.016	.633	.527
AL3	-.021	1.118	.263
SM1	-.008	.441	.659
SM2	-.027	.751	.453
SM3	-.031	1.895	.058
SM4	.054	2.665	.008
Age	1.833E-5	.030	.976
Body Mass1	.001	.887	.376
% Body Fat1	-.023	12.820	.0001
WHR1	.024	.209	.834

Results of the Estimated Stepwise Regression Model of the Outcome Variable: Relative Change in Percent Body Fat

Table 4-19 illustrates the stepwise regression to predict and account for the relative change in percent body fat with the 16 predictor variables.

In this analysis three variables were identified as significant predictors. The first step identified initial percent body fat as the single best predictor of the relative change in percent body fat, accounting for 19 percent of the variance. The correlation between the fitted and observed values, predicted from initial percent body fat was .435. The second step identified sex as the best predictor, with a multiple correlation between the observed dependent and fitted scores was .509. the fitted scores were determined, predicted using initial percent body fat and sex as the independent variables in the multiple regression equation. The proportion of the relative change in percent body fat that could be predicted by this new two variable multiple regression equation was .259 or 25.9 percent. Smokers that smoked from 1981 to 1988 were indicated in the final step respectively, as a significant factor in predicting the relative change in percent body fat. The final multiple correlation coefficient was .520 and 27.0 percent of the variation was accounted for, using the three independent variables.

Summary

Based on the results of this study, it can be concluded that initial percent body fat, sex, and smokers have a significant effect on the body composition measurement; the relative change in percent body fat.

Table 4-19 The Stepwise Regression Results of the Sixteen Independent Variables on the Dependent Variable: Relative Change in Percent Body Fat

Durbin Watson
1.93

Step No. 1 Variable Entered: Initial Percent Body Fat

R	R-Squared	Adj. R-Sq.	RMS Res.	F-test
.435	.190	.189	.199	210.295

Step No.2 Variable Entered: Sex

R	R-Squared	Adj. R-Sq.	RMS Res.	F-test
.509	.259	.257	.191	156.997

Step No.3 Variable Entered: SM4

R	R-Squared	Adj. R-Sq.	RMS Res.	F-test
.520	.270	.267	.189	110.530

Variables In Equation

Variable	Coefficient	Std. Error	Std. Coeffic.	F to Remove
Intercept	.507			
%BF1	-.021	.001	-.708	290.748
Sex	.171	.018	.385	86.312
SM4	.066	.018	.104	13.297

Results of the Estimated Multiple Regression Model For the Outcome Variable: Relative Change in Waist-to-Hip Ratio

The computed R^2, coefficient of determination for this analysis was 0.305, indicating a satisfactory overall fit of the estimated regression equation. The percentage of the total variation in the dependent variable has been successfully explained by the regression was 30.5 percent.

The F-ratio of 24.693 indicated that the overall fit of the equation to be statistically significant at the $p<.0001$ level.

Analysis of the Independent Variables

The independent variables that were not considered to be significant predictors of the relative change in WHR were all of the activity levels, initial body mass, all of the alcohol consumption categories except those subjects that have maintained the same alcohol level, and all of the smoking categories except for smokers that have continued to smoke from 1981 through to 1988. The following, explains those independent variables that were significant predictors of the dependent variable.

Sex

The independent variable, sex, revealed a beta coefficient of -.095 and was significant at the $p<.0001$ level. This result indicated that for females, the relative change in WHR, holding all other variables constant, was 9.5 percent less than for the male subjects.

Alcohol Consumption

Those subjects that have not increased or decreased their alcohol consumption (frequency and amount) were indicated as significant predictors of the relative change in WHR. The beta coefficient was -.010 and was significant at the p<.032 level, indicating a 1.0 percent smaller relative increase in WHR, for subjects who have not changed their alcohol consumption.

Age

Age, was indicated to be a significant factor in the relative change in WHR, with a beta coefficient of .001 (p<.0001). The older a person was in 1981, the more likely the individual would experience a greater the relative change in WHR over the seven years. A person that is one year older in 1981 would experience a 0.1 percent greater relative in WHR, than a person one year younger.

Initial Percent Body Fat

Initial percent body fat was indicated as a significant predictor with a beta coefficient of .002 (p<.0001), showing that the higher the percent body fat was in 1981, the greater the relative change in WHR that would occur. An individual with a one percent higher body fat percentage would experience a .2 percent greater relative increase in WHR over the seven years.

Initial WHR

Initial WHR was indicated as a significant predictor of the relative change in WHR, with a beta coefficient of -.546 (p<.0001). This result revealed the higher the initial WHR, the smaller the relative increase in WHR that would occur.

Table 4-20 The Multiple Regression and Analysis of Variance Results of the Sixteen Independent Variables on the Dependent Variable : Relative Change in Waist-to Hip Ratio

Degrees of Freedom	Durbin Watson	R and R^2
918	1.86	.552 .305

Analysis of Variance

Source	D of F	Sum Squares	F-test
Regression	16	.913	24.693
Residual	902	2.085	p<.0001
Total	918	2.998	

Beta Coefficients

Variable	B Coefficient	t Value	Probability
Intercept	.398		
Sex	-.095	10.930	.0001
A1	-.007	1.229	.219
A2	-.008	1.552	.121
A3	-.001	.249	.803
A4	-.005	.985	.325
AL1	-.010	2.144	.032
AL2	-.003	.391	.696
AL3	-.003	.731	.465
SM1	-.003	.673	.501
SM2	.012	1.312	.190
SM3	.010	2.474	.013
SM4	.008	1.547	.122
Age	.001	5.425	.0001
Body Mass1	3.668E-4	1.772	.077
% Body Fat1	.002	5.430	.0001
WHR1	-.546	19.364	.0001

Results of the Estimated Stepwise Regression Model of the Outcome Variable: Relative Change in Waist-to-Hip Ratio

Table 4-21 illustrates the stepwise regression to predict and account for the relative change in WHR using sixteen independent variables.

In this analysis six variables were identified as significant predictors of the relative change in WHR. The first step identified initial WHR as the single best predictor, accounting for 8.2 percent of the variance. The correlation between the fitted relative change in WHR, predicted from initial WHR, and the observed relative change in WHR was .287. The second step identified sex as a significant predictor, with a multiple correlation coefficient of .448. The fitted scores were determined, predicted using initial WHR and sex as the independent variables in the multiple regression equation. The proportion of the relative change in WHR variance that could be predicted by this new two variable multiple regression equation was .201 or 20.1 percent. Initial percent body fat, age, alcohol, and smokers that quit were indicated in the final four steps to contribute significantly to the overall variance. At the sixth and final step, the multiple correlation coefficient between observed and fitted scores was .544, predicted from all eight variables mentioned above. The proportion of variance that can be predicted from this eight variable multiple regression equation was .296 or 29.6 percent.

Summary

Based on the results of this study, it can be concluded that initial WHR, sex, initial percent body fat, age, initial body mass, and maintaining the same alcohol consumption are significant predictors of the relative change in WHR.

Table 4-21 The Stepwise Regression Results of the Sixteen Independent Variables on the Dependent Variable: Relative Change in Waist-to-Hip Ratio

Durbin Watson
1.86

Step No. 1 Variable Entered: Initial Waist-to-Hip Ratio

R	R-Squared	Adj. R-Sq.	RMS Res.	F-test
.287	.082	.081	.055	82.257

Step No.2 Variable Entered: Sex

R	R-Squared	Adj. R-Sq.	RMS Res.	F-test
.448	.201	.199	.051	114.909

Step No.3 Variable Entered: Initial Percent Body Fat

R	R-Squared	Adj. R-Sq.	RMS Res.	F-test
.516	.266	.263	.049	110.468

Step No.4 Variable Entered: Age

R	R-Squared	Adj. R-Sq.	RMS Res.	F-test
.536	.287	.284	.048	91.883

Step No.5 Variable Entered: SM3-Smoke 1981-1988

R	R-Squared	Adj. R-Sq.	RMS Res.	F-test
.540	.291	.287	.048	75.058

Table 4.21 Continued. The Stepwise Regression Results of the Sixteen Independent Variables on the Dependent Variable: Relative Change in Waist-to-Hip Ratio

Step No.6 Variable Entered: Alcohol Consumption: (AL1)

R	R-Squared	Adj. R-Sq.	RMS Res.	F-test
.544	.296	.291	.048	63.842

Variables In Equation

Variable	Coefficient	Std. Error	Std. Coeffic.	F to Remove
Intercept	.400			
WHR1	-.531	.028	-.821	368.614
Sex	-.103	.007	-.896	240.527
% BF1	.003	3.469E-4	.376	69.740
Age	.001	1.495E-4	.166	31.003
SM3	.009	.004	.072	6.520
AL1	-.008	.003	-.068	5.792

Summary of Main Results Associated With the Three Hypotheses

1. Activity Level

Activity level was not a significant predictor of the relative change in body composition measurements; relative change in body mass, BMI, sum of skinfolds, percent body fat, and WHR. This is not in agreement with the originally stated hypothesis that subjects increasing activity level or maintaining activity levels, would experience decreases in the body composition measurements.

2. Initial Body Fat Distribution

Initial WHR was indicated as a significant predictor of the relative change in WHR. Holding all other variables constant (independent of sex), the higher the initial WHR or the more android the body fat distribution, the smaller the relative increase in WHR. Activity level, as stated previously, did not produce any significantly different changes in WHR, irrespective of initial fat distribution. The original hypothesis of greater decreases (or smaller relative increases) was found for subjects with initial upper body fat, however it was hypothesized that increases in activity or maintenance of activity would produce these changes. Initial body fat distribution contributed 8.2 percent of the total overall variation in the relative change in WHR of 29.6 percent.

3. Sex

Men experienced smaller relative increases in sum of skinfolds and in percent body fat. Women experienced smaller relative increases in WHR than males. These differences in changes in body composition measurements occurred irrespective of activity level, since no particular activity level produced significantly different changes. Sex was only indicated in the stepwise multiple regression analyses to independently contribute significantly to the overall variation in the relative changes in sum of skinfolds, percent body fat, and WHR.

4. Other Significant Predictors of the Body Composition Changes

Age

Age was a significant predictor of the relative change in body mass, BMI, and WHR. It was identified that the younger the individual was in 1981 the greater the relative increase in body mass and BMI that would occur. Older people in 1981 experienced, smaller increases in body mass and BMI compared to younger individuals. In addition, it was identified that the older an individual was in 1981 the greater the relative increase in WHR that would occur over the seven years between testing sessions.

Smoking

Individuals that quit smoking after the 1981 testing were found to experience significantly greater relative increases in body mass, BMI, sum of skinfolds, and percent body fat than other subjects holding all other variables constant. Individuals that continued to smoke from 1981 through until 1988, experienced significantly greater relative increases in WHR than other subjects, holding all other variables constant.

Alcohol Consumption

Subjects that maintained the same level of consumption of alcohol in terms of frequency and amount experienced smaller relative increases in WHR than other subjects, holding all other variables constant.

Initial Body Mass

Subjects that were heavier in 1981 experienced significantly smaller relative increases in body mass and BMI than lighter subjects, holding all other variables constant.

Initial Percent Body Fat

Subjects with higher initial percent body fat values experienced smaller relative increase in the sum of skinfolds and percent body fat, holding all other variables constant. Initial percent body fat contributed 8.7 and 19 percent to the overall variation in the relative change in sum of skinfolds and percent body fat, respectively.

Smoking, age, and alcohol consumption as predictors of the relative changes in body composition, contributed minimally to the overall variation, in the dependent variables.

CHAPTER 5

DISCUSSION

Introduction

This chapter is a discussion of the results presented in Chapter Four. The focus of this section will be directed under the following headings: a) statement of the problem, b) discussion of the results pertaining to the main hypothesis, c) summary and conclusions.

Statement of the Problem

The beneficial effects of physical activity on fitness and lifestyle are well accepted (Fox & Matthews, 1981; Shepard, 1986). Physical activity is recommended as part of body mass-reduction programs in order to increase energy expenditure thus utilizing energy reserves or fat stores. Many adverse consequences are associated with severe obesity however the precise amount of body fat that will increase health risks is not known (Gray,1989). It has been recognized recently that the pattern of distribution of adipose tissue throughout the body affects metabolic consequences and may be a more important factor than the total adipose tissue mass. A person with fat predominantly in the abdominal region may be at a greater risk of hypertension, heart disease, and diabetes mellitus than another individual with a greater total amount of tissue that is located predominantly in the gluteal area (Kissebah et al., 1982). Consequently this research was directed toward determining whether the modulating factor of physical activity can alter body fat distribution, decreasing the WHR and ultimately susceptibility to disease.

The purpose of this study was to determine the effects of changes in physical activity from an inactive level to a moderate or active level compared to subjects that either remained at a sedentary, moderate, or active level of physical activity on the body fat distributions of men and women that participated in the 1981 Canada Fitness Survey and the 1988 Campbell's Follow-up Survey.

The Canada Fitness Survey (CFS) was initiated by Fitness Canada in order to describe the physical recreation habits, physical fitness, and health status of the Canadian population. The 1988 Campbell's Survey was designed to provide an update of the 1981 information, examine the contribution of exercise to health, and to investigate the adherence to exercise over time.

In 1981, a total of 14,365 subjects completed both the fitness measurements and questionnaire. From the sample of 3068 males and females that participated in the 1981 CFS and 1988 CS, 950 subjects were eligible for this study, providing the necessary variables from the questionnaire and physical assessment sections of each survey.

The proposed research problem was formulated retrospectively in order to interpret the results of this major prospective study (1981 and 1988 surveys). Secondary data analysis of longitudinal data, allows the researcher to analyze a group of individuals who have self-selected various lifestyle patterns (e.g., physical activity). Consequently, this type of research allows the investigator to determine changes in body composition over time.

<u>Discussion of the Results</u>

The main hypotheses of this study focus on whether there are differences in the ability to change body composition measurements based on activity level, sex, and initial body fat distribution. In addition, other lifestyle factors such as alcohol consumption and smoking status and initial body composition measurements (body mass and percent body fat) were considered because of their influence on the relative changes in body composition measurements.

Activity Level

Activity level was not a significant predictor of the relative changes in any of the body composition measurements (body mass, BMI, sum of skinfolds, percent body fat, and WHR). Consequently, subjects, independent of activity level, experienced relative increases in each of the dependent variables. Therefore, no evidence exists in this study, to suggest that varying activity levels produce different changes in body composition measurements. As a result, comparisons of androids versus gynoids, and males versus females at the different activity levels was not possible, since activity level was not a predictor of the relative changes in body composition.

Physical activity, may not have been identified as a predictor of the relative changes in body composition measurements because of an insignificant change in energy balance, as more active individuals may have experienced: 1) an insufficient energy expenditure to elicit significant changes in body composition and 2) an excess in energy intake in response to activity. For each activity level category, the energy expenditure requirement for sedentary, moderate, and active may not be significantly different in terms of the energy expenditure requirements. Activity level was a classification based on the total energy expenditure in all leisure-time activities (Stephens & Craig, 1990). Active respondents reported a 12 month average of at least 3 kilocalories of energy expenditure daily per kilogram of body mass. Moderate respondents values of 1.5 through 2.9, inclusive, while inactive refers to values below 1.5 kcal/kg/day. For example, an active 60 kilogram individual would be considered to be expending approximately 180 kcal-300 kcal (approximate upper limit) per day due to leisure activity. A moderately active, 60 kilogram individual would be considered to be expending approximately 90-174 kcal per day, while a sedentary individual of the same body mass would be considered to be expending less than 84 kcal/day. The active level appears to be insufficiently active as 180 kcal/day is expended by jogging 15 minutes, swimming 13 minutes, or cross-country skiing for 14 minutes a day, respectively (Fox & Matthews, 1981), and this amount of energy expenditure was not enough to significantly change body composition.

Daily energy expenditure was estimated from each subjects self-completed questionnaire of (a) weekly activities over the last three months, (b) other activities in the past month, and (c) other activities in the past year. The classification of each subject according to activity level was based on each subjects interpretation of the amount of physical activity performed. Subjects may have under or over reported the amount of physical activity. Consequently, the operationalization of the level of activity may possibly fail to discriminate with respect to body composition changes.

The American College of Sports Medicine (1990) has made the following recommendations for the quantity and quality of training for developing and maintaining cardiorespiratory fitness, body composition, and muscular strength and endurance: 1) frequency of training 3-5 times per week, 2) intensity of training at 60-90 percent of max heart rate or 50-85 percent of maximal oxygen consumption,

3) duration of training 20-60 minutes of continuous aerobic activity, 4) activities that utilize large muscle groups that are aerobic in nature, such as walking, jogging and cycling, and 5) resistance training at least two times per week with 8 to 12 repetitions. This is the recommended minimum amount of exercise prescribed and is emphasized more for maintenance. Based on these recommendations it is evident that the appropriate volume of exercise (frequency and duration) at a moderate intensity will create a total energy expenditure that will produce significant body composition changes. Thus the subjects were probably not expending enough energy to produce significantly different and more beneficial changes than the sedentary individuals, or energy expenditure itself was poorly measured.

In a study of the effect of walking and subsequent caloric expenditure on body mass loss, the amount of time walking, paralleled the amount of body mass lost. Significant mass loss occurred only after subjects walked for longer than 30 minutes daily (Gwinup, 1975). In comparison, subjects classified as active may not have expended a significant amount of energy to produce noticeable or significantly greater changes in composition than less active subjects. According to Björntorp (1976), the period of time that is required to obtain a body fat reduction probably differs with the intensity, duration, and frequency of the exercise sessions. With a training program that was as intensive as possible for one hour, three times a week for six weeks produced small but significant decreases in body fat in eight male and female subjects (Björntorp, 1976). Björntorp (1972) also found that in subjects who exercised at a low intensity for 30 minutes three times per week, consistently for nine months, showed significant decreases in body fat, almost 40 percent of the original body fat, obtained without food restriction. Björntorp (1976) concluded that in order to elicit decreases in body fat, a minimum period of two months is required, provided the exercise is strenuous enough. Also, persons who prefer to exercise at the level of walking, must exercise more regularly and for longer durations.

There are two components involved in the total energy cost of physical activity. One component is the energy that is expended during exercise itself, which accounts for the majority of the caloric expenditure. The second component, which is termed excess post exercise oxygen consumption (EPOC), is the energy expenditure that occurs after exercise while the metabolic rate remains elevated above the pre-exercise level (Sedlock, Fissinger & Melby, 1989). The latter component has been historically neglected when quantifying the caloric cost of various physical activities (Sedlock et al., 1989). Prolonged excess post-exercise oxygen consumptions have been found following studies of strenuous exercise for long durations (Bahr, Ingnes, Vaage, Sejersted & Newsholme, 1987; Edwards, Thorndike & Dill, 1935). However, in other studies strenuous exercise failed to produce a prolonged EPOC (Freedman-Akabas, Colt, Kissileff & Pi-Sunyer, 1985). Sedlock et al (1989) found no evidence of a prolonged elevated metabolic rate following exercise conditions of: 1) high intensity and short duration, 2) low intensity and short duration, and 3) low intensity and long duration. There was not a prolonged EPOC found in this study, however the magnitude of the EPOC may be of some value in the long term. An EPOC of approximately 30 kcal (which was produced by high intensity-short duration exercise), performed five times per week for 52 weeks, amounts to 7800 kcals or the energy equivalent of approximately 1 kilogram of fat or 10 kilograms in ten years. The component of EPOC is mentioned in order to stress that if subjects are not exercising regularly for a sufficient duration and intensity, they may not be expending enough energy during the activity itself and therefore are not experiencing adequate benefits of an elevated post exercise metabolic rate. As a result, energy expenditure is insufficient to elicit positive changes in body composition measurements.

The second major factor that may have attributed to the result of no significant physical activity affect on body composition was energy overcompensation. Energy overcompensation has been speculated in other studies as a cause of increases in percent body fat, and this may have also affected the results of the present study, as we were unable to control for caloric intake. However, the results of these studies involving animals (Rodin et al ,1990) and humans (Andersson et al., 1991; Tremblay et al., 1988) concluded that females react to exercise by increasing their caloric intake more than males. Studies by Woo, Garrow & Sunyer (1982) and Woo & Sunyer (1985) have examined compensatory intake in detail, under fully controlled conditions in groups of obese and non-obese women. In these studies non-obese women increased energy intake to compensate for the increased energy output. There is no real physiological reason why this should occur, however it has been speculated that females overcompensate in order to protect their body fat stores. There may have been some methodological flaw in these studies, as it would appear that energy over-compensation is likely to occur just as often in males as in females.

Exercise can be extremely beneficial in creating a negative energy balance since the energy cost of prolonged exercise of moderate intensity can increase substantially the daily energy needs. Also, the post exercise increment in metabolic rate may also contribute to an increment in daily energy expenditure (Tremblay et al., 1988). Consequently, it can be seen that if the metabolic effects of exercise are not over-compensated by changes in energy intake or in other components of energy expenditure, training will induce a substantial energy deficit. Thus activity has the ability to alter body fatness, and possibly body fat distribution. Further controlled investigations need to be addressed as to whether there is a psychological and/or physiological explanation for energy over-compensation.

In the present study, the investigator was unable to control for "weight" cyclers: subjects that have had a history of repeated cycles of "weight" gain and "weight" loss (Rodin et al., 1990; Lissner, Odell, D"Agostino, Stokes, Kreger, Belanger & Brownell, 1988). If the subjects that increased their activity level consisted of more "weight" cyclers, this may have influenced the results. Appelbaum (1976) stated that dieting on low calorie diets can decrease the basal metabolic rate significantly. It has been demonstrated that people who have undergone a cycle or several cycles of body mass loss and regain, show slower rates of body mass loss on each subsequent try of a diet (Rodin et al., 1990) or possibly of an exercise program. It is possible that mass fluctuation may compel the body to subsist at a reduced caloric intake level, which derives in part from a lowered metabolic rate (Rodin et al., 1990). In other words, chronic dieting, resulting from unsuccessful attempts at weight loss or failure to maintain mass loss, appears to result in an adaptation of the body to energy restriction, by improved fuel efficiency which will lead to a resistance to further mass loss and faster mass regain (Björntorp & Yang, 1982). Consequently, it may be necessary for an individual with this characteristic, to adhere to regular exercise of a sufficient duration, intensity, and type, in order to counter the adverse effects of "weight" cycling on metabolism. Exercise may circumvent or reduce the depression in resting energy requirements due to calorie restriction (King & Tribble, 1991). Investigators have also found, independent of the changes in energy metabolism as a result of weight cycling, the behavioral consequences of repeated episodes of "weight" cycling may influence individuals, to select a diet high in fat relative to the diets of other individuals (Rodin et al., 1990).

It is evident that controlling for dietary intake is essential, as energy over-compensation and the composition of an individuals diet seem to present themselves as confounding issues. Subsequently, no apparent differences in changes in body composition based on activity level can be detected, and these confounding issues may have been present in this study.

Sex

Male subjects experienced slightly greater relative increases in body mass and BMI compared to female subjects, holding all other variables constant. Younger male subjects tended to experience greater increases in body mass and BMI compared to older male subjects.

Female subjects experienced greater relative increases in sum of skinfolds and percent body fat compared to the male subjects, independent of age. The female subjects also experienced smaller relative increase in WHR than males, however for post-menopausal women, the relative change in WHR was significantly greater compared to premenopausal women. Younger female subjects also tended to experience greater relative increases in body mass and BMI compared to older female subjects, however, experiencing smaller relative increases than the male subjects.

The effects of sex steroid hormones are not entirely specific on the metabolic differences in fat depots, however some features of the roles of these hormones on fat accumulation are known and must be considered when analyzing the changes in body composition (Rebuffe-Scrive, 1988).

Men tend to experience a protection against fat accumulation in early adulthood due to high testosterone levels which inhibit LPL activity (enzyme which helps store fat-lipogenesis) and stimulates lipolysis (the breakdown of fat), creating relatively leaner men compared to women of the same age (Rebuffe-Scrive, 1988). Men do not have the high LPL activity in the femoral region experienced by premenopausal women and this LPL activity is even lower than in postmenopausal women, suggesting an inhibitory role of testosterone. In men and women the lipolytic response to norepinephrine of the abdominal adipocytes is high compared to the femoral region however this decreases with age in men, most likely due to the decline in testosterone levels (Rebuffe-Scrive, 1988). Consequently, it appears that men, because of the hormone testosterone experienced smaller relative increases in sum of skinfolds and percent body fat. The effect of testosterone on the lean body mass, assists in explaining the slightly greater relative increase in body mass and BMI found in the male subjects, since the males experienced smaller relative increases in skinfolds and percent body fat than females (Rebuffe-Scrive, 1988).

Women, specifically in premenopause, tend to accumulate fat preferentially in the femoral region due to high LPL activity, compared to the abdominal region, and this body fat is difficult to mobilize, because norepinephrine stimulated lipolysis is low. Menopause is associated with a change in the characteristics of adipose tissue distribution from a gynoid pattern, with fat accumulating without regional preference, due to the decrease in estrogen and the relative increase in androgenic to estrogenic balance (Rebuffe-Scrive, 1988). It appears that the female sex hormones seem to regulate the accumulation of fat in the gluteal-femoral region by activating LPL.

It has been well documented that men and women show differences in the pattern of change in body fat in the waist and hip regions. Shimokata et al. (1989) demonstrated that men clearly show much larger waist than hip changes and, therefore, WHR changes are more significant than in women. The magnitude of the changes in the waist and hip are more equal in women and therefore, changes in the

WHR are small or insignificant, especially for premenopausal women, as found in this study.

At this point, it is important to consider seriously, the effect of sex hormones on body composition, and the changes in body composition measurements over time. As the results indicated, the independent variables used in this study contributed minimally to the relative changes in body mass (7.4 %) and BMI (5.0 %), while contributing substantially more to the relative changes in sum of skinfold (17.9 %), percent body fat (27.0 %), and WHR (29.6 %). Independent of age, sex hormones would appear to significantly affect body fat distribution and the subsequent changes over time and would most likely contribute substantially to the total variation in each of the dependent variables. Sex, contributed minimally to the relative increase in body mass, sum of skinfolds, percent body fat, and WHR, however age contributes minimally to the relative increases in body mass and BMI.

Not only are there hormonal differences between men and women, there are also differences in metabolic rate (Vander et al., 1985). The metabolic rate of women is generally less than that of men, even after taking into account body size. The metabolic cost of living gradually decreases with advancing age (Vander et al., 1985). This explains the greater relative increase in sum of skinfolds and percent body fat experienced by both the males and to a greater extent in the females over the seven year period.

In addition to the hormonal differences of men and women and their effects on body fat accumulation and distribution, "weight" cycling, as described previously may also be a contributing factor.

"Weight" cycling, which is experienced more often in women (Rodin et al., 1990), results in a lowered metabolic rate and increased fat consumption, which together would contribute to greater relative increases in skinfolds and percent body fat in women. Another factor which could not be controlled for is the mass gain and mass loss from repeated pregnancies, which are associated with abdominally distributed fat and greater relative levels of body fat.

Initial Body Fat Distribution

In the present study, initial body fat distribution was indicated as a significant predictor of the relative change in WHR. Females were initially on average of the gynoid fat distribution (lower body fat), and experienced smaller relative changes in WHR, compared to the males who were on average more of the android or upper body fat distribution, at the same initial age and percent body fat. Subjects who were more android, independent of gender experienced smaller relative increase in WHR.

It was originally hypothesized that individuals of a more android fat distribution would experience greater reductions in the WHR due to an increase in activity level. However, as stated previously, activity levels were not found to produce significantly different changes in body composition measurements.

Subjects independent of sex, on average experienced smaller relative increases in WHR if their initial body fat distribution was more android. However, females experienced significantly smaller relative increases than the male subjects. This finding was expected as premenopausal women with a more gynoid fat distribution, would accumulate fat in both regions (abdominal and gluteal). In fact, as the results indicated, initially younger women tend to experience a decrease in the WHR due to fat primarily accumulating in the gluteal region. As a woman approaches and enters menopause, fat deposits in both regions with no specific preference (Rebuffe-Scrive, 1988).

Conversely, males continually deposit fat preferentially in the abdominal region, thus experiencing continual increases in the WHR. This upper body distribution of fat is harmful, and a high WHR correlates strongly with risk factors for cardiovascular disease and diabetes mellitus (Larsson et al., 1984; Gillum, 1987)

Due to the regional differences in adipose tissue metabolism, it was hypothesized, as stated previously, that subjects with upper body fat would experience greater decreases in the WHR, as well as other body composition measurements due to the physiology of this abdominal fat depot.

Human adipose tissue contains vast quantities of alpha and beta adrenoreceptors. The binding of agonists such as norepinephrine to beta receptors enhances lipolysis whereas binding to alpha receptors inhibits lipolysis, with a greater alpha receptor activity in the abdominal tissue. Lipoprotein lipase (LPL), is the main enzyme controlling fat accumulation, particularly in the gluteal-femoral region of premenopausal women. In menopause, this regional preference for fat accumulation disappears. Testosterone, the male sex hormone, seems to play a role in the lower LPL activity in the femoral region of men compared to pre and post-menopausal women. Due to the abdominal adipocytes showing a higher lipolytic response to norepinephrine, it was hypothesized that with an increase in physical activity, there would be significant changes in body composition measurements (relative decreases or smaller relative increases).

Smoking

Smoking, specifically subjects who quit smoking after the initial testing in 1981 experienced significantly greater increases in body mass, BMI, sum of skinfolds, and percent body fat. This behavior had no specific influence on WHR. However, subjects that continued to smoke from 1981 through to 1988 experienced greater relative increases in WHR. These results were expected and have been found in previous research.

It has been well documented (Troisi, Heinold, Vokonas & Weiss, 1991; Moffat & Owens, 1991) that former smokers have higher mean body weights and percent body fat values than current smokers, and to a lesser extent than never-smokers. Smokers have been found to consume approximately the same number of calories per day and fewer calories than former and never-smokers (Troisi et al., 1991), however the diet is composed of a higher percentage of total calories from saturated fats and a lower percentage of total calories from complex carbohydrates (Troisi et al., 1991). Former smokers have also been found to consume less total calories from carbohydrates than never smokers. Smokers generally consume more alcohol and caffeine and less dietary fibre than former and non-smokers. Former smokers also consume more alcohol and caffeine than non-smokers (Troisi et al., 1991). Non-smokers have been found to weigh significantly more than smokers and the smokers have been found to gain body mass and body fat upon the cessation of smoking (Moffat & Owens, 1991).

Smoking appears to increase metabolism, mediated by sympathetic-nervous system activity with high levels of norepinephrine in the blood (Cryer, Haymond, Santiago & Shah, 1976) and in the urine in response to smoking. Nicotine has been found to increase resting metabolic rate as measured by indirect calorimetry (Perkins, Epstein, Stiller, Marks & Jacob, 1989) and therefore, smokers have been found to expend more energy than non-smokers (Hofstetter, Schultz, Jequier & Wahren, 1986).

Consequently, smokers who quit experience a decrease in metabolism while maintaining and possibly increasing caloric intake, experiencing significantly greater increase in body composition measurements. Former smokers, therefore, have two factors which influence the body composition measurement increases: a decrease in resting metabolic rate and no compensatory decrease in caloric intake.

Smokers experienced greater relative increases in WHR, and this result was expected. Despite less adiposity found in smokers, centripetal adiposity is greater and increases with smoking (Troisi et al., 1991). Smoking appears to cause an increase in androgenic activity, with greater total and free testosterone being demonstrated. Increases in androgenic activity have been associated with an increased WHR in obese (Hauner et al., 1988) and non obese (Sirdell, 1989) women and to a lesser extent in men (Cox, 1989).

Cox (1989) found in his study that for women, there was a significant association between smoking and WHR independent of alcohol consumption. However in men, alcohol consumption was a confounding variable as smoking and alcohol consumption were related. In men who drank alcoholic beverages not including beer, the

WHR was significantly related to smoking independent of the level of consumption. Whereas with men who were smokers and beer drinkers, the level of consumption of alcohol was more related to WHR.

Alcohol

In the present study, subjects that did not change the level of alcohol consumption experienced significantly smaller relative increases in WHR. It was expected that subjects that drink alcohol or have increased their alcohol consumption level would have experienced significantly greater relative increases in the WHR than non-drinkers or subjects that decreased their level of consumption. Epidemiological evidence suggests that high alcohol consumption seems to be an independent contributing factor to an elevated WHR (Cox, 1989; Björntorp, 1989). It has been postulated that alcohol leads to a high corticosteriod/sex steroid hormone ratio, which tends to activate lipid accumulating activity in intra-abdominal depots through their high density of corticosteroid receptors with the accumulation of lipid from peripheral depots (Björntorp, 1990).

Summary and Conclusions

The purpose of this study was to assess the effect of varying physical activity levels on the changes in body fat distribution of men and women who participated in the 1981 Canada Fitness Survey and the 1988 Campbell's Survey. It was hypothesized that individuals who increased their activity level from sedentary to more active (moderate or active) would experience the most significant relative decreases (or smaller relative increases) in body mass, BMI, sum of skinfolds, percent body fat, and WHR, than less active individuals. It was also hypothesized that men would experience significantly greater relative decreases in body composition measurements compared to similarly active woman as a result of an increase in physical activity. In addition, subjects with an initial upper body fat distribution were hypothesized to experience significantly greater relative decreases (or smaller relative increases) in body composition measurements as a result of an increase in physical activity, than individuals with a more gynoid fat distribution.

Nine hundred and fifty, healthy men (n=451) and women (n=499) ages 18 to 71, who participated in both the 1981 and 1988 surveys were included in this study, providing both questionnaire and physical assessment data. Questionnaire data were used in order to take into account some important lifestyle factors such as activity level, smoking status, and alcohol consumption. The anthropometric data were used to assess the relative changes in body composition measurements. Percent body fat was calculated using the sum of four skinfolds (triceps, biceps, subscapular, and suprailiac), using the equation described by Benke (1942) to calculate body density, and then Siri's equation to calculate percent body fat. The relative change in each of the dependent variables was calculated by subtracting the 1988 value from the 1981 value and dividing by the 1981 value.

The mean values and standard deviations for each of the dependent variables were calculated for males and females according to each of the activity levels, and there were generally no specific trends according to activity level. The problems associated with regression research were addressed such as multicollinearity, autocorrelation, and heteroskedasticity. Since many of the body composition measurements are inter-related, multicollinearity was presented as a problem. However, none of the independent variables were eliminated from the analysis. Heteroskedasticity and autocorrelation were not confounding issues in this study.

Multiple regression analysis was utilized to describe and test the relationship of each dependent variable (body mass, BMI, sum of skinfolds, percent body fat, and WHR) and a combination of independent variables (sex, activity level, initial body fat distribution, age, smoking status, alcohol consumption, initial body mass, and initial percent body fat). Secondly, stepwise multiple regression analysis was used in order to determine the contribution of each of the significant independent variables to the total variation in each of the dependent variables. The purpose of regression analysis was to determine those independent variables that explain the relative changes in the body composition measurements.

Conclusions

As a result of this investigation of the 1981 Canada Fitness Survey data and 1988 Campbell's Survey data utilized in this study a number of conclusions are drawn and stated below.

1. Physical activity level was not found to be a significant predictor of the relative change in body composition measurements. Therefore, comparisons of individuals with varying initial body fat distribution patterns (androids versus gynoids) at different activity levels was not possible. Consequently, explanations as to why more active individuals did not experience greater relative decreases (or smaller relative increases) as originally hypothesized were as follows; 1) the activity level categories were not distinctly different in terms of energy

expenditure requirements, 2) the energy expenditure and subsequent activity level classification was not measured adequately, 3) diet was not controlled or measured and individuals increasing activity level may have experienced energy over-compensation in response to activity, and 4) there may have been more "weight" cyclers in the activity categories that increased to a more active level.

2. Males experienced slightly greater relative increases in body mass and BMI compared to female subjects while the female subjects experienced greater relative increases in sum of skinfolds and percent body fat compared to the male subjects. Females experienced on average decreases in the WHR whether they were initially of the android or gynoid fat distribution. This is due to the fact that the majority of the women were initially premenopausal and the accumulation of fat in the buttocks and thigh region, would cause the WHR to decrease.

3. Age was a significant predictor of the relative change in body mass and BMI with initially younger subjects experiencing greater increases in body mass and BMI than initially older subjects.

4. Subjects who indicated they had quit smoking experienced significantly greater relative increases in body mass, BMI, sum of skinfolds, and percent body fat, while subjects that continued to smoke experienced significantly greater increases in the WHR.

Recommendations

The following general recommendations are made on the basis of the current study:

1) Other factors appear to be responsible for the relative change in each of the dependent variables besides the independent variables

considered in this study which include sex, activity level, initial body fat distribution, initial body composition measurements, smoking, alcohol, and age. It appears that an individual's total daily energy expenditure must be consistently significant in order to produce substantial decreases in body fat. It also appears that possibly an individuals sex hormone profile would present itself as a more substantial indicator of the relative change in body composition measurements. More precisely, the relative change in an individuals sex hormone profile may be the most significant indicator of the changes in body composition. Body fat distribution has been found to be a reflection of an individuals sex hormone profile, however it is not possible to predict the extent to which an individuals hormone sex profile will change over time and therefore the subsequent changes in body composition. Restated, it may be difficult to predict the extent to which an individuals body composition changes over time unless we have some indication of the relative change in sex hormones over time.

2) The Canada Fitness Survey and the Campbell's Survey do not recognize many important variables. Research suggests that factors such as energy over-compensation and "weight" cycling affect the changes in body composition and therefore it would be appropriate for future observational surveys and experimental research to recognize important lifestyle information such as calorie intake, the number of energy restricted diets the subjects have been on and an indication of the amount of body mass loss and regain with each diet, and whether the female subjects have given birth or not so that the investigator is able to control for these factors.

3) There is a need to conduct a longitudinal study incorporating both a diet and exercise program for moderately obese individuals, controlling for all confounding variables, to determine whether different body fat distributions (androids or gynoids) differ in their ability to reach a goal body mass.

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APPENDIX A
1981 CANADA FITNESS SURVEY

Canada Fitness Survey — Enquête condition physique Canada

HOUSEHOLD RECORD CARD

IDENTIFICATION

Docket Number

DWELLING DATA

DWELLING NUMBER	01	OF 02
1. Is this a single detached dwelling?	03 [ ]1 Yes	[ ]2 No
IF NO, Floor level of main entrance of dwelling	04	
Total number of floors in building	05	
Total number of dwellings in building	06	

RECORD OF CALLS

HOUSEHOLD MEMBERSHIP

Person Numbers →	PERSON NUMBER 07 [1]	PERSON NUMBER 20 [2]	PERSON NUMBER 32 [3]	PERSON NUMBER 44 [4]	PERSON NUMBER 56 [5]	PERSON NUMBER 68 [6]
1. Please name all the people who now live here.	08 GIVEN NAME	21 GIVEN NAME	33 GIVEN NAME	45 GIVEN NAME	57 GIVEN NAME	69 GIVEN NAME
2. Is there anyone else who usually lives here?	09 SURNAME	22 SURNAME	34 SURNAME	46 SURNAME	58 SURNAME	70 SURNAME
3. What is ______'s date of birth?	10 Month 11 Year	23 Month 24 Year	35 Month 36 Year	47 Month 48 Year	59 Month 60 Year	71 Month 72 Year
4. That would make ______'s age	12 Age	25 Age	37 Age	49 Age	61 Age	73 Age
5. Verify sex and 'X' appropriate box	13 [ ]1 M [ ]2 F	26 [ ]1 M [ ]2 F	38 [ ]1 M [ ]2 F	50 [ ]1 M [ ]2 F	62 [ ]1 M [ ]2 F	74 [ ]1 M [ ]2 F
6. Hand Reference Card to respondent and say: I now want to find out how people are related to each other. Please refer to the Reference Card. How is ______ related to you?	14 Relationship Code; If 13, 24, 44, Specify 15	27 Relationship Code; If 13, 24, 44, Specify 28	39 Relationship Code; If 13, 24, 44, Specify 40	51 Relationship Code; If 13, 24, 44, Specify 52	63 Relationship Code; If 13, 24, 44, Specify 64	75 Relationship Code; If 13, 24, 44, Specify 76
7. Test Group Number	16 [ ] Test Group	29 [ ] Test Group	41 [ ] Test Group	53 [ ] Test Group	65 [ ] Test Group	77 [ ] Test Group

PARTICIPATION

Some measurement information present?	17 [ ]1 Yes [ ]2 No [ ]3 Less than 7 or over 69	30 [ ]1 Yes [ ]2 No [ ]3 Less than 7 or over 69	42 [ ]1 Yes [ ]2 No [ ]3 Less than 7 or over 69	54 [ ]1 Yes [ ]2 No [ ]3 Less than 7 or over 69	66 [ ]1 Yes [ ]2 No [ ]3 Less than 7 or over 69	78 [ ]1 Yes [ ]2 No [ ]3 Less than 7 or over 69
Some questionnaire information present?	18 [ ]1 Yes [ ]2 No [ ]3 Less than 10	31 [ ]1 Yes [ ]2 No [ ]3 Less than 10	43 [ ]1 Yes [ ]2 No [ ]3 Less than 10	55 [ ]1 Yes [ ]2 No [ ]3 Less than 10	67 [ ]1 Yes [ ]2 No [ ]3 Less than 10	79 [ ]1 Yes [ ]2 No [ ]3 Less than 10
Household Response Code	19 [ ] IF CODE IS NOT X, COMMENT					

APPOINTMENT

Telephone Number

Scheduling Information

Test Group	Date · Time	Confirmed
01		
02		
03		

COMMENTS

REGIONAL SUPERVISOR 80 [ ]

Signature ____________________

ADULT DATA CARD

IDENTIFICATION

Docket number		
Person number	001	
Age	002	
Sex	003	[ ]1 M [ ]2 F
Signed consent	004	[ ]1
Refusal		[ ]2
Temporarily Absent		[ ]3

STATION 1

WEIGHT

Weight – to nearest 0.1 kg	005	
IF UNABLE TO MEASURE: Ask respondent to estimate weight ______ and convert to kg	006	
Refusal	007	[ ]1
Specify why measurement was not possible: Confined to bed or wheelchair		[ ]2
Over scale value		[ ]3
Other		[ ]4

HEIGHT

Height – to nearest 0.1 cm	008	
IF UNABLE TO MEASURE: Ask respondent to estimate height ______ and convert to cm.	009	
Refusal	010	[ ]1
Specify why measurement was not possible: Confined to bed or wheelchair		[ ]2
Severe curvature of the spine		[ ]3
Other		[ ]4

SKINFOLDS

Triceps – to nearest 0.2 mm	011	
	012	
	013	
Mean	014	
Refusal	015	[ ]1
Unable to obtain		[ ]2
Subscapular – to nearest 0.2 mm	016	
	017	
	018	
Mean	019	
Refusal	020	[ ]1
Unable to obtain		[ ]2
Biceps – to nearest 0.2 mm	021	
	022	
	023	
Mean	024	
Refusal	025	[ ]1
Unable to obtain		[ ]2
Suprailiac – to nearest 0.2 mm	026	
	027	
	028	
Mean	029	
Refusal	030	[ ]1
Unable to obtain		[ ]2
Medial calf – to nearest 0.2 mm	031	
	032	
	033	
Mean	034	
Refusal	035	[ ]1
Unable to obtain		[ ]2

DIAMETERS

Humerus (right elbow) – to nearest 0.5 mm	036	
Refusal	037	[ ]1
Unable to obtain		[ ]2
Femur (right knee) – to nearest 0.5 mm	038	
Refusal	039	[ ]1
Unable to obtain		[ ]2

GIRTHS

Upper arm (right arm) – to nearest 0.1 cm	040	
Refusal	041	[ ]1
Unable to obtain		[ ]2
Chest – to nearest 0.1 cm	042	
Refusal	043	[ ]1
Unable to obtain		[ ]2
Abdomen – to nearest 0.1 cm	044	
Refusal	045	[ ]1
Unable to obtain		[ ]2
Gluteal – to nearest 0.1 cm	046	
Refusal	047	[ ]1
Unable to obtain		[ ]2
Thigh (right leg) – to nearest 0.1 cm	048	
Refusal	049	[ ]1
Unable to obtain		[ ]2
Calf (right leg) – to nearest 0.1 cm	050	
Refusal	051	[ ]1
Unable to obtain		[ ]2

STATION 2 – SCREENING

PAR-Q

Has the doctor ever said you have heart trouble?	052	[ ]1 No [ ]2
Do you frequently have pains in your heart and chest?	053	[ ]1 No [ ]2
Do you often feel faint or have spells of severe dizziness?	054	[ ]1 No [ ]2
Has a doctor ever told you your blood pressure was too high?	055	[ ]1 No [ ]2
Are you taking any medication prescribed by your doctor?	056	[ ]1 No [ ]2
Has your doctor ever told you that you have a bone or joint problem such as arthritis that has been aggravated by exercise or might be made worse by exercise?	057	[ ]1 No [ ]2
Exercise such as going up and down stairs for a period of time?	058	[ ]1 No [ ]2
Is there any good physical reason not mentioned why you should not follow an activity program even if you wanted to?	059	[ ]1 No [ ]2
Please specify	060	
Over age 65 – Are you accustomed to vigorous physical exercise?	061	[ ]1 No [ ]2

OBSERVATION

With the exception of pregnancy, these conditions are to be observed, not asked

Pregnancy	072
Blindness	062
Deafness	063
Fever	073
Persistent cough	074
Muscular co-ordination or orthopedic problem	075
Limb problem (not serious enough to be screened out)	064
Some indication of impairment from alcohol	076
Other	077

Canada Fitness Survey

STATION 2 (Con't)

BLOOD PRESSURE

Assure 5 minute rest period with no postural change prior to measurement.

Child cuff	078	☐1
Adult cuff		☐2
Large cuff		☐3
Resting heart rate	079	☐☐☐
Systolic	080	☐☐☐
Diastolic	081	☐☐☐
Refusal	082	☐1
Unable to obtain	082	☐2

If resting heart rate is greater than 100, or systolic is greater than 150, or diastolic is greater than 100, have respondent rest 5 minutes and then repeat measurements.

Resting heart rate	083	☐☐☐	Over 100	086 ☐
Systolic	084	☐☐☐	Over 150	087 ☐
Diastolic	085	☐☐☐	Over 100	088 ☐
Refusal				089 ☐1
Unable to obtain				☐2

ACTIVITIES OF DAILY LIVING

If one or more boxes in the right hand column under PAR-Q, OBSERVATION or BLOOD PRESSURE has been checked, ask the following questions
DO NOT COMPLETE STATION 2 OR 3

		With out diffi-culty	With minor diffi-culty	With major diffi culty	Not at all
Can you run 100 yards?	090	☐1	☐2	☐3	☐4
Can you walk 300 yards without resting?	091	☐	☐	☐	☐
Can you walk up or down one flight of stairs (8 steps) without resting?	092	☐	☐	☐	☐
Can you get in and out of bed?	093	☐	☐	☐	☐
Can you, when standing, bend down and pick up a shoe from the floor?	094	☐	☐	☐	☐
Can you carry an object of 10 pounds for 10 yards?	095	☐	☐	☐	☐
Can you cut your own food (such as meat, fruit, etc.)?	096	☐	☐	☐	☐
Can you get dressed by yourself?	097	☐	☐	☐	☐

ADULT DATA CARD

STEP TEST

Temperature	098	☐☐☐ °C
Refusal	099	☐
Pulse 1st	100	☐☐☐
2nd	101	☐☐☐
3rd	102	☐☐☐

If exercise was interupted or discontinued, specify reason

Final stage	103	☐
Systolic	104	☐☐☐
Diastolic	105	☐☐☐
Refusal	106	☐1
Unable to obtain		☐2
Systolic	107	☐☐☐
Diastolic	108	☐☐☐
Refusal	109	☐1
Unable to obtain		☐2
Heart rate	110	☐☐

STATION 3

GRIP STRENGTH

Right hand 1st	111	☐☐☐
2nd	112	☐☐☐
Max	113	☐☐☐
Refusal	114	☐1
Unable to obtain		☐2
Left hand 1st	115	☐☐☐
2nd	116	☐☐☐
Max	117	☐☐☐
Refusal	118	☐1
Unable to obtain		☐2
Total	119	☐☐☐

PUSH-UPS

Number	120	☐☐☐
Refusal	121	☐1
Screened out		☐2

TRUNK FLEXION

to nearest 0.5 cm	122	☐☐☐
	123	☐☐☐
Max	124	☐☐☐
Refusal	125	☐1
Screened out		☐2

SIT-UPS

Number in 60 sec.	126	☐☐☐
Refusal	127	☐1
Screened out		☐2

LONGITUDINAL DATA

Would you please give the name of three relatives or friends outside the household with whom we can keep in touch? (We are hoping to repeat this survey in 5 years. We ask this in case we have trouble to reach you and you are not living at this address.)

Name	128	
Relationship	129	
Address	130	
Name	131	
Relationship	132	
Address	133	
Name	134	
Relationship	135	
Address	136	

COMMENTS

CHILD DATA CARD

IDENTIFICATION

Docket number
Person number 001
Age 002
Sex 003 [ ]1 M [ ]2 F
Signed consent 004 [ ]1
Refusal [ ]2
Temporarily Absent [ ]3

STATION 1

WEIGHT

Weight – to nearest 0.1 kg 005
IF UNABLE TO MEASURE: Ask respondent to estimate weight and convert to kg 006
Refusal 007 [ ]1
Specify why measurement was not possible
Confined to bed or wheelchair [ ]2
Over scale value [ ]3
Other [ ]4

HEIGHT

Height – to nearest 0.1 cm 008
IF UNABLE TO MEASURE: Ask respondent to estimate height and convert to cm 009
Refusal 010 [ ]1
Specify why measurement was not possible
Confined to bed or wheelchair [ ]2
Severe curvature of the spine [ ]3
Other [ ]4

SKINFOLDS

Triceps – to nearest 0.2 mm 011, 012, 013
Mean 014
Refusal 015 [ ]1
Unable to obtain [ ]2

Subscapular – to nearest 0.2 mm 016, 017, 018
Mean 019
Refusal 020 [ ]1
Unable to obtain [ ]2

Biceps – to nearest 0.2 mm 021, 022, 023
Mean 024
Refusal 025 [ ]1
Unable to obtain [ ]2

Suprailiac – to nearest 0.2 mm 026, 027, 028
Mean 029
Refusal 030 [ ]1
Unable to obtain [ ]2

Medial calf – to nearest 0.2 mm 031, 032, 033
Mean 034
Refusal 035 [ ]1
Unable to obtain [ ]2

DIAMETERS

Humerus (right elbow) – to nearest 0.5 mm 036
Refusal 037 [ ]1
Unable to obtain [ ]2

Femur (right knee) – to nearest 0.5 mm 038
Refusal 039 [ ]1
Unable to obtain [ ]2

GIRTHS

Upper arm (right arm) – to nearest 0.1 cm 040
Refusal 041 [ ]1
Unable to obtain [ ]2

Chest – to nearest 0.1 cm 042
Refusal 043 [ ]1
Unable to obtain [ ]2

Abdomen – to nearest 0.1 cm 044
Refusal 045 [ ]1
Unable to obtain [ ]2

Gluteal – to nearest 0.1 cm 046
Refusal 047 [ ]1
Unable to obtain [ ]2

Thigh (right leg) – to nearest 0.1 cm 048
Refusal 049 [ ]1
Unable to obtain [ ]2

Calf (right leg) – to nearest 0.1 cm 050
Refusal 051 [ ]1
Unable to obtain [ ]2

STATION 2 — SCREENING

Is ________ limited for health reasons from doing strenuous physical activity at school and with friends? 052 [ ]1 No [ ]2

Has ________ been in the hospital or under a doctor's care in the last year? 053 [ ]1 No [ ]2

Has ________ now returned to normal activity at school and with friends, with no restrictions? 054 [ ]1 No [ ]2

Is there any reason why ____________ should not do moderately strenuous exercise such as climbing stairs, push-ups and sit-ups? 055 [ ]1 No [ ]2

OBSERVATION

Blindness ________ 062
Deafness ________ 063
Fever ________
Persistent cough ________
Muscular co-ordination or orthopedic problem ________
Limb problem (not serious enough to be screened out) ________ 064
Some indication of impairment from alcohol
Other: ________

CHILD DATA CARD

STATION 2 (Con't)

BLOOD PRESSURE

Assure 5 minute rest period with no postural change prior to measurement

Child cuff	078	[ ]1
Adult cuff		[ ]2
Large cuff		[ ]3
Resting heart rate	079	[ ]
Systolic	080	[ ]
Diastolic	081	[ ]
Refusal	082	[ ]1
Unable to obtain	082	[ ]2

If resting heart rate is greater than 100, or systolic is greater than 150, or diastolic is greater than 100, have respondent rest 5 minutes and then repeat measurements

Resting heart rate	083	[ ]	Over 100	086 [ ]
Systolic	084	[ ]	Over 150	087 [ ]
Diastolic	085	[ ]	Over 100	088 [ ]
Refusal				089 [ ]1
Unable to obtain				[ ]2

ACTIVITIES OF DAILY LIVING

If one or more boxes in the right hand column under PAR Q, OBSERVATION or BLOOD PRESSURE has been checked, ask the following questions
DO NOT COMPLETE STATION 2 OR 3

		With out difficulty	With minor difficulty	With major difficulty	Not at all
Can you run 100 yards?	090	[ ]1	[ ]2	[ ]3	[ ]4
Can you walk 300 yards without resting?	091	[ ]	[ ]	[ ]	[ ]
Can you walk up or down one flight of stairs (8 steps) without resting?	092	[ ]	[ ]	[ ]	[ ]
Can you get in and out of bed?	093	[ ]	[ ]	[ ]	[ ]
Can you, when standing, bend down and pick up a shoe from the floor?	094	[ ]	[ ]	[ ]	[ ]
Can you carry an object of 10 pounds for 10 yards?	095	[ ]	[ ]	[ ]	[ ]
Can you cut your own food (such as meat, fruit, etc.)?	096	[ ]	[ ]	[ ]	[ ]
Can you get dressed by yourself?	097	[ ]	[ ]	[ ]	[ ]

STEP TEST

Temperature	098	[ ] c
Refusal	099	[ ]
Pulse 1st	100	[ ]
2nd	101	[ ]
3rd	102	[ ]

If exercise was interupted or discontinued, specify reason

Final stage	103	[ ]
Systolic	104	[ ]
Diastolic	105	[ ]
Refusal	106	[ ]1
Unable to obtain		[ ]2
Systolic	107	[ ]
Diastolic	108	[ ]
Refusal	109	[ ]1
Unable to obtain		[ ]2
Heart rate	110	[ ]

STATION 3

GRIP STRENGTH

Right hand 1st	111	[ ]
2nd	112	[ ]
Max	113	[ ]
Refusal	114	[ ]1
Unable to obtain		[ ]2
Left hand 1st	115	[ ]
2nd	116	[ ]
Max	117	[ ]
Refusal	118	[ ]1
Unable to obtain		[ ]2
Total	119	[ ]

PUSH-UPS

Number	120	[ ]
Refusal	121	[ ]1
Screened out		[ ]2

TRUNK FLEXION

to nearest 0.5 cm

	122	[ ]
	123	[ ]
Max	124	[ ]
Refusal	125	[ ]1
Screened out		[ ]2

SIT-UPS

Number in 60 sec	126	[ ]
Refusal	127	[ ]1
Screened out		[ ]2

COMMENTS

1

PHYSICAL ACTIVITIES

WHAT YOU DO AT WORK OR AT SCHOOL OR IN THE HOME, PLUS YOUR ACTIVITY IN YOUR LEISURE TIME ALL CONTRIBUTE TO YOUR CURRENT LEVEL OF FITNESS. THE FOLLOWING QUESTIONS WILL PROVIDE A COMPLETE PICTURE OF ALL YOUR ACTIVITIES.

TO HELP YOU DESCRIBE YOUR ACTIVITIES, WE HAVE DESIGNED FOUR QUESTIONS – ONE FOR THOSE YOU DO DAILY, ONE FOR THOSE YOU DO EACH WEEK, ONE FOR THOSE YOU HAVE DONE IN THE LAST MONTH, AND THE FOURTH FOR THOSE ACTIVITIES YOU HAVE DONE IN THE LAST YEAR.

1. DAILY ACTIVITIES

For those activities which you do most days of the week (such as work, school and housework), how much time do you spend. . .

		Almost all of the time	About 3/4 of the time	About 1/2 of the time	About 1/4 of the time	Almost none of the time
Sitting	01	1	2	3	4	5
Standing	02	1	2	3	4	5
Walking	03	1	2	3	4	5
Walking up stairs	04	1	2	3	4	5
Lifting or carrying heavy objects	05	1	2	3	4	5

2. WEEKLY ACTIVITIES

Please refer to the reference card for a list of activities. Answer the following for the physical activities you do each week.

Light housework and handywork: washing dishes, ironing, making beds, mowing lawn, etc

Number of occasions each month: J F M (06)	A M J (07)	J A S (08)	O N D (09)	Average time actually spent on each occasion: Hrs (10)	Mins (11)	Intensity (12): Light – Slight change from normal	Medium – Some perspiration Above normal breathing	Heavy – Heavy perspiration Heavy breathing
						1	2	3

Heavy housework and handywork: washing and waxing floors, painting, etc

Number of occasions each month: J F M (13)	A M J (14)	J A S (15)	O N D (16)	Average time actually spent on each occasion: Hrs (17)	Mins (18)	Intensity (19): Light – Slight change from normal	Medium – Some perspiration Above normal breathing	Heavy – Heavy perspiration Heavy breathing
						1	2	3

Name of activity ______ 20 ______ 21

Number of occasions each month: J F M (22)	A M J (23)	J A S (24)	O N D (25)	Average time: Hrs (26)	Mins (27)	Intensity (28): Light	Medium	Heavy	Organized in levels or in a league (29): Yes	No	Competitive (30): Yes	No
						1	2	3	1	2	1	2

Name of activity ______ 31 ______ 32

Number of occasions each month: J F M (33)	A M J (34)	J A S (35)	O N D (36)	Average time: Hrs (37)	Mins (38)	Intensity (39): Light	Medium	Heavy	Organized (40): Yes	No	Competitive (41): Yes	No
						1	2	3	1	2	1	2

Name of activity ______ 42 ______ 43

Number of occasions each month: J F M (44)	A M J (45)	J A S (46)	O N D (47)	Average time: Hrs (48)	Mins (49)	Intensity (50): Light	Medium	Heavy	Organized (51): Yes	No	Competitive (52): Yes	No
						1	2	3	1	2	1	2

Name of activity ______ 53 ______ 54

Number of occasions each month: J F M (55)	A M J (56)	J A S (57)	O N D (58)	Average time: Hrs (59)	Mins (60)	Intensity (61): Light	Medium	Heavy	Organized (62): Yes	No	Competitive (63): Yes	No
						1	2	3	1	2	1	2

2

3. ACTIVITIES IN THE LAST MONTH

Please refer to the reference card for a list of activities. Answer the following for the physical activities you have done at least once in the last month. (**Do not include activities already listed in Weekly Activities.**)

Gardening and cultivating such as spading, digging, weeding

Occasions in the last month	Average time actually spent on each occasion Hrs	Mins	Intensity: Light (Slight Change from normal state)	Medium (Some perspiration Above normal breathing)	Heavy (Heavy perspiration Heavy breathing)
☐ 01	☐ 02	☐ 03	1 ☐ 04	2 ☐	3 ☐

Shovelling snow

Occasions in the last month	Average time actually spent on each occasion Hrs	Mins	Intensity: Light (Slight Change from normal state)	Medium (Some Perspiration Above normal breathing)	Heavy (Heavy perspiration Heavy breathing)
☐ 05	☐ 06	☐ 07	1 ☐ 08	2 ☐	3 ☐

Mowing the lawn (pushing a power mower)

Occasions in the last month	Average time actually spent on each occasion Hrs	Mins	Intensity: Light (Slight Change from normal state)	Medium (Some perspiration Above normal breathing)	Heavy (Heavy perspiration Heavy breathing)
☐ 09	☐ 10	☐ 11	1 ☐ 12	2 ☐	3 ☐

Name of activity ______ 13 ☐ 14

Occasions in the last month	Average time Hrs	Mins	Intensity: Light	Medium	Heavy	Organized in levels or in a league: Yes	No	Competitive: Yes	No
☐ 15	☐ 16	☐ 17	1 ☐ 18	2 ☐	3 ☐	1 ☐ 19	2 ☐	1 ☐ 20	2 ☐

Name of activity ______ 21 ☐ 22

Occasions in the last month	Average time Hrs	Mins	Intensity: Light	Medium	Heavy	Organized: Yes	No	Competitive: Yes	No
☐ 23	☐ 24	☐ 25	1 ☐ 26	2 ☐	3 ☐	1 ☐ 27	2 ☐	1 ☐ 28	2 ☐

Name of activity ______ 29 ☐ 30

Occasions in the last month	Average time Hrs	Mins	Intensity: Light	Medium	Heavy	Organized: Yes	No	Competitive: Yes	No
☐ 31	☐ 32	☐ 33	1 ☐ 34	2 ☐	3 ☐	1 ☐ 35	2 ☐	1 ☐ 36	2 ☐

Name of activity ______ 37 ☐ 38

Occasions in the last month	Average time Hrs	Mins	Intensity: Light	Medium	Heavy	Organized: Yes	No	Competitive: Yes	No
☐ 39	☐ 40	☐ 41	1 ☐ 42	2 ☐	3 ☐	1 ☐ 43	2 ☐	1 ☐ 44	2 ☐

Name of activity ______ 45 ☐ 46

Occasions in the last month	Average time Hrs	Mins	Intensity: Light	Medium	Heavy	Organized: Yes	No	Competitive: Yes	No
☐ 47	☐ 48	☐ 49	1 ☐ 50	2 ☐	3 ☐	1 ☐ 51	2 ☐	1 ☐ 52	2 ☐

Name of activity ______ 53 ☐ 54

Occasions in the last month	Average time Hrs	Mins	Intensity: Light	Medium	Heavy	Organized: Yes	No	Competitive: Yes	No
☐ 55	☐ 56	☐ 57	1 ☐ 58	2 ☐	3 ☐	1 ☐ 59	2 ☐	1 ☐ 60	2 ☐

3

4. ACTIVITIES IN THE LAST YEAR

Please refer to the reference card for a list of activities. Answer the following for the physical activities you have done in the last 12 months.
(Do not include activities you have already listed.)

	Months in which activity was done												Number of occasions in last 12 months	Average number of minutes spent on each occasion			
	J	F	M	A	M	J	J	A	S	O	N	D		15 or less	16 to 30	31 to 60	61 or more
	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17
Walking for exercise																	
Jogging (using short strides)																	
Running (using long strides)																	
Bicycling																	
	J	F	M	A	M	J	J	A	S	O	N	D		15 or less	16 to 30	31 to 60	61 or more
	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
Home exercise (push-ups, sit-ups)																	
Exercise classes																	
Weight training																	
Yoga																	
	J	F	M	A	M	J	J	A	S	O	N	D		15 or less	16 to 30	31 to 60	61 or more
	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51
Golf (walking and carrying clubs)																	
Racquetball																	
Squash																	
Tennis																	
	J	F	M	A	M	J	J	A	S	O	N	D		15 or less	16 to 30	31 to 60	61 or more
	52	53	54	55	56	57	58	59	60	61	62	63	64	66	66	67	68
Baseball																	
Softball																	
Ice hockey																	
Curling																	
	J	F	M	A	M	J	J	A	S	O	N	D		15 or less	16 to 30	31 to 60	61 or more
	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85
Swimming at a pool																	
Cross country skiing																	
Alpine/Downhill skiing																	
Ice skating																	
Names of activities:	J	F	M	A	M	J	J	A	S	O	N	D		15 or less	16 to 30	31 to 60	61 or more
86 87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104
	J	F	M	A	M	J	J	A	S	O	N	D		15 or less	16 to 30	31 to 60	61 or more
105 106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123

4

PHYSICAL ACTIVITY IN YOUR LEISURE TIME

5. Here is a list of reasons why some people do physical activities during their leisure time. How important is each of these **to you**?

	Very important	Of some importance	Of little importance	Of no importance
To feel better mentally and physically	01 ☐ 1	☐ 2	☐ 3	☐ 4
To be with other people	02 ☐ 1	☐ 2	☐ 3	☐ 4
For pleasure, fun or excitement	03 ☐ 1	☐ 2	☐ 3	☐ 4
To control weight or to look better	04 ☐ 1	☐ 2	☐ 3	☐ 4
To move better or to improve flexibility	05 ☐ 1	☐ 2	☐ 3	☐ 4
As a challenge to my abilities	06 ☐ 1	☐ 2	☐ 3	☐ 4
To relax or reduce stress	07 ☐ 1	☐ 2	☐ 3	☐ 4
To learn new things	08 ☐ 1	☐ 2	☐ 3	☐ 4
Because of fitness specialist's advice for improving health in general	09 ☐ 1	☐ 2	☐ 3	☐ 4
Because of doctor's orders for therapy or rehabilitation	10 ☐ 1	☐ 2	☐ 3	☐ 4
Other	11 ☐ 1	☐ 2	☐ 3	☐ 4

6. With whom do you *usually* do your physical activities in your leisure time?

12 ☐ No one
13 ☐ Friends
14 ☐ Immediate family or relatives
15 ☐ Co-workers
16 ☐ Classmates at school
17 ☐ Others

7. When do you *usually* do your physical activities? (Indicate one only.)

18 ☐ 1 Weekdays
☐ 2 Weekends
☐ 3 Both

8. At what time do you *usually* do your physical activities? (Indicate more than one if you usually do activities *more than once a day.*)

19 ☐ In the morning
20 ☐ At lunchtime
21 ☐ In the afternoon
22 ☐ In the evening
23 ☐ At no special time

9. Where do you *usually* do your physical activities? (Indicate one or more.)

24 ☐ Home
27 ☐ Work
30 ☐ School, college or university facility
25 ☐ Park
28 ☐ Recreational facility
31 ☐ Other
26 ☐ Commercial facility or private club
29 ☐ Outside using no special facility

10. How long have you been doing some physical activity in your leisure time at least once a week?

32 ☐ I don't do an activity each week
33 ☐ For less than 3 months
34 ☐ From 3 months to just under 6 months
35 ☐ From 6 months to just under 1 year
36 ☐ From 1 year to just under 3 years
37 ☐ From 3 years to just under 5 years
38 ☐ Five or more years

11. Comparing yourself to others of your own age and sex, would you say you are . . .

39 ☐ 1 More fit
☐ 2 Less fit
☐ 3 As fit

12. If you want to participate more in physical activities than you do now, why aren't you able to? (Check at most 3 reasons.)

- 01 ☐ I don't want to participate more
- 02 ☐ Ill health
- 03 ☐ Injury or handicap
- 04 ☐ Lack of energy
- 05 ☐ Lack of time because of work (school)
- 06 ☐ Lack of time because of other leisure activities
- 07 ☐ Costs too much
- 08 ☐ No facilities nearby
- 09 ☐ Available facilities are inadequate
- 10 ☐ No leaders available
- 11 ☐ Requires too much self-discipline
- 12 ☐ Lack the necessary skills
- 13 ☐ Other ____________

13. If you wanted to participate more in physical activities, which of the following would increase the amount of physical activity you do? (Check at most 3.)

- 14 ☐ Nothing
- 15 ☐ Better or closer facilities
- 16 ☐ Different facilities
- 17 ☐ Less expensive facilities
- 18 ☐ More information on the benefits of doing physical activity
- 19 ☐ Employer or union sponsored activities available
- 20 ☐ Organized sports available
- 21 ☐ Organized fitness classes available
- 22 ☐ Fitness test with personal activity program available
- 23 ☐ People with whom to participate
- 24 ☐ Common interest of family
- 25 ☐ Common interest of friends
- 26 ☐ More leisure time
- 27 ☐ Other ____________

14. Which of the following have you heard of?

- 28 ☐ Canadian Home Fitness Test
- 29 ☐ Canada Games
- 30 ☐ Canada Fitness Awards
- 31 ☐ FIT KIT
- 32 ☐ INFORMaction
- 33 ☐ PARTICIPaction
- 34 ☐ Standardized Test of Fitness
- 35 ☐ Fitness and Amateur Sport
- 36 ☐ Fitness Canada
- 37 ☐ 5 BX/10 BX
- 38 ☐ Exercise Break
- 39 ☐ Canada Fitness Facts

15. What is the name of your provincial fitness program?

- 40 ☐ No provincial program
- 41 ☐ Don't know

Name of program:

42 ____________

Office Use 43 ☐

PARTICIPACTION

16. Have you ever seen this symbol?

- 01 [1] Yes
- [2] No – Go to question 17
- [3] Not Sure – Go to question 17

Where have you heard of or seen the PARTICIPaction symbol or message? (Indicate all applicable.)

- 02 On television
- 07 On radio
- 12 In newspapers
- 03 In magazines
- 08 In booklets or pamphlets
- 13 On billboards
- 04 On posters
- 09 On buses or subways
- 14 On milk cartons
- 05 On T shirts
- 10 At school
- 15 At ParticiParks
- 06 In 'Fitness: The Facts'
- 11 Student notebooks
- 16 Don't know

17. Have you previously taken a physical fitness test?

- 17 [1] Yes
- [2] No – Go to question 18
- [3] Don't know – Go to question 18

What type of cardio-vascular (aerobic) exercise did this test use?

- 18 [1] Stepping
- [2] Treadmill
- [3] Walk/Jog/Run
- [4] Bicycle
- [5] Other ____________________

Where did you take this fitness test?

- 19 [1] YMCA/YWCA
- [2] Commercial club or facility
- [3] University
- [4] Work or school
- [5] Other ____________________

When did you take this test?

- 20 [1] In the last 6 months
- [2] From 6 months to 1 year ago
- [3] Over 1 year ago

Were you satisfied with the way the test was explained and administered?

- 21 [1] Very satisfied
- [2] Satisfied
- [3] Not at all satisfied

Has taking the fitness test increased the amount of physical activity you do?

- 22 [1] Yes
- [2] No
- [3] Don't know

18. In the past year, what physical activities have you stopped doing?
(*Do not include those stopped due to a change in the season.*)

23 [1] None or Activity ____________________ 24 — Office Use 25

Why did you stop doing this activity? ____________________ 26 — Office Use 27

Activity ____________________ 28 — Office Use 29

Why did you stop doing this activity? ____________________ 30 — Office Use 31

19. What physical activities would you like to start in order to improve your fitness and health?

01 ☐ None or Activity 02 ______ Office Use 03

What is the main reason you have not yet started this? 04 ______ Office Use 05

Activity 06 ______ Office Use 07

What is the main reason you have not yet started this? 08 ______ Office Use 09

Activity 10 ______ Office Use 11

What is the main reason you have not yet started this? 12 ______ Office Use 13

20. How important are each of the following to you in gaining a feeling of well being?

		Very Important	Of some Importance	Of little Importance	Of no Importance
Adequate rest and sleep	14	1	2	3	4
A good diet	15	1	2	3	4
Low calorie snacks between meals	16	1	2	3	4
Maintenance of proper weight	17	1	2	3	4
Participation in social and cultural activities	18	1	2	3	4
Control of stress	19	1	2	3	4
Regular physical activity such as exercise, sports or games	20	1	2	3	4
Using alcohol moderately or being a non-drinker	21	1	2	3	4
Being a non-smoker	22	1	2	3	4
Adequate medical and dental care	23	1	2	3	4
Positive thinking/meditation	24	1	2	3	4

LIFESTYLE AND YOUR HEALTH

21. What do you *usually* eat for breakfast? (*Usually means at least four days a week.*) Check all that apply.

- 25 ☐ I don't eat breakfast
- 26 ☐ Eggs
- 27 ☐ Bacon or other meat, fish or poultry
- 28 ☐ Bread, danish or donut
- 29 ☐ Granola
- 30 ☐ Other cereals
- 31 ☐ Fruit or fruit juice
- 32 ☐ At least 6 ounces of milk
- 33 ☐ Cheese
- 34 ☐ Yogurt
- 35 ☐ Tea or coffee

22. In the last year, have you been eating . . .

... sweet foods and candies	36	1 More	2 Less	3 Same amount as before
... fruit and vegetables	37	1 More	2 Less	3 Same amount as before
... fats and fried foods	38	1 More	2 Less	3 Same amount as before
... salt and salty food	39	1 More	2 Less	3 Same amount as before
... meals on a regular basis	40	1 More	2 Less	3 Same amount as before
... the same amount of food or calories	41	1 No, more	2 No, less	3 Same amount as before

23. About how often do you *usually* drink alcohol?

01
- 1 More than once a day
- 2 4 to 7 times a week
- 3 1 to 3 times a week
- 4 1 to 3 times a month
- 5 Less than once a month
- 6 I don't drink alcohol — Go to question 24

About how many drinks do you usually have at a time?

Where one drink is: — one pint of beer — 12 ounces
— one small glass of wine
— one shot of liquor or spirits
i.e. 1 - 1 1/2 ounces with or without mix.

02
- 1 One
- 2 Two or three
- 3 Four or five
- 4 Six or seven
- 5 Eight or more

24. Which of the following best describes your experience with tobacco. Check all that apply.

03
- 1 I haven't smoked

I currently smoke:

04
- 1 cigarettes occasionally
- 2 less than 1/2 pack of cigarettes daily
- 3 about a pack of cigarettes daily
- 4 two or more packs of cigarettes daily
- 5 a pipe, cigar or cigarillo occasionally
- 6 a pipe, cigar or cigarillo daily

I stopped smoking:

05
- 1 cigarettes recently
- 2 cigarettes over a year ago
- 3 a pipe, cigars or cigarillos recently
- 4 a pipe, cigars or cigarillos over a year ago

25. Here is a list that describes some of the ways people feel at different times. During the past few weeks, how often have you felt . . .

		Often	Sometimes	Never
On top of the world?	06	1	2	3
Very lonely or remote from other people?	07	1	2	3
Particularly excited or interested in something?	08	1	2	3
Depressed or unhappy?	09	1	2	3
Pleased about having accomplished something?	10	1	2	3
Bored?	11	1	2	3
Proud because someone complimented you on something you had done?	12	1	2	3
So restless you couldn't sit long in a chair?	13	1	2	3
That things were going your way?	14	1	2	3
Upset because someone criticized you?	15	1	2	3

26. About how many hours of sleep do you *usually* get each day?

01 [1] Six hours or less
[2] Seven
[3] Eight
[4] Nine
[5] Ten
[6] Eleven hours or more

27. Are you limited in the *type* or *amount* of work you can do (or school you can attend) because of an illness, injury or handicap?

02 [1] No
[2] Yes, because of a temporary illness
[3] Yes, because of a chronic or long-term illness
[4] Yes, because of a temporary injury
[5] Yes, because of a permanent injury or handicap

28. Are you limited in the *type* or *amount* of physical activity you can do during your leisure time because of an illness, injury or handicap?

03 [1] No
[2] Yes, because of a temporary illness
[3] Yes, because of a chronic or long-term illness
[4] Yes, because of a temporary injury
[5] Yes, because of a permanent injury or handicap

29. In general, how would you describe your state of health?

04 [1] Very good
[2] Good
[3] Average
[4] Poor
[5] Very Poor

SOME FACTS ABOUT YOU

30. Were you born in Canada?

05 [1] Yes
[2] No

31. What language do you use all or most of the time? Check one only.

06 [1] English
[2] French
[3] German
[4] Italian
[5] Ukrainian
[6] Other ______________

32. Is there another language that you are in the habit of using?

07 [1] None
[2] English
[3] French
[4] German
[5] Italian
[6] Ukrainian
[7] Other ______________

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33. Are you . . .

[1] Male 01 — [2] Female 01

34. How old are you?

[ ] Years 02

IF YOU ARE 14 YEARS OF AGE OR YOUNGER,
YOU HAVE FINISHED THE QUESTIONNAIRE.

THANK YOU!

WE WOULD BE GRATEFUL FOR YOUR COMMENTS.
A SPACE FOR THIS HAS BEEN LEFT ON THE LAST PAGE.

IF YOU ARE 15 YEARS OF AGE OR OLDER, . . .

35. What is your present marital status? Are you presently . . .

- [1] Married 03
- [2] Widowed
- [3] Divorced
- [4] Separated
- [5] Single (Never married)

36. What is the highest level of education you have reached?

- [1] Elementary or less 04
- [2] Some secondary
- [3] Secondary diploma
- [4] Some post-secondary
- [5] Post-secondary diploma or certificate
- [6] Community college or CEGEP diploma
- [7] One or more University degrees

37. Are you . . . (Check all that apply.)

- [1] Retired 05
- [2] Employed full-time
- [3] Employed part-time
- [4] Student full-time
- [5] Student part-time
- [6] Homemaker/Housewife full-time
- [7] Homemaker/Housewife part-time
- [8] Unemployed or on strike
- [9] Other ______________________

38. How many hours a week do you spend doing your main activity? (work, going to school, housework)

[ ] hours 06

39. How many hours a week do you spend doing other chores?

[ ] hours 07

40. How many hours a week do you have for doing leisure activities?

[ ] hours 08

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11

41. Have you worked or had a job in the past 2 weeks?

☐ 1 Yes (01)

☐ 2 No – Go to question 43

What kind of work do you do? (eg. posting invoices, selling shoes, etc.) Please provide as much detail as possible.

02 ____________________

03 ____________________

For whom do you work? (Name of business, government department, agency, person, or are you self employed?)

04 ____________________

05 ____________________

What kind of business, industry or service is this? (eg. paper box manufacturing, retail shoe store, municipal board of education.)

06 ____________________

07 ____________________

42. Is there an opportunity for physical recreation where you work?

☐ 1 Yes, at lunch (08)

☐ 2 Yes, at coffee break

☐ 3 Yes, after work

☐ 4 No (08)

43. Approximately what was your family's total income last year, before taxes?

☐ 1 Less than $5,000 (09)

☐ 2 $5,000 to $9,999

☐ 3 $10,000 to 14,999

☐ 4 $15,000 to $24,999

☐ 5 $25,000 to $29,999 (09)

☐ 6 $30,000 to $35,000

☐ 7 Over $35,000

☐ 8 Don't know

APPENDIX B
1988 CAMPBELL'S SURVEY ON WELL-BEING IN CANADA

YOUR LIFESTYLE

1. In a typical week, how many hours do you spend doing the following activities?

	hours per week					
	0	1-2	3-4	5-9	10-14	15 or more
watching television	☐	☐	☐	☐	☐	☐
reading	☐	☐	☐	☐	☐	☐
crafts or hobbies done mainly on your own	☐	☐	☐	☐	☐	☐
visiting with relatives	☐	☐	☐	☐	☐	☐
visiting with friends	☐	☐	☐	☐	☐	☐
attending cultural events (such as musical performances or plays)	☐	☐	☐	☐	☐	☐
organizing or coaching physical activity or sport programs as a volunteer	☐	☐	☐	☐	☐	☐
involvement with religious groups or church activity	☐	☐	☐	☐	☐	☐
involvement in service or fraternal organizations such as hospital auxiliary, Rotary or Shriners	☐	☐	☐	☐	☐	☐
involvement with social or entertainment groups such as a card club or a cooking club	☐	☐	☐	☐	☐	☐
other group activities (please specify):						
activity: ______________________	☐	☐	☐	☐	☐	☐
activity: ______________________	☐	☐	☐	☐	☐	☐

2. Spare time provides a chance to reach many different goals. How important is it to you to reach each of these goals in <u>your</u> spare time?

	very important				not at all important
just relaxing, forgetting about your cares	☐	☐	☐	☐	☐
getting together with other people	☐	☐	☐	☐	☐
having fun	☐	☐	☐	☐	☐
earning money	☐	☐	☐	☐	☐
getting outdoors	☐	☐	☐	☐	☐
competing, winning	☐	☐	☐	☐	☐
feeling independent	☐	☐	☐	☐	☐
feeling better mentally	☐	☐	☐	☐	☐
feeling better physically	☐	☐	☐	☐	☐
improving/maintaining physical fitness	☐	☐	☐	☐	☐
challenging your abilities, learning new things	☐	☐	☐	☐	☐
looking better, controlling your weight	☐	☐	☐	☐	☐
taking risks, seeking adventure	☐	☐	☐	☐	☐

3. Which of the following best describes your experience with tobacco? *(Check all that apply.)*

I have never smoked : ☐

I stopped smoking cigarettes: ☐ recently
☐ over a year ago → ⌊_⌋ years ago

I stopped smoking a pipe, cigar or cigarillos: ☐ recently
☐ over a year ago

I currently smoke: ☐ cigarettes occasionally
☐ less than 1/2 pack daily
☐ about a pack daily
☐ 2 or more packs daily
☐ a pipe, cigars or cigarillos

4. Does your spouse (or mate) currently smoke cigarettes, a pipe, cigars or cigarillos?

does not smoke: ☐

currently smokes: ☐ cigarettes
☐ a pipe, cigars, cigarillos

don't have a spouse (or mate): ☐

5. How many close relatives do you have -- people that you can talk to about private matters, and can call on for help?

⌊_⌋ close relatives

6. How many close friends do you have that you feel really close to -- people that you can talk to about private matters, and can call on for help?

⌊_⌋ close friends

7. Does your spouse (or mate) exercise regularly?

☐ yes
☐ no
☐ don't have one

8. Of your other relatives and friends, how many exercise regularly?

⌊_⌋ relatives

⌊_⌋ friends

☐ none exercise regularly

PHYSICAL ACTIVITY IN YOUR SPARE TIME

9. The following activities refer to physical activities that are not related to work. Have you done any of the following physical activities in the past 12 months?

Please indicate whether you have done each activity listed below. Then for those activities which you have done, please complete the number of times done each month, and the average time spent on each occasion (not counting travel time, changing etc.).

			Number of times each month												Average time per occasion	
	No	Yes	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	hrs	min
walking for exercise	☐	☐														
bicycling	☐	☐														
jogging or running	☐	☐														
home exercises	☐	☐														
exercise class, aerobics	☐	☐														

	No	Yes	J	F	M	A	M	J	J	A	S	O	N	D	hrs	min
ice skating	☐	☐														
cross-country skiing	☐	☐														
downhill skiing	☐	☐														
ice hockey	☐	☐														
swimming	☐	☐														

	No	Yes	J	F	M	A	M	J	J	A	S	O	N	D	hrs	min
gardening, yard work	☐	☐														
golf	☐	☐														
tennis	☐	☐														
weight training	☐	☐														
baseball, softball	☐	☐														

	No	Yes	J	F	M	A	M	J	J	A	S	O	N	D	hrs	min
popular or social dance	☐	☐														
ballet, modern or jazz dance	☐	☐														
square or folk dance	☐	☐														
bowling	☐	☐														

Please refer to the Physical Activity Reference Card and list any other activities that you have done in the past 12 months.

	J	F	M	A	M	J	J	A	S	O	N	D	hrs	min
________														
________														
________														
________														
________														

10. In the past year, did you <u>stop</u> doing any physical activity in your spare time (not including any activity stopped because of a change in season)?

☐ No

☐ Yes: What was it? ______

What was the main reason for stopping?

______

Any other activity? ______

What was the main reason for stopping?

______

11. Have you done some physical activity at least once a week during the past 3 months?

☐ No

☐ Yes: Which exercise or sport activity contributed most to your fitness during the past 3 months?

______

b. Was this activity... *(Check all that apply.)*

- ☐ scheduled at specific times
- ☐ directed by an instructor or supervisor
- ☐ competitive, with organized tournaments, leagues or races
- ☐ casual, freely scheduled with little or no direction from an instructor

c. What usually happened to your heart rate and breathing when you did this activity? Was it ... *(Choose one.)*

- ☐ a little faster than normal
- ☐ a lot faster but talking was possible
- ☐ so fast that talking was impossible
- ☐ unchanged

d. How long have you been doing some physical activity in your spare time at least once a week?

- ☐ less than 3 months
- ☐ 4-6 months
- ☐ 6 months to just under 1 year
- ☐ 1-2 years
- ☐ 3-4 years
- ☐ 5-7 years
- ☐ more than 7 years (since before 1981)

12. Comparing your activity in your spare time during the last 12 months with 3 to 4 years ago, would you say you are... *(Choose one.)*

- ☐ much more physically active
- ☐ a little more physically active
- ☐ a little less physically active
- ☐ much less physically active
- ☐ about the same -- I have always been active
- ☐ about the same -- I have never been active

13. Compared to other people your age when you were 15 years old, would you say you were...

much more active ☐ ☐ ☐ ☐ ☐ much less active

14. Compared to the way other people your age spend their spare time, would you say you are...

much more active ☐ ☐ ☐ ☐ ☐ much less active

15. With whom do you usually do your physical activities in your spare time? *(Choose one.)*

☐ no one
☐ friends
☐ immediate family
☐ co-workers
☐ classmates at school
☐ others

16. Where do you usually do your physical activities in your spare time? *(Choose one.)*

☐ home
☐ park
☐ recreational facility
☐ work
☐ commercial facility or private club
☐ outside using no special facility
☐ school, college or university facility
☐ other

17.. Are there any exercise or sports activities you would like to start in the next year?

☐ No

☐ Yes: First choice: ______________________

Second choice: ______________________

18. How important are the following in preventing you from being more physically active?

	very important				not at all important
lack of time due to work or school	☐	☐	☐	☐	☐
lack of time due to family obligations	☐	☐	☐	☐	☐
lack of time due to other interests	☐	☐	☐	☐	☐
lack of energy, too tired	☐	☐	☐	☐	☐
lack of athletic ability	☐	☐	☐	☐	☐
lack of programs, leaders or accessible facilities	☐	☐	☐	☐	☐
lack of a partner	☐	☐	☐	☐	☐
lack of support from family or friends	☐	☐	☐	☐	☐
lack of babysitting services	☐	☐	☐	☐	☐
cost	☐	☐	☐	☐	☐
lack of self-discipline or willpower	☐	☐	☐	☐	☐
self-conscious, ill at ease	☐	☐	☐	☐	☐
long-term illness, disability or injury	☐	☐	☐	☐	☐
fear of injury	☐	☐	☐	☐	☐

OPINIONS ABOUT VIGOROUS PHYSICAL ACTIVITY

For the next few questions, regular participation in vigorous physical activity means doing some activity in your spare time:

- 3 or more times each week,
- for 20 minutes or more each time, and
- at a level which causes your breathing to be a lot faster, but at which talking is still possible

19. How do you feel about participating regularly in vigorous physical activity? Do you think it is...

boring	☐	☐	☐	☐	☐	fun
beneficial	☐	☐	☐	☐	☐	harmful
unpleasant	☐	☐	☐	☐	☐	pleasant
convenient	☐	☐	☐	☐	☐	inconvenient
painful	☐	☐	☐	☐	☐	not painful
easy	☐	☐	☐	☐	☐	difficult

20. All things considered, how much choice do you have over whether you participate regularly in vigorous physical activity?

completely my choice	☐	☐	☐	☐	☐	too many constraints imposed on me

21. How much do the following people encourage you to participate regularly in vigorous physical activity?

	doesn't apply don't have one	encourages me, very supportive				discourages me, very negative
spouse, boyfriend, girlfriend	☐	☐	☐	☐	☐	☐
parents	☐	☐	☐	☐	☐	☐
son, daughter	☐	☐	☐	☐	☐	☐
other family members	☐	☐	☐	☐	☐	☐
most of your close friends	☐	☐	☐	☐	☐	☐
your employer	☐	☐	☐	☐	☐	☐
your doctor	☐	☐	☐	☐	☐	☐

22. How much does (or would) participation in vigorous physical activity help you to....
(Please answer whether or not you are now active in your spare time.)

	a great deal				not at all
relax, forget about your cares	☐	☐	☐	☐	☐
get together with other people	☐	☐	☐	☐	☐
have fun	☐	☐	☐	☐	☐
earn money	☐	☐	☐	☐	☐
get outdoors	☐	☐	☐	☐	☐
compete, win	☐	☐	☐	☐	☐
feel independent	☐	☐	☐	☐	☐
feel better mentally	☐	☐	☐	☐	☐
feel better physically	☐	☐	☐	☐	☐
challenge your abilities, learn new things	☐	☐	☐	☐	☐
look better	☐	☐	☐	☐	☐
control / lose weight	☐	☐	☐	☐	☐
take risks, seek adventure	☐	☐	☐	☐	☐
improve/maintain overall physical fitness	☐	☐	☐	☐	☐
improve/maintain cardiovascular fitness	☐	☐	☐	☐	☐
improve/maintain muscular strength and endurance	☐	☐	☐	☐	☐
improve/maintain flexibility	☐	☐	☐	☐	☐

23. Would you agree or disagree that, if you wanted to, you could easily participate in vigorous physical activity 3 or more times a week for at least 20 minutes at a time?

strongly agree ☐ ☐ ☐ ☐ ☐ strongly disagree

24. In the coming year, how often do you intend to participate regularly in vigorous physical activity?

- ☐ never
- ☐ less than once a week
- ☐ 1-2 times per week
- ☐ 3 times per week
- ☐ 4-5 times per week
- ☐ 6 or more times a week

NUTRITION

25. In answering the following questions, think about your typical eating pattern. For each food listed, please give the number of servings eaten on a typical day and then the average number of days each week that you eat this type of food.

Servings are defined on the reference card. For a combination dish, such as pizza, casserole or soup, please try to break it down into individual ingredients. For example, one slice of pizza includes bread, cheese and perhaps meat.

How often do you have ...	never or less than once a week	servings per day	days per week
red meat (beef, pork, lamb, liver, etc.)	☐	⊔	⊔
processed meats (bacon, hot dogs, cold cuts, etc.)	☐	⊔	⊔
chicken, turkey, other poultry	☐	⊔	⊔
fish	☐	⊔	⊔
eggs	☐	⊔	⊔
dried beans, dried peas, nuts	☐	⊔	⊔

	never <1 a week	servings per day	days per week
vegetable juice	☐	⊔	⊔
yellow vegetables (carrots, squash, sweet potato, etc.)	☐	⊔	⊔
green vegetables (broccoli, green beans, cabbage, spinach, etc.)	☐	⊔	⊔
potato	☐	⊔	⊔
other vegetables including tomatoes	☐	⊔	⊔
oranges, grapefruit, lemons	☐	⊔	⊔
orange, grapefruit, or lemon juice	☐	⊔	⊔
other fruit (apples, bananas, peaches, etc.)	☐	⊔	⊔
other fruit juice	☐	⊔	⊔

	never <1 a week	servings per day	days per week
milk (whole or evaporated)	☐	⊔	⊔
milk (2%, skim, buttermilk)	☐	⊔	⊔
milk products (puddings, yogurt, ice cream)	☐	⊔	⊔
cheese and cheese products (whole)	☐	⊔	⊔
cheese and cheese products (low fat)	☐	⊔	⊔
bread, muffins, cereals etc. made from whole grains	☐	⊔	⊔
bread, muffins, cereals etc. made with refined white flour	☐	⊔	⊔
rice, pasta (macaroni, spaghetti, etc.)	☐	⊔	⊔
margarine, vegetable oils, salad dressings, butter	☐	⊔	⊔

	never <1 a week	servings per day	days per week
sweets (soft drinks, cookies, cakes, pie, sweet cereals, jams, jellies, candy, donuts, etc.)	☐	⊔	⊔
sugar added at the table	☐	⊔	⊔
salt added at the table	☐	⊔	⊔
salty snacks (potato chips, pretzels, etc.)	☐	⊔	⊔
tea, coffee	☐	⊔	⊔
alcohol (beer or wine or liquor)	☐	⊔	⊔
other ______________________________	☐	⊔	⊔

26. How often do you eat the following store-bought foods?

	never or less than once a week	servings per day	days per week
frozen meals	☐	└┘	└┘
frozen vegetables	☐	└┘	└┘
canned vegetables	☐	└┘	└┘
frozen desserts and pastries	☐	└┘	└┘
fresh baked goods	☐	└┘	└┘
canned soup	☐	└┘	└┘

27. How many days per week do you...

	days per week
eat small amounts all day rather than any regular meals	└┘
replace 1 or 2 regular meals by eating small amounts	└┘
eat 3 regular meals	└┘
eat breakfast (not just coffee or tea)	└┘
eat at a restaurant, take-out, or snack bar	└┘

28. Compared to about 6 or 7 years ago, that is in 1981, have you been consuming more, less, or the same amount of:

	same as before	more	less		When did you make this change? less than 12 months ago	more than 12 months ago
red meat	☐	☐	☐	→	☐	☐
poultry	☐	☐	☐	→	☐	☐
fish	☐	☐	☐	→	☐	☐
fruit and vegetables	☐	☐	☐	→	☐	☐
fats and fried foods	☐	☐	☐	→	☐	☐
sugar and sweet foods	☐	☐	☐	→	☐	☐
salt and salty food	☐	☐	☐	→	☐	☐
store-bought, prepared foods	☐	☐	☐	→	☐	☐
total calories	☐	☐	☐	→	☐	☐
meals on a regular basis	☐	☐	☐	→	☐	☐
whole grain cereals	☐	☐	☐	→	☐	☐
low-fat dairy products	☐	☐	☐	→	☐	☐
alcohol (beer or wine or liquor)	☐	☐	☐	→	☐	☐

29. At what weight do you look your best? └┴┴┘ lbs <u>or</u> └┴┴┘ kg

30. Do you watch what you eat, for health reasons?

☐ No ☐ Yes

Do you take dietary measures to... *(Check all that apply.)*

- lose weight ☐
- maintain weight ☐
- prevent specific health problems ☐
- control heart disease ☐
- control high blood pressure ☐
- control diabetes ☐
- control food allergies ☐
- another reason: ☐

____

____

31. Are you on a diet prescribed for you by a doctor or dietitian?

☐ No ☐ Yes

32. How often do you...

	very often				never
eat second helpings	☐	☐	☐	☐	☐
avoid sugar and sweet foods	☐	☐	☐	☐	☐
avoid salt and salty foods	☐	☐	☐	☐	☐
choose broiling, roasting, etc. over frying	☐	☐	☐	☐	☐
use artificial sweeteners instead of sugar	☐	☐	☐	☐	☐
trim visible fat off meat	☐	☐	☐	☐	☐
remove skin from chicken	☐	☐	☐	☐	☐
choose diet food and drinks over regular	☐	☐	☐	☐	☐
induce vomiting, take laxatives to lose weight	☐	☐	☐	☐	☐
take appetite suppressants	☐	☐	☐	☐	☐
choose foods high in calcium	☐	☐	☐	☐	☐

YOUR HEALTH AND WELL-BEING

33. How important is each of the following to your health?

	very important				not at all important
adequate rest and sleep	☐	☐	☐	☐	☐
good diet	☐	☐	☐	☐	☐
maintaining proper weight	☐	☐	☐	☐	☐
participation in social and cultural activities	☐	☐	☐	☐	☐
control of stress	☐	☐	☐	☐	☐
regular physical activity such as exercise, sports or games	☐	☐	☐	☐	☐
a smoke-free environment	☐	☐	☐	☐	☐

34. Here is a list of how people feel at different times. During the past few weeks, how often have you felt ....

	often	sometimes	never
on top of the world	☐	☐	☐
very lonely or remote from other people	☐	☐	☐
particularly excited or interested in something	☐	☐	☐
depressed or very unhappy	☐	☐	☐
pleased about having accomplished something	☐	☐	☐
bored	☐	☐	☐
proud because someone complimented you on something you had done	☐	☐	☐
so restless you couldn't sit long in a chair	☐	☐	☐
that things were going your way	☐	☐	☐
upset because someone criticized you	☐	☐	☐
stressed	☐	☐	☐

35. Are you limited in the type or amount of work you can do (or school you can attend) because of illness, injury or handicap? *(Check all that apply.)*

☐ no
☐ yes, because of a temporary illness
☐ yes, because of a long-term illness
☐ yes, because of a temporary injury
☐ yes, because of a permanent injury or handicap

36. Are you limited in the amount of leisure-time physical activity you can do because of illness, injury or handicap? *(Check all that apply.)*

☐ no
☐ yes, because of a temporary illness
☐ yes, because of a long-term illness
☐ yes, because of a temporary injury
☐ yes, because of a permanent injury or handicap

37. Did your mother or your father ever have . . .

	Mother yes	Mother no	Mother don't know	Father yes	Father no	Father don't know
heart disease	☐	☐	☐	☐	☐	☐
high blood pressure	☐	☐	☐	☐	☐	☐
diabetes, non-insulin-dependent	☐	☐	☐	☐	☐	☐
diabetes, insulin-dependent	☐	☐	☐	☐	☐	☐
a stroke	☐	☐	☐	☐	☐	☐
cancer	☐	☐	☐	☐	☐	☐
overweight problem	☐	☐	☐	☐	☐	☐

38. Do you presently have...

	no	yes	for how many years?
anemia	☐	☐ →	└─┴─┘
skin allergies	☐	☐ →	└─┴─┘
hay fever or other allergies	☐	☐ →	└─┴─┘
asthma	☐	☐ →	└─┴─┘
arthritis or rheumatism	☐	☐ →	└─┴─┘
lower back problems	☐	☐ →	└─┴─┘
cancer	☐	☐ →	└─┴─┘
diabetes, non-insulin-dependent	☐	☐ →	└─┴─┘
diabetes, insulin-dependent	☐	☐ →	└─┴─┘
cerebral palsy	☐	☐ →	└─┴─┘
emphysema or chronic bronchitis	☐	☐ →	└─┴─┘
any emotional disorders	☐	☐ →	└─┴─┘
epilepsy	☐	☐ →	└─┴─┘
high blood pressure	☐	☐ →	└─┴─┘
heart or circulation problems	☐	☐ →	└─┴─┘
paralysis of the arms	☐	☐ →	└─┴─┘
paralysis of the legs	☐	☐ →	└─┴─┘
kidney problems	☐	☐ →	└─┴─┘
stomach or intestinal ulcer	☐	☐ →	└─┴─┘
thyroid trouble or goiter	☐	☐ →	└─┴─┘
recurring migraine headaches	☐	☐ →	└─┴─┘
missing arm(s) or hand(s)	☐	☐ →	└─┴─┘
missing leg(s) or foot (feet)	☐	☐ →	└─┴─┘

39. Do you have any other long-term illness or impairment not listed above?

☐ no ☐ yes: What is it? ______________________

Any others? ______________________

____

____

40. The next question asks about trouble you have doing certain activities even when using a special aid. Report only those problems which you expect to last 6 months or more.

Do you have any trouble...	have trouble	no trouble
hearing what is said in a normal conversation with one other person?	☐	☐
hearing what is said in a group conversation with at least three other people?	☐	☐
reading ordinary newsprint, with glasses if normally worn?	☐	☐
seeing clearly the face of someone from 12 feet (4 metres), with glasses if normally worn?	☐	☐
speaking and being understood?	☐	☐
walking 400 yards (400 metres) without resting?	☐	☐
walking up and down a flight of stairs?	☐	☐
carrying an object of 10 pounds for 30 feet (5 kg for 10 metres)?	☐	☐
moving from one room to another?	☐	☐
standing for long periods of time, that is for more than 20 minutes?	☐	☐
when standing, bending down and picking up an object from the floor?	☐	☐
dressing and undressing yourself?	☐	☐
getting in and out of bed?	☐	☐
cutting your own toenails?	☐	☐
using your fingers to grasp and handle?	☐	☐
reaching in any direction?	☐	☐
cuting your own food?	☐	☐

41. In the past 12 months, have you suffered an injury as a result of doing sports or exercise?

☐ no ☐ yes: Most recent injury: ______________________

What activity? ______________________

For how long did this injury prevent you from . . .

working or studying: └┴┘ days or └┴┘ weeks or └┴┘ months

exercising: └┴┘ days or └┴┘ weeks or └┴┘ months

42. **During the last 12 months...**

...did you see or talk to a doctor about your health?

☐ no ☐ yes: how many times? └┴┘ times

...did you see or talk to any other kind of health professional?

☐ no ☐ yes: how many times? └┴┘ times

...how many nights did you spend a in hospital, a nursing home or a convalescent home?

☐ none or └┴┘ nights

43. **During the past two weeks...**

...how many days did you stay in bed all or most of the day because of illness, injury or some other health problem?

☐ none or ⌊_⌋ days

How many of these days were work or school days?

☐ none or ⌊_⌋ days

... not counting days in bed, how many days did your health keep you from your normal activities?

☐ none or ⌊_⌋ days

How many of these days were work or school days?

☐ none or ⌊_⌋ days

44. Below is a list of how you might have felt or behaved. Please indicate how often you have felt this way in the past week. During the past week...

	less than one day	1-2 days	3-4 days	5-7 days
I was bothered by things that don't usually bother me.	☐	☐	☐	☐
I did not feel like eating; my appetite was poor.	☐	☐	☐	☐
I felt that I could not shake off the blues even with help from my family or friends	☐	☐	☐	☐
I felt that I was just as good as other people.	☐	☐	☐	☐
I had trouble keeping my mind on what I was doing.	☐	☐	☐	☐
I felt depressed.	☐	☐	☐	☐
I felt that everything I did was an effort.	☐	☐	☐	☐
I felt hopeful about the future.	☐	☐	☐	☐
I thought my life had been a failure.	☐	☐	☐	☐
I felt fearful.	☐	☐	☐	☐
My sleep was restless.	☐	☐	☐	☐
I was happy.	☐	☐	☐	☐
I talked less than usual.	☐	☐	☐	☐
I felt lonely.	☐	☐	☐	☐
People were unfriendly.	☐	☐	☐	☐
I enjoyed life.	☐	☐	☐	☐
I had crying spells.	☐	☐	☐	☐
I felt sad.	☐	☐	☐	☐
I felt that people disliked me.	☐	☐	☐	☐
I could not get "going".	☐	☐	☐	☐

45. What do you consider to be your ideal weight from the point of view of health?

⌊_⌋ lbs or ⌊_⌋ kg

46. In general, how would you describe your state of health?

☐ very good
☐ good
☐ average
☐ poor
☐ very poor

ABOUT YOU

47. Are you ...

☐ male? ☐ female?

48. What is your date of birth?

|__|__| day |__|__| month |__|__| year

49. Where were you born?

☐ Newfoundland
☐ Nova Scotia
☐ New Brunswick
☐ Prince Edward Island
☐ Quebec
☐ Ontario
☐ Manitoba
☐ Saskatchewan
☐ Alberta
☐ British Columbia
☐ Northwest Territories
☐ Yukon
☐ outside of Canada: ____________________

50. What language did you first learn at home?

☐ English
☐ French
☐ German
☐ Italian
☐ Ukrainian
☐ other

51. What is your marital status?

☐ married (including a common-law relationship)
☐ widowed
☐ divorced
☐ separated
☐ single (never married)

52. How would you describe yourself? *(Check all that apply.)*

☐ student full-time
☐ student part-time
☐ homemaker full-time
☐ homemaker part-time
☐ employed full-time
☐ employed part-time
☐ retired: since ______
☐ unemployed or on strike: since ______

other: ____________________

53. What is the highest level of education you have reached?
If you are a student, please indicate your current level of education.

☐ elementary or less
☐ some secondary school
☐ secondary diploma
☐ some post-secondary
☐ community college or CEGEP diploma
☐ one or more university degrees

54. About how many years have you lived in this province?

└─┴─┘ years

55. About how many years have you lived in this city?

└─┴─┘ years

56. About how many years have you lived in this neighbourhood?

└─┴─┘ years

57. What are the highest levels of education your father and your mother reached?

Father's education:

- ☐ elementary or less
- ☐ some secondary school
- ☐ secondary diploma
- ☐ some post-secondary
- ☐ post-secondary diploma or certificate
- ☐ one or more university degrees

Mother's education:

- ☐ elementary or less
- ☐ some secondary school
- ☐ secondary diploma
- ☐ some post-secondary
- ☐ post-secondary diploma or certificate
- ☐ one or more university degrees

58. Where were your father and mother born?

Father:

- ☐ Newfoundland
- ☐ Nova Scotia
- ☐ New Brunswick
- ☐ Prince Edward Island
- ☐ Quebec
- ☐ Ontario
- ☐ Manitoba
- ☐ Saskatchewan
- ☐ Alberta
- ☐ British Coloumbia
- ☐ Northwest Territories
- ☐ Yukon
- ☐ outside of Canada

Mother:

- ☐ Newfoundland
- ☐ Nova Scotia
- ☐ New Brunswick
- ☐ Prince Edward Island
- ☐ Quebec
- ☐ Ontario
- ☐ Manitoba
- ☐ Saskatchewan
- ☐ Alberta
- ☐ British Coloumbia
- ☐ Northwest Territories
- ☐ Yukon
- ☐ outside of Canada

59. What kind of work do you do?

☐ am not working

Please provide as much detail as possible (e.g. posting invoices, selling shoes).

____

____

b. For whom do you work? Please indicate what kind of business, industry or service this is (e.g. retail shoe store, paper box manufacturing, board of education, government department, self-employed carpentry).

____

c. How many people are you in charge of at work (including those directly and indirectly under your supervision)?

☐ none
☐ 1
☐ 2 to 4
☐ 5 to 10
☐ 11 to 49
☐ 50 to 99
☐ 100 or more

d. How many hours per week do you normally work at your job?

__ __ hours

e. Do you have any of the following at or near your place of work?

☐ pleasant places to walk, jog or wheel
☐ showers or change rooms
☐ playing fields or open spaces for ball games, etc.
☐ organized recreational sport teams
☐ organized fitness classes
☐ other physical activities

f. At work, do you have...

☐ programs to improve health, physical fitness or nutrition
☐ a total ban on smoking
☐ smoking restricted to designated areas

g. At work, how much time do you spend....

	almost all	about 3/4	about 1/2	about 1/4	almost none
sitting	☐	☐	☐	☐	☐
standing	☐	☐	☐	☐	☐
walking, wheeling	☐	☐	☐	☐	☐
walking up and down stairs	☐	☐	☐	☐	☐
lifting or carrying heavy objects	☐	☐	☐	☐	☐

h. Comparing your present physical activity level at work with 6 or 7 years ago, that is in 1981, would you say you're...

much more active ☐ ☐ ☐ ☐ ☐ much less active

60. Before taxes, approximately what were your total personal and total household incomes last year?

Total personal income:
- ☐ less than $10,000
- ☐ $10,000 - $14,000
- ☐ $15,000 - $19,000
- ☐ $20,000 - $24,000
- ☐ $25,000 - $34,000
- ☐ $35,000 - $54,000
- ☐ $55,000 and over

Total household income:
- ☐ less than $10,000
- ☐ $10,000 - $14,000
- ☐ $15,000 - $19,000
- ☐ $20,000 - $24,000
- ☐ $25,000 - $34,000
- ☐ $35,000 - $54,000
- ☐ $55,000 and over

INFORMATION FOR FUTURE FOLLOW-UP

Would you please give the names of two relatives or friends outside this household with whom you keep in touch? (We are hoping to repeat this survey in 5 years. We ask this in case we should want to reach you and you are no longer living at this address.)

Name ______________________________

Address ______________________________

____

______________________________ Relationship ______________

Name ______________________________

Address ______________________________

____

______________________________ Relationship ______________

Would you please give your provincial health insurance number? (We are asking for this number so that we may have access to health records in future. The number will be used only for this purpose and will be kept strictly confidential.)

Health Plan Number: ______________________________

This completes the questionnaire portion of the survey.
Thank you for participating.

PHYSICAL MEASUREMENTS

Signed Consent ☐ no-stop ☐ yes-proceed

Station 1

Weight |_|_|_|.|_| kg or |_|_|_|.|_| estimated ☐ lbs ☐ kg

Height |_|_|_|.|_| cm or |_|_|_|.|_| estimated ☐ in ☐ cm

Skinfolds		1st	2nd	3rd	refusal	unable to obtain
	Triceps	|_|_|_|.|_|	|_|_|_|.|_|	|_|_|_|.|_|	☐	☐
	Subscapular	|_|_|_|.|_|	|_|_|_|.|_|	|_|_|_|.|_|	☐	☐
	Biceps	|_|_|_|.|_|	|_|_|_|.|_|	|_|_|_|.|_|	☐	☐
	Iliac crest	|_|_|_|.|_|	|_|_|_|.|_|	|_|_|_|.|_|	☐	☐
	Medial calf	|_|_|_|.|_|	|_|_|_|.|_|	|_|_|_|.|_|	☐	☐

Girths			refusal	unable to obtain
	Upper arm	|_|_|.|_|	☐	☐
	Chest	|_|_|_|.|_|	☐	☐
	Abdomen	|_|_|_|.|_|	☐	☐
	Gluteal	|_|_|_|.|_|	☐	☐
	Thigh	|_|_|_|.|_|	☐	☐

Station 2

PAR-Q

heart trouble ☐

frequent pain in heart and chest? ☐

spells of severe dizziness? ☐

blood pressure medication prescribed by doctor ☐

bone or joint problem ☐

other reason (please specify) ☐

____

Screening for Children

limited for health reasons ☐

under doctor's care ☐

other reason (please specify) ☐

____

Observation

With the exception of pregnancy, these conditions are to be observed not asked.

Conditions- Not Screened Out

- Blindness ☐
- Deafness ☐
- Limb problem ☐

Conditions- Screened Out of Fitness Tests

- Pregnancy ☐
- Fever ☐
- Persistent cough ☐
- Muscular co-ordination or orthopedic problem ☐
- Impairment from alcohol ☐

Other ____________________

Resting Heart Rate and Blood Pressure

Cuff size ☐ child ☐ adult ☐ large

				over limit	refusal	unable to obtain
Resting heart rate	└┴┴┘	If ≥ 100 rest 5 min	└┴┴┘	☐	☐	☐
Systolic	└┴┴┘	If ≥ 150 rest 5 min	└┴┴┘	☐	☐	☐
Diastolic - D4	└┴┴┘	If ≥ 100 rest 5 min	└┴┴┘	☐	☐	☐
- D5	└┴┴┘		└┴┴┘		☐	☐

Canadian Aerobic Fitness Test

Temperature └┴┘ ☐ refusal

Starting Stage └┴┘

	1st bout	2nd bout	3rd bout	4th bout	5th bout
Exercise Heart Rates	└┴┴┘	└┴┴┘	└┴┴┘	└┴┴┘	└┴┴┘

If the exercise was interrupted or discontinued, specify reason

____

Station 3

Muscular Strength and Endurance

		1st	2nd	refusal	unable to obtain	screened out
Grip Strength	Right hand	└┴┴┘	└┴┴┘	☐	☐	☐
	Left hand	└┴┴┘	└┴┴┘	☐	☐	☐

		refusal	screened out	
Push-ups	└┴┴┘	☐	☐	☐
Sit-ups	└┴┴┘	☐	☐	☐

		1st	2nd	refusal	screened out	
Flexibility	Trunk flexion	└┴.┘	└┴.┘	☐	☐	☐

CRUDE ESTIMATES OF THE COEFFICIENT OF VARIATION

ESTIMATED PERCENTAGE OF CANADIANS
based on population in 000's

Observations (cases)	1%	2%	5%	10%	15%	20%	25%	30%	35%	40%	50%	60%	70%	80%	90%
15	257%	181%	113%	77%	61%	52%	45%	39%	35%	32%	26%	21%	17%	13%	9%
20	222%	157%	97%	67%	53%	45%	39%	34%	30%	27%	22%	18%	15%	11%	7%
25	199%	140%	87%	60%	48%	40%	35%	31%	27%	24%	20%	16%	13%	10%	7%
30	182%	128%	80%	55%	43%	37%	32%	28%	25%	22%	18%	15%	12%	9%	6%
35	168%	118%	74%	51%	40%	34%	29%	26%	23%	21%	17%	14%	11%	8%	6%
40	157%	111%	69%	47%	38%	32%	27%	24%	22%	19%	16%	13%	10%	8%	5%
45	148%	104%	65%	45%	35%	30%	26%	23%	20%	18%	15%	12%	10%	7%	5%
50	141%	99%	62%	42%	34%	28%	24%	22%	19%	17%	14%	12%	9%	7%	5%
55	134%	94%	59%	40%	32%	27%	23%	21%	18%	17%	13%	11%	9%	7%	4%
60	128%	90%	56%	39%	31%	26%	22%	20%	18%	16%	13%	11%	8%	6%	4%
65	123%	87%	54%	37%	30%	25%	21%	19%	17%	15%	12%	10%	8%	6%	4%
70	119%	84%	52%	36%	28%	24%	21%	18%	16%	15%	12%	10%	8%	6%	4%
80	111%	78%	49%	34%	27%	22%	19%	17%	15%	14%	11%	9%	7%	6%	4%
90	105%	74%	46%	32%	25%	21%	18%	16%	14%	13%	11%	9%	7%	5%	4%
100	99%	70%	44%	30%	24%	20%	17%	15%	14%	12%	10%	8%	7%	5%	3%
125	89%	63%	39%	27%	21%	18%	15%	14%	12%	11%	9%	7%	6%	4%	3%
150	81%	57%	36%	24%	19%	16%	14%	12%	11%	10%	8%	7%	5%	4%	3%
175	75%	53%	33%	23%	18%	15%	13%	12%	10%	9%	8%	6%	5%	4%	3%
200	70%	49%	31%	21%	17%	14%	12%	11%	10%	9%	7%	6%	5%	4%	2%
225	66%	47%	29%	20%	16%	13%	12%	10%	9%	8%	7%	5%	4%	3%	2%
250	63%	44%	28%	19%	15%	13%	11%	10%	9%	8%	6%	5%	4%	3%	2%
275	60%	42%	26%	18%	14%	12%	10%	9%	8%	7%	6%	5%	4%	3%	2%
300	57%	40%	25%	17%	14%	12%	10%	9%	8%	7%	6%	5%	4%	3%	2%
350	53%	37%	23%	16%	13%	11%	9%	8%	7%	7%	5%	4%	3%	3%	2%
400	50%	35%	22%	15%	12%	10%	9%	8%	7%	6%	5%	4%	3%	3%	2%
450	47%	33%	21%	14%	11%	9%	8%	7%	6%	6%	5%	4%	3%	2%	2%
500	44%	31%	19%	13%	11%	9%	8%	7%	6%	5%	4%	4%	3%	2%	1%
600	41%	29%	18%	12%	10%	8%	7%	6%	6%	5%	4%	3%	3%	2%	1%
700	38%	26%	16%	11%	9%	8%	7%	6%	5%	5%	4%	3%	2%	2%	1%
800	35%	25%	15%	11%	8%	7%	6%	5%	5%	4%	4%	3%	2%	2%	1%
900	33%	23%	15%	10%	8%	7%	6%	5%	5%	4%	3%	3%	2%	2%	1%
1000	31%	22%	14%	9%	8%	6%	5%	5%	4%	4%	3%	3%	2%	2%	1%
1500	26%	18%	11%	8%	6%	5%	4%	4%	4%	3%	3%	2%	2%	1%	1%
2000	22%	16%	10%	7%	5%	4%	4%	3%	3%	3%	2%	2%	1%	1%	1%

Notes
a. Coefficients of variation (c.v.) represent the relative variation of the estimate compared to the estimate's value. The c.v.'s are expressed in percents.
b. To identify the appropriate c.v. for an estimated percentage, use the row closest to the number of observations (cases) on which the percentage is based and the column closest to the estimated percentage of individuals (in 000's, calculated from weighted data).
c. Do not use the estimated percentage if the c.v. is greater than 33%. Use with caution if the c.v. is between 17% and 33%.
The coefficients of variation in this table are presented for screening purposes on[illegible]hey are not official estimates of the c.v.'s.

APPENDIX C

SAMPLE CALCULATIONS:

1. BODY DENSITY

2. PERCENT BODY FAT

3. RELATIVE CHANGE IN BODY COMPOSITION MEASUREMENTS

1. Body Density

$$\text{Men: } Db = 1.1631 - 0.0632 \log_{10} \sum_{0}^{4} S$$

$$\text{Women: } Db = 1.1599 - 0.0717 \log_{10} \sum_{0}^{4} S$$

Where S equals the sum of four skinfolds (biceps, triceps, subscapular, and suprailiac) (Benke et al., 1942).

2. Percent Body Fat

$$\% \text{ Body Fat (SIRI EQUATION)} = \frac{4.950}{Db} - 4.50 \quad X \quad 100$$

(Jackson et al., 1980).

2. Relative Change in Body Composition Measurements

ie. relative change in sum of skinfolds=

$$\frac{\text{Sum of five skinfolds (1981)- Sum of five skinfolds (1988)}}{\text{Sum of five skinfolds (1981)}}$$

APPENDIX D
POWER ANALYSIS

Power Analysis

The proposed number of subjects (N) is dependent on the number of subjects in each of the two groups (androids and gynoids) undergoing the same changes in activity levels (ie. inactive to active) which is dependent on the parameters being assessed-regional adiposity or the change in body fat distribution. Body fat distribution possesses its own variability, influencing the number of subjects required. In the literature there is information regarding the differences in the changes in WHR between android and gynoid obese women. From the data available it is possible to calculate the "EFFECT SIZE" based on the results of other experiments.

In order to calculate this we follow the calculation of sample size for studies involving two sample means as described by Hassard (1991).

$$n = 2 \left(PI \quad \frac{\sigma}{(H_1 - H_0)} \right)^2$$

The allowable risk of Type I error will be 5%; thus α =0.05. Power will be 0.95 and therefore β will be equal to 0.05 and the risk of Type II error is 5%.

In order to calculate the required number of subjects for each of the two groups: $\alpha = 0.05$, $z_\alpha = 1.64$ (one-tailed)
$\beta = 0.05$, $z_\beta = 1.64$ (one-tailed)

Based on a study conducted by Wadden et al., (1988) on the changes in fat distribution (WHR) accompanying weight reduction in early and late premenopausal women $\frac{\sigma}{H_1 - H_0}$ can be set at $\frac{0.04}{0.024}$.

in order to calculate the number of subjects required for two groups (android and gynoid) based on the initial fat distribution of the individuals.

Therefore according to Hassard (1991): $n = 2[\ 3.28\ \underline{(0.04)}]^2$
$\qquad 0.024$

$n = 80.2 \sim 81$ in each group.

Based on a study conducted by Vansant et al., (1988) on the changes in body fat distribution (WHR) of android and gynoid obese women, the following information allows for the estimation of effect size.

$H_1 - H_0 = 0.03$, $\sigma = 0.04$.

Therefore according to (Hassard, 1991): $n = 2[\ 3.28\ \underline{(0.04)}]^2$
$\qquad 0.03$

$n = 38.3 \sim 39$ in each group

APPENDIX E
DEFINITIONS OF VARIABLES IN DATA SET

RECORD8-1988-Record Id Number
SMKHIST1-1981-Smoking History
SMKHIST8-1988-Smoking History
QUITCIG8-1988-Number of years since quit smoking
ACTCHNG-Activity change index
ACTMNTH1-1981-All activities number of months
ACTMNTH8-1988-All activities number of months
ACTTMYR1-1981-All activities-time spent per year in minutes
ACTTMYR8-1988-All activities-time spent per year in minutes
ACTEXYR1-1981-All activities-total yearly energy expenditure in hrs
ACTEXYR8-1988-All activities-total yearly energy expenditure in hrs
AECPHA1-1981-All activities-average daily energy expenditure in hrs (CPHA)
AECPHA8-1981-All activities-average daily energy expenditure in hrs (CPHA)
AECVEXP1-1981-All activities-average daily energy expenditure in hrs (CV)
AECVEXP8-1988-All activities-average daily energy expenditure in hrs (CV)
ACT81D1-1981-Level of activity (hours/day)
ACT81D8-1988-Level of activity (hours/day)
ACTCVEX1-1981-Level of activity based on AECVEXP1
ACTCVEX8-1988-Level of activity based on AECVEXP8
WKACTLG1-1981-Weekly activity duration
WKACTLG8-1988-Weekly activity duration
ACTPAST8-1988-Level of activity compared to four years ago
ALCFRQ1-1981-Alcohol consumption-frequency
ALCHSRV8-1988-Alcohol consumtion-number of servings per day
ALCAMT1-1981-Alcohol consumtion-servings at a time
INJEXDD8-1988 Injury preventing exercise in days
LMACTIL8-1988-Activity limitation due to temporary illness
LMACTIJ8-1988-Activity limitation due to temporary injury
SEX8-Gender
AGE8-1988- Age (yrs)
HEALTH8-1988-State of health
WGT1-1981-Weight (kg)

WGT8-1988-Weight (kg)
HGT1-1981-Height (cm)
HGT8-1988-Height (cm)
TRIMEAN1-1981-Tricep skinfold (mm)
TRIMEAN8-1988-Tricep skinfold (mm)
SCPMEAN1-1981-Subscapular skinfold (mm)
SCPMEAN8-1988-Subscapular skinfold (mm)
BICMEAN1-1981-Bicep skinfold (mm)
BICMEAN8-1988-Bicep skinfold (mm)
ILMEAN1-1981-Iliac skinfold (mm)
ILMEAN8-1988-Iliac skinfold (mm)
CLFMEAN1-1981-Calf skinfold (mm)
CLFMEAN8-1988-Calf skinfold (mm)
BMI1-1981-Body Mass Index
BMI8-1988-Body Mass Index
SOS1-1981-Sum of skinfolds
SOS8-1988-Sum of skinfolds
WHR1-1981-Waist-to-Hip Ratio
WHR8-1988-Waist-to-Hip Ratio
ARMG1-1981-Upper arm girth (cm)
ARMG8-1988-Upper arm girth (cm)
CHG1-1981-Chest girth (cm)
CHG8-1988-Chest girth (cm)
ABDG1-1981-Abdominal girth (cm)
ABDG8-1988-Abdominal girth (cm)
GLUG1-1981-Gluteal/Hip girth (cm)
GLUG8-1988-Gluteal/Hip girth (cm)
BD1-1981-Body Density
BD8-1988-Body Density
%BF1-1981-Percent Body Fat
%BF8-1988-Percent Body Fat

APPENDIX F

CHI -SQUARED RESULTS

Chi-Squared Results

One Group Chi-Square X1:Education Expected Y1:Education Observed

DF:	Chi-Square:	Probability:
5	105.574	.0001

One Group Chi-Square X1:Region Expected Y1:Region Observed

DF:	Chi-Square:	Probability:
3	7.594	.0552

One Group Chi-Square X1:Income Expected Y1:Income Observed

DF:	Chi-Square:	Probability:
6	35.376	.0001

One Group Chi-Square X1:Sex Expected Y1:Sex Observed

DF:	Chi-Square:	Probability:
1	3.310E-4	.9855

One Group Chi-Square X1:Age Expected Y1:Age Observed

DF:	Chi-Square:	Probability:
5	105.574	.0001