BODY COMPOSITION OF VEGETARIAN AND OMNIVOROUS MEN

by

ADAM SCHWARTZ

B.A., The Unversity of Western Ontario, 1999

A THESIS SUBMITTED IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE

in

THE FACULTY OF GRADUATE STUDIES

The Faculty of Education; School of Human Kinetics; Exercise Physiology

We accept this thesis as conforming
to the required standard

THE UNIVERSITY OF BRITISH COLUMBIA

April 2003

In presenting this thesis in partial fulfilment of the requirements for an advanced degree at the University of British Columbia, I agree that the Library shall make it freely available for reference and study. I further agree that permission for extensive copying of this thesis for scholarly purposes may be granted by the head of my department or by his or her representatives. It is understood that copying or publication of this thesis for financial gain shall not be allowed without my written permission.

Department of Human Kinetics

The University of British Columbia
Vancouver, Canada

Date April 24, 2003

DE-6 (2/88)

Abstract

Background: The relationship between diet and human body composition has become a popular topic in recent years. Despite the popularity of vegetarianism little research has been conducted in the area of vegetarianism and body composition, and the focus of the minimal research to date has been on children and women. There is recent evidence that suggests that among older men, the ability to gain skeletal muscle with resistance training may be substantially diminished for individuals consuming a vegetarian versus an omnivorous diet. This issue has yet to be examined in a group of younger males. There is also some evidence to suggest that vegetarians may have lower levels of body fat in comparison to omnivores.
Objective: The objective of this study was to identify body composition differences (muscle and fat) between young men consuming either a vegetarian or omnivorous diet.
Design: 54 young males between 18-30 y participated in this study. Half of these subjects were vegetarians. Body fat and muscle mass were estimated from anthropometry. In addition, subjects completed the Three-Factor Eating Questionnaire (TFEQ) and the Godin Leisure-Time Exercise Questionnaire (GLTEQ), which were used as indicators of eating habits and activity levels. All subjects completed 3-day diet records.
Results: Vegetarians had significantly lower predicted muscle mass (30.9kg vs. 32.7, $p=0.049$ 1-tailed), and a lower sum of 12 corrected muscle girths compared to omnivores (2.5×10^6 cm^3 vs. $2.7 \times 10^6 cm^3$, $p=0.033$ 1-tailed). Vegetarians had higher dietary intakes of fiber (139.8 vs. 92.3, $p=0.006$) and polyunsaturated fats (67.5 vs. 42.7, $p=0.001$) and lower intakes of saturated fats (93.8 vs. 129.1, $p=0.031$) than omnivores. There were no significant differences between groups with regard to body fat, dietary restraint (TFEQ), activity levels (GLTEQ and reported hours of weekly activity), or other dietary intake variables.
Conclusion: Vegetarian men were found to have significantly lower muscle mass than omnivores, and these differences could not be accounted for by dietary restraint or activity levels.

Table Of Contents

List of Tables

Number and Title

List of Figures

Number and Title

1. INTRODUCTION

1.1 Vegetarianism: a popular diet

The vegetarian diet is a popular dietary choice for people of all ages. In Canada 1997, the National Nutrition Survey showed that 4% of people define themselves as vegetarian (1). Reasons for selecting this diet include religious beliefs, philosophical, ecological and health concerns (2). To date, very little is actually known about the impact of vegetarian diets on some important aspects of human body composition. Understanding the relationship between a vegetarian diet and the specific components of body composition would be useful for assessing the adequacy of this diet and issues related to health and sport training. If vegetarianism has a relationship with muscle, fat or bone, this would have important implications for dieters, children, the elderly and athletes.

1.2 Subclasses of vegetarian diets

The term "vegetarian diet" refers to a broad classification of plant based diets that are usually further divided into subclasses. The common vegetarian subclasses include: lacto-ovo-vegetarian (LOV), lacto-vegetarian (LV), and vegan. The LOV consumes milk products and eggs and excludes any meat, poultry and fish (2). The LV avoids eggs, meat, poultry and fish (2). The vegan excludes milk and any milk product in addition to meat and eggs, and in some cases any product of animal origin (2). The macrobiotic diet is a diet that doesn't necessarily exclude, but strictly limits animal foods including dairy products, and from nutritional profiles is often considered amongst vegetarian diets (2). Some people who consume fish and or poultry might consider themselves to be "vegetarians", however these individuals would more appropriately be classified as semi or partial vegetarians (2).

1.3 Vegetarianism & body composition: possible repercussions

Body composition is a broad term that generally speaks collectively of the gross tissues which include adipose tissue, muscle, bone, and skin (3). The present consideration is to determine whether the vegetarian diet has a relationship with one or more of the components of body composition.

The LOV diet is the least extreme of the vegetarian diets, allowing for the consumption of dairy and eggs. The LOV diet has recently been called into question regarding a reported relationship between the consumption of this diet and the muscle mass response to strength training interventions. In a study of older adults, researchers found that consumption of a LOV diet during a 12 week resistance training (RT) program did not result in the expected muscle hypertrophy (4). Subjects in this study were randomly assigned to consume either a higher protein LOV diet or a lower protein LOV diet. After 12 weeks of RT there was no significant increase in either whole body muscle mass or in mid-thigh muscle in either group. The researchers hypothesized that meat in the diet may have had a direct influence on the ability of older adults to gain muscle with RT. This research group decided to further investigate by comparing skeletal muscle gains with 12 weeks of RT between a group of older men who were omnivores and a group of men who changed from their typical meat containing diet to a LOV diet (5). After 12 weeks of training, omnivores showed gains in whole body muscle mass, while the LOV group showed losses with respect to this variable. No significant differences were found in mean dietary energy or macronutrient intakes between the groups. These results indicated that the absence of meat in the diet negatively influenced muscle mass response to RT in older men.

Body fat is another topic of interest with regard to vegetarianism. When comparing vegetarian and omnivorous groups, vegetarians are found to be the leaner of the two (6-10).

An inherent weakness of these studies is their use of few skinfold sites, which failed to account for differences in fat patterning between individuals.

The possibility of a vegetarian diet impacting bone is an important consideration for populations such as growing children and at risk elderly populations who suffer from reduced bone mass and density. In a study of 195 Dutch adolescents; 93 had followed a macrobiotic diet for on average 6-years during childhood. Whole body bone mineral content (measured by dual x-ray absorptiometry) was significantly lower among those consuming macrobiotic diets compared with controls (11). The between-group differences could not be accounted for by current calcium intakes or physical activity levels, and researchers proposed that different diets during childhood provided the best explanation. This study raises some important concerns about the possible repercussions of a childhood diet on bone development in later years.

A general overview of childhood growth can be examined through the dietary effects on height and weight. Nathan and colleagues examined 50 vegetarian and 50 age, sex, and ethnic-group matched omnivorous children (age 7-11) for a one year period, and found no differences in height or weight at baseline or after one year (12).

1.4 Gaps in the literature

Currently, very few studies have investigated the relationship between vegetarianism and body composition in men. As a result of past difficulties in affordable and accurate methods for quantifying skeletal muscle, little is presently known about the relationship between vegetarianism and skeletal muscle mass. A recent model has been developed in an attempt to remedy this (13). Lee et al. (13) have developed an anthropometric prediction equation (using skinfolds and muscle girths) for predicting total body skeletal muscle mass

(SMM), derived using multiple magnetic resonance imaging (MRI) scans. This model has not previously been used in a study of vegetarianism and body composition. In studies that looked at the relationship between vegetarianism and some indicator of fat or muscle, most have relied on crude measurements of these components. Studies on this topic that measured skinfolds, often relied on 3 or fewer subcutaneous sites to draw conclusions about body fat (6-8, 10, 12, 14, 15). Researchers have also made attempts to assess muscle using a single skinfold-corrected girth (6, 7, 12). These studies provide only a site-specific analysis, and should be interpreted with great caution. To our knowledge there are no studies that have compared fat mass and muscle mass between a vegetarian and omnivorous group of young men.

1.5 Purpose of the study

This study will compare the differences in body composition between young adult male vegetarians and young adult male omnivores. This study will assess whether there are differences in fat mass and skeletal muscle mass between these two groups. By observing groups of younger males (rather than older males) with relatively large amounts of skeletal muscle mass, if a difference exists between vegetarians and omnivores it would be magnified in this population. To our knowledge this is the first study on this topic to use the recent Lee et al. (13) prediction equation for quantifying skeletal muscle mass using simple anthropometric measurements. There is limited research on the topic of vegetarianism and body composition, and this study is the first to investigate a population of young adult males. A significant difference between dietary groups with regard to the components studied (skeletal muscle, body fat) would serve as the foundation on which to base future experimental research. Little is known about the relationship between a vegetarian diet and selected body composition outcomes, therefore it is important to address the adequacy of these diets. This study will add to the small body of knowledge in this area.

2. LITERATURE REVIEW

2.1 Overview

There are few studies to choose from when examining the topic of vegetarianism and body composition, therefore this review will include any study which examined a vegetable-based (no meat) diet and looked at one or more body composition variables. The populations of focus for these studies have largely been children and women, but they reveal some important trends that may also be applicable to a group of adult males. In an effort to gain a greater understanding of the health benefits or problems associated with a vegetarian diet, a good place to start is the impact of this diet on the body composition of children. This will be followed by an examination of studies comparing body composition differences between vegetarians and omnivores among adult and finally elderly populations. Important questions to consider for all these populations of vegetarians include: are vegetarians leaner, and do they have less muscle mass than omnivorous controls? It should be noted that many of the studies that address these questions are cross-sectional in nature, making it impossible to attribute diet as the only cause of observed differences.

2.2 Body composition of vegetarians vs. omnivores: studies in children

If vegetarian children are leaner than omnivores, then this may suggest a potential strategy for dealing with the increasing numbers of obese children. However, it is also important that there be no detrimental impact on muscle. A study by Tayter and Stanek (6) compared the triceps skinfold and the skinfold-corrected mid-arm circumference in 17 LOV and 22 omnivorous boys and girls aged 10-12. The triceps skinfold (used as an indicator of body fatness) was significantly higher among omnivorous boys but not girls, and no differences were found in skinfold-corrected mid-arm circumference (used as an indicator of muscle) between vegetarian and omnivorous boys and girls. Unfortunately, this study only measured a single skinfold and skinfold-corrected girth. Drawing conclusions about total body muscle and fat differences based on these single measures is difficult. In an effort to understand the effect of diet on the body composition of children over time, Nathan and colleagues (12) examined anthropometric variables over the course of one year in 50 vegetarian and 50 age, sex, and ethnic group matched 7-11 year olds. Investigators measured height, weight, biceps and triceps skinfolds, and upper arm circumference, at baseline and after one year. No significant differences were found between groups at baseline or after 1 year in any of the measured variables. The longitudinal nature of this study makes it more methodologically sound, but its inherent weakness is the lack of measures taken (skinfolds and muscle girths) that would have provided a much clearer picture and perhaps identified important group differences. In support of these findings, Dwyer et al. (14) found no significant differences in the triceps skinfold in a cross-sectional study of 39 pre-school aged children consuming various vegetarian diets, compared to age matched norms.

Other evidence suggests that significant differences in fat and muscle do exist between vegetarian and omnivorous children. In an earlier study by Dwyer et al. (7) comparing 142 pre-school vegetarian children (77 macrobiotic, 65 other vegetarian groups) to norms, significant differences were observed between vegetarian children and normative data. Triceps and subscapular skinfolds were measured in addition to a skinfold-corrected arm muscle circumference. Macrobiotic and other vegetarian children who were more than a year old had significantly smaller subscapular skinfolds compared to the normative data. Arm muscle circumference in both vegetarian groups was significantly smaller than norms for children 3 years or older. Smaller skinfold measurements were also observed among female vegetarian children in a study by Hebbelinck et al. (8). Flemish female LOV children had lower triceps and suprailiac but not calf skinfolds, than reference data for age matched Flemish children. A criticism of this study is the small number of vegetarian children included (5 males, 5 females), which may have resulted in an erroneous null finding in the males, due to a lack of statistical power for detecting a difference. This study also examined some anthropometric variables in vegetarian adolescents (n=19), finding lower skinfolds in both males (triceps, suprailiac) and females (calf, suprailiac). Energy intakes of vegetarians were significantly lower than reference data, which may explain the subcutaneous fat differences.

2.3 Body composition of vegetarians vs. omnivores: adult populations

Body composition research undertaken on adult populations also suffers from a lack of study. The greater leanness (lower skinfolds) of adult vegetarians is often assumed, but this is not a universal finding. Howie and Schultz (15) measured the chest, abdomen, and thigh skinfolds in 12 vegetarian and 18 non-vegetarian men between the ages of 49-62, and found no significant differences between groups. Hebbelinck et al. (8) considered vegetarianism and body fat differences, taking skinfold measurements (triceps, calf, suprailiac) on young adult Flemish male (n=8) and female (n=11) vegetarians, but found no significant differences in any of the skinfolds, between vegetarians and reference values. However, both of these studies used small sample sizes, and as a result may have missed an important difference. Barr et al. (9) measured skinfolds (triceps, abdominal, suprailiac, and thigh) in 23 healthy vegetarian women and 22 omnivorous women and found predicted body fat percent was lower in vegetarians than controls ($24.0 \pm 5.5\%$ vs. $27.4 \pm 5.1\%$, $p<0.05$).

2.4 Body composition of vegetarians vs. omnivores: elderly populations

Just as there are concerns for children, there are some important issues concerning the practice of a vegetarian diet among elderly populations, and the impact on body composition. With increasing age, which is often accompanied by a decrease in activity, elderly individuals are at risk of having lowered levels of muscle mass, and the adequacy of a vegetarian diet in optimally maintaining these components of the body must be assessed. One advantage of conducting diet-related studies in the elderly is that often these individuals have been adhering to a particular diet for a long time. This can help provide insight into the long-term effects of a vegetarian diet on body composition.

The issue of fatness has not been well studied in elderly vegetarians. Anthropometric variables were measured in one study of elderly females (10). Three skinfolds (triceps, suprailiac, and thigh) and % fat estimated by quadratic regression were examined in 12 postmenopausal Caucasian vegetarian (mixed types) women and 12 postmenopausal Caucasian non-vegetarian women. The non-vegetarians had significantly higher thigh skinfolds (39.9mm vs. 30.8mm, $p<0.01$) and sum of three skinfolds than the vegetarian group (85.0mm vs. 67.2mm, $p<0.05$). These results reveal substantial differences in body fat between elderly vegetarians and non-vegetarians, but certainly the replication of these results is necessary before any definitive statements can be made. The individuals in this study were all Seventh Day Adventists, and the likelihood is that the lifestyle of these individuals is different from other vegetarians. Thus, these results may not be generalizeable to a wider population of vegetarians.

Some interesting studies regarding the influence of a vegetarian diet on muscle mass during resistance training have been observed in elderly populations. The two studies by Campbell et al (previously mentioned in section 1.3) revealed that consumption of a meat-free diet during a 12 week RT program does not lead to the expected gains in muscle hypertrophy or muscle mass (4, 5). Cross-sectional comparisons of muscle between vegetarians and omnivores have been neglected in an elderly population.

2.5 Body composition of vegetarians vs. omnivores: summary

After investigating the small number of studies that have compared body composition variables (muscle and fat) among vegetarians and omnivores, it is difficult to draw any definitive conclusions. It seems likely that vegetarians are leaner than omnivores (6, 7, 9, 10) but many of the studies to date comparing fat differences have used only a few skinfold (3 or less) sites to assess body fatness (6-8, 10, 12, 14, 15). More comprehensive research accounting for all major body fat stores is necessary. Assessing whether or not there are muscle differences between the two dietary groups is the most difficult task of all. The cross-sectional studies that considered a muscle comparison relied on a single skinfold-corrected (7) or uncorrected (12) muscle girth of the arm as their sole measurement. Although corrected arm girth has been found to have a good correlation with criterion measures of total muscle mass (13), squaring this corrected girth and adjusting for stature to yield a three-dimensional measure shows an improved correlation (13). Surprisingly, cross-sectional studies done on adults and the elderly have ignored a comparison of muscle all together.

2.6 Estimating skeletal muscle mass

An important variable of body composition that has been almost completely neglected on the topic of vegetarianism is skeletal muscle mass. The reason has long been an absence of affordable and accurate techniques to take this measurement. Skeletal muscle masses obtained through dissection are known for only 25 men (3), meaning that any current methods that have been developed and validated rely on a physical or chemical property of muscle to obtain their measurement (17), and therefore are subject to some degree of error.

Computed tomography (CT) and magnetic resonance imaging (MRI) are widely regarded as the most accurate techniques to measure muscle mass in vivo. However, each of these methods have limitations. CT relies on the passage of X-rays through the body, which are attenuated. The degree of attenuation of the x-rays is related to the density of the tissues it has passed through. A computer then constructs a visual image (cross-sectional image) using the attenuated values of the x-rays. Based on different attenuation values for components of body composition such as adipose tissue, bone, and muscle, these components can be assessed independently (17). The tissue of interest is traced on the computer yielding a cross-sectional area. The thickness of the image (slice) is a known value, and with this value tissue volumes can be calculated. However, even with a set of slices taken at intervals covering most of the body, a calculation of total body muscle mass requires filling in the blank unmeasured sections with predicted values. Another problem encountered with using CT to calculate muscle mass is that the attenuation of normal muscle widely varies, depending on which muscle group is measured (17). A further drawback of this technique is that it requires x-ray exposure, and the use of radiation in body composition studies involving healthy individuals would be considered unethical. Finally, this method is very costly which serves to further narrow its scope of use in body composition research.

Similar to CT, MRI can be used to assess regional muscle and to predict total body muscle by filling in the blank unmeasured sections. This method uses a magnetic field to align the nuclei in a body segment. A radio frequency electromagnetic wave is then directed through the body, and some of the nuclei absorb energy. The wave is then shut off, and the nuclei that have absorbed its energy emit the radio signal. A computer then transforms this signal to an image of the chemical composition of the tissue (17). This method also yields a cross-sectional image with a known thickness, making volume calculations possible. In contrast to CT, MRI does not involve the use of radiation, however this technique finds little use in body composition studies due to its considerable expense, but might serve as a criterion method.

Techniques that have been more readily used in body composition research to measure muscle include the measurement of muscle metabolites. One of the popularly measured metabolites is creatinine. Creatinine is a waste product of creatine which resides primarily in skeletal muscle (98%) (18) in (17). To obtain a measurement of muscle mass, first 24-hour urinary creatinine is measured, then assuming a constant ratio of urinary creatinine to skeletal muscle tissue, a total muscle mass can be calculated. However, there is some debate as to the ratio of urinary creatine to muscle mass (17), and there is variability in daily urinary creatinine excretion within an individual who consumes a self-selected diet (17). These variables leave this method of muscle estimation open to criticism.

In an attempt to provide a simple method to measure skeletal muscle mass, the Brussels cadaver study (3) was the first study to dissect cadavers for tissue masses in addition to taking anthropometric measurements of the same cadavers. Regression equations were then developed for the estimation of whole-body muscle mass based on the anthropometric measures (19). The authors determined that regional anthropometric measurements were very good indicators of total dissected muscle mass, and the following equation was derived for predicting muscle mass in men, $MM = STAT\ (0.0546\ CTG^2 = 0.119\ FG^2 + 0.0256\ CCG^2)-2980$. In this equation MM is muscle mass in kg, STAT is equal to stature in cm, CTG is corrected thigh girth, FG is uncorrected forearm girth, and CCG is corrected calf girth. This equation had an R^2 =0.93 and SEE =1.58kg. However, the limitation of this equation is that it was generated on a small number of older cadavers, and as a result is very sample specific.

Recently, researchers have sought to build on this foundation and provide a simple answer to the problem concerning muscle measurement. In a manner similar to the earlier anthropometric prediction equation based on cadavers (19), Lee et al. (13) developed a simple anthropometric prediction model for estimating total body skeletal mass, based on MRI measured muscle mass. The instruments required to take anthropometric measurements are both inexpensive and portable making this an attractive approach for skeletal muscle mass prediction. The model was developed in a group of non-obese adults (n=244, 139 men and 109 women) with a wide age range (20-81 years old). In this study, equations were developed taking into account height, age, sex, and race parameters in addition to skinfold-corrected muscle girths from the arm, thigh, and calf. To obtain a skinfold-corrected muscle girth, first a limb circumference measurement is taken, a skinfold measurement is then used to correct the cross-sectional area for adipose tissue. The result is a cross-sectional area that represents muscle. This method of estimation assumes that the measured limb segments are circular and that the portion of the cross-section that is bone is negligible. Skinfold-corrected muscle girths were calculated using the following equation where muscle circumference (C_m) = measured limb circumference (C_{limb}) - π x skinfold (SF) (19). The best equation generated for predicting total body skeletal muscle mass by Lee's study is: SM (kg) = Ht x (0.00744 x CAG^2 + 0.00088 x CTG^2 + 0.00441 x CCG^2) + 2.4 x sex – 0.048 x age + race + 7.8, where SM is skeletal muscle, Ht is height in meters, CAG is corrected arm girth in cm, CTG is corrected thigh girth, and CCG is corrected calf girth. This equation has a high R^2 value (0.91), and a low standard error of 2.2 kg. It must be noted that the skinfold-corrected muscle girths cannot account for intramuscular fat, and the authors did not make adjustments for bone that passes through the extremities, which makes up 5-10% of the cross-sectional area (20). A further limitation of Lee's method for predicting SMM is that the model is population specific. The sample did include a wide age range and was racially diverse. However, the non-obese model developed would not be appropriate for use in highly trained athletes, body builders, obese individuals, or patients with anorexia nervosa.

Another simple measure of skeletal muscle can be obtained through a sum or set of skinfold-corrected girths. Previous studies have shown that certain skinfold-corrected limb girths show a strong correlation with dissected measures of muscle mass (19), and MRI measured muscle mass (13). In a study of male cadavers (aged 50-94) complete anthropometry, dissection, and weighing of body segments, showed a high correlation coefficient between skinfold-corrected girths and total muscle mass from dissection (19). In 6 unembalmed male cadavers, corrected girths had correlation coefficients of 0.896 in the arm, 0.998 in the forearm, 0.990 in the thigh, and 0.911 in the calf. In a larger sample of younger non-obese men and women (n=244), high correlation coefficients were observed between MRI measured total body skeletal muscle mass and skinfold-corrected girths (adjusted for height) in the arm ($r=0.90$, SEE 3.19kg^2), thigh ($r=0.83$, SEE 4.18 kg^2), and calf ($r=0.87$, SEE 3.74 kg^2) (13). Some authors believe that a central weakness of skinfold-corrected muscle girths is that often only one or two measurements are used as indices of muscle mass (19). The result is a failure to account for individual differences in muscle distribution.

It has been shown that despite some limitations simple anthropometric measurements have been validated as good predictors of skeletal muscle, and researchers can now afford to study this important component of body composition.

2.7 Anthropometric prediction of body fat

Skinfold measurement has become a common practice for estimation of body fat (21). A common method for the development of a skinfold prediction equation requires the measurement of subcutaneous fat sites (skinfolds) in a group of subjects, in addition to a criterion measure of body density such as underwater weighing, and then by regression an equation is established to predict body density by skinfold measures alone. Body density is then converted to percent fat, most commonly by using the Siri equation (22), where % body fat = 495/body density – 450. However, in the process of deriving body fat from initial skinfold measurements, several assumptions are made. These assumptions include: the compressibility of adipose tissue is constant, skin thickness is negligible, there is a fixed adipose tissue pattern, adipose tissue maintains a constant fat fraction, there is a fixed proportion of internal to external fat, and the density of fat and fat free masses are constants. A thorough discussion of these assumptions and the potential for error has previously been presented (23). Often variables other than skinfolds (such as age and girth measurements) are included in prediction equations in an effort to improve the relationship with the criterion measure. Jackson and Pollock (16) have established a set of body density prediction equations in this manner using a sample of 308 adult men (mean age 32.6yrs ± 10.8) and cross-validated their equations in a sample of 95 men (33.3y ± 11.5 y), using underwater weighing as the criterion method for body density measurement. Eight body density prediction equations were developed in total, using a variety of different variables, which included age, waist girth, forearm girth, and seven different skinfolds. Equation number 4 from this study was selected because it included the maximum number of skinfolds (7 in total) in addition to age. In this equation body density (g/ml) = $1.11200000 - 0.00043499\ (X_1) + 0.00000055\ (X_1)^2 - 0.00028826\ (X_3)$ where X_1 is the sum of 7 skinfolds taken at the chest, axilla, triceps, subscapula, abdomen, suprailium and front thigh, and X_3 is age (years). Body density predicted with this equation showed a strong correlation with body density from underwater weighing in both the original sample (R=0.902, SE 0.0078 g/ml) and the cross validation group (R=0.915, SE 0.0078g/ml). These results indicate that this is a very useful body density prediction equation for adult men.

2.8 Skinfold measurement of subcutaneous adipose tissue

To measure and compare subcutaneous adipose tissue, a simple sum of skinfolds taken from major adipose storage sites is a common technique. Failure to account for all the major adipose storage sites will result in an inability to account for fat patterning differences between individuals. Differences in skinfold compressibility and possibly skin thickness between individuals are limiting factors to this technique (23). Overall, skinfold measurements provide a direct measure of subcutaneous fat and as a result have good face validity (21).

2.9 Possible explanations for vegetarian vs. omnivore differences

The possibility exists that vegetarians and omnivores are different with respect to more than just the consumption of meat in their diets. Lifestyle differences, such as eating behaviours and physical activity levels, should also be considered, as differences between dietary groups could contribute to differences in body composition. If health issues are a primary motivator for dietary choice among vegetarians, then it might also be hypothesized that these individuals would likely engage in more frequent bouts of physical activity than omnivorous controls. Janelle and Barr (24) considered eating behaviour differences and hours of exercise per week among 45 weight stable, regularly menstruating health conscious vegetarian (n=23) and nonvegetarian (n=22) women between 20-40 years of age. Sixteen of the 22 vegetarian women (70%) in this study cited health reasons when asked to indicate their motivation for becoming a vegetarian. Investigators used the Three-Factor Eating Questionnaire (TFEQ) to assess eating behaviours. This 51-item questionnaire has subscales for dietary restraint (conscious limitation of food intake), disinhibition (a tendency to eat more than usual when control over intake is lost), and hunger (25). Results indicated that vegetarians had significantly lower dietary restraint scores, and no significant differences were observed between disinhibition and hunger scores. These results lend support to the argument that health conscious vegetarians may have lower levels of dietary restraint than health conscious omnivorous controls. It should be noted that subjects in this study were selected to exclude individuals who might have eating disorders. Vegetarians in this study exercised 4.0 hours per week (± 2.3) and nonvegetarians 3.1 hours (± 1.80) but this difference was not significant. In contrast to these findings, Martins et al. (26) found that there was a link between vegetarians and higher restraint scores measured by the TFEQ. This study examined the relationships between dietary style (from meat eating to veganism) cognitive restraint (TFEQ), and feminist values in a group of 227 men and women. Among males, it was found that individuals who scored high in cognitive restraint were more likely to be vegetarians than individuals low in restraint. Only females who were high in feminist values showed the same trend. In response to their findings, the authors of this study suggested that selection of a vegetarian diet might be a way of masking dieting behaviours.

2.10 Vegetarian vs. omnivore differences in protein, fat, and fiber &possible influences on body composition

It has previously been mentioned that there are different sub-classifications of the broad term "vegetarian". Although each of these diets is distinct, individuals consuming vegetarian diets share some common differences in macronutrient intakes from those consuming omnivorous diets. In general, the vegetarian diet has been found to contain considerably more dietary fiber (10, 15, 24, 27-30), less protein (6, 24, 27-30), and saturated (10, 27, 28) and polyunsaturated fat (27). Total fat has consistently shown a trend to be lower in vegetarians than omnivores (6, 10, 24, 27-29, 31), but achieved statistical significance in only two of these studies (28, 31). Unfortunately only two of the mentioned studies were carried out in samples of adult men (27, 28), making it difficult to draw conclusions about dietary intake trends in this population.

It has been speculated that dietary differences may have an influence on male sex hormones (testosterone and free-testosterone) and possibly contribute to differences in skeletal muscle between vegetarian and omnivorous populations (5). Testosterone is the male sex hormone most frequently measured, and from a body composition perspective this hormone plays an important role in muscle development (32). Specifically, it is the unbound or free-testosterone that is believed to be the most active and have the greatest androgenic effect. Thus, if a vegetarian diet were to lead to lower levels of testosterone and free testosterone then this might serve as a possible mechanism for muscle differences. Sex hormone binding globulin (SHBG) in the serum is another important quantity, because it has an inverse relationship with free testosterone (33) in (34). Results from cross-sectional studies on this issue have shown a trend towards equivalence between vegetarians and omnivores for testosterone and calculated free testosterone levels (27, 28). However, an experimental study utilizing a crossover design to examine the relationship between diet, serum sex hormones and endurance performance did find a that a vegetarian diet had a significant impact on testosterone levels (35). Eight male endurance athletes consumed two isocaloric diets in succession (6 weeks for each) with a two-week washout period. One diet was LOV (57% CHO, 15% protein, 28% fat), and the other was a meat-rich omnivorous diet (58% CHO, 13% protein, 29% fat). After 6 weeks on the LOV diet, a significant decrease in total testosterone was identified (33). Although the sample of this study was small, the results of this well designed study suggest that a vegetarian diet might lead to reduced levels of total testosterone.

2.11 Conclusions

The possible impact of a vegetarian diet on major components of body composition (muscle, fat) needs more study. Preliminary research indicates that there may be significant body composition differences between vegetarians and omnivores. There is a need to investigate the body composition differences between vegetarians and omnivores in a young adult male population, a group that has been neglected to this point. With recent innovations in the field of skeletal muscle mass prediction, and simple anthropometric methods for fat prediction, there is a considerable amount of insight to be gained into the relationship between vegetarianism and body composition from a cross-sectional study. There is also the need to study eating behaviors and physical activity levels as these may be contributing factors to body composition differences. The primary aim of this study is to gain a clearer picture of the relationship between vegetarianism and body composition particularly with regards to the effect of this diet on skeletal muscle. In addition to providing a better understanding of the influences of diet on body composition, this study may serve as a foundation on which to base future experimental research.

2.12 Research questions & hypotheses

2.12.1 Primary questions and hypotheses

Question 1: Are there differences in whole body skeletal muscle mass from anthropometric prediction (13) between vegetarians and omnivores?

Hypothesis 1: Whole body skeletal muscle mass from anthropometric prediction will be greater in omnivores than vegetarians.

Question 2: Are there group differences in a sum of skinfold-corrected muscle girths taken from 6 upper limb and 6 lower limb sites?

Hypothesis 2: Omnivores will have a higher sum of skinfold-corrected muscle girths than vegetarians.

Question 3: Are there subcutaneous fat differences between dietary groups calculated from a sum of skinfolds?

Hypothesis 3: Vegetarians will have a lower sum of skinfolds than omnivores.

Question 4: Are there differences in percent body fat between groups calculated from Jackson and Pollock's (16) anthropometric prediction equation?

Hypothesis 4: Vegetarians will have a lower percent body fat than omnivores, calculated from anthropometric prediction.

2.12.2 Secondary research questions

Question 5: Are scores of dietary restraint (TFEQ) different between vegetarians and omnivores?

Question 6: Are scores for activity level measured by the Godin Leisure-Time Exercise Questionnaire (GLTEQ) (36) different between vegetarians and omnivores?

Question 7: What is the relationship between TFEQ scores of restraint and measures of fat and muscle?

Question 8: What is the relationship between scores from the GLTEQ and fat and muscle measures?

Question 9: Are intakes of protein, dietary fat, fiber, and calories, measured by three-day food records different between dietary groups?

3. METHODS

3.1 Subjects

The study sample consisted of 27 men who were vegetarians (Veg) and 27 omnivorous men (Omni) between the ages of 20-34 years. This population had not previously been studied with regard to vegetarianism and body composition. Subjects were recruited through flyers and posters, distributed at restaurants, bus stops, fitness centers, community centers, local colleges, and the University of British Columbia. Upon seeing a poster or flyer advertising the study, subjects phoned the investigator and were informed about the study and asked a series of screening questions (Appendix III). Approximately half of all subjects interested in participation did not meet the entry criteria and were excluded.

3.1.1 Vegetarian inclusion criteria

1) Vegetarian subjects permitted entry to the study must not have consumed meat products (red or white meat, fish) more than once a month, for a minimum of two years prior to recruitment.

3.1.2 Vegetarian and omnivore inclusion criteria

1) Subjects must have been between 20-35 years of age.
2) Subjects must not have been involved in regular resistance training (more than once a week) in the last year, as this training has an obvious influence on body composition.
3) Subjects must not have been involved in more than 7 hours of moderate intensity physical activity per week (recreational jogging, swimming, cycling, climbing, volleyball, tennis etc.).

4) Subjects were required to be non-smokers, to limit any confounding influences on weight.
5) Subjects must not have taken any medication in the previous year, known to effect body composition.

This information (initially obtained on the phone) was confirmed with a short screening questionnaire (Appendix III).

3.2 Study design

This is a cross-sectional study. Initially, subjects participated in a testing session where each subject underwent a set of anthropometric measurements (height, weight, skinfolds, muscle girths), and completed questionnaires concerning dietary behaviours and physical activity levels. Following this session, subjects completed a three-day diet record. Dietary groups (Veg and Omni) were then compared on the basis of anthropometric measurements of muscle and fat, questionnaire measures of dietary behaviours and physical activity, and nutrient intakes from diet records.

3.3 Testing procedure

Testing sessions required approximately one hour. Upon arrival subjects were greeted, the study was explained and informed consent was obtained (Appendix I). Subjects then rotated through three stations. At the first station subjects completed the Godin Leisure-Time Exercise Questionnaire (GLTEQ) and the TFEQ questionnaires. Subjects also formally filled out a copy of the screening questionnaire (note: any questions that would have excluded the subject from participating were previously asked on the phone). Total time for this station was between fifteen and twenty minutes. The second station was for anthropometric measurements, and took approximately twenty minutes. The final station was used to explain how to complete a three-day diet record, and subjects received a booklet to keep this record along with a set of measuring cups and spoons. This station took approximately twenty minutes. One researcher conducted each testing session. The same researcher oversaw and answered any questions regarding study procedures and performed all anthropometric measurements. All testing sessions were carried out at University of British Columbia's Buchanan Exercise Science Lab.

3.4 Questionnaires

3.4.1 Screening questionnaire

The information provided ensured that subjects met all inclusion criteria prior to participation (Appendix III).

3.4.2 Three-day diet record

Three-day diet records were completed by participants on three consecutive days including one weekend day, following the testing session, and returned to the instructor in person or by mail. Participants were instructed on how to complete the diet record following the anthropometric assessment stage of the testing session. An open form was used, where subjects were asked to describe all of the foods and beverages eaten for each day (37). Subjects were provided with a set of measuring cups and spoons and asked to estimate serving sizes with the given utensils when practical to do so.

3.4.3 The three-factor eating questionnaire (TFEQ)

This 51-item eating behavior questionnaire (Appendix III) has subscales to measure dietary restraint, disinhibition, and hunger (25). A copy of the TFEQ was distributed to subjects and used to assess whether men who were Veg or Omni differ with respect to dietary behaviours, with a particular focus on dietary restraint. There are 21 questions related to the dietary restraint subscale (factor 1 items), and they have proven to be reliable among both free eaters (α= 0.92) and dieters (α= 0.79) (25). In addition, factor 1 items have been able to discriminate between dieters and free eaters (25). Scores for dietary restraint were calculated according to the instructions of the author of the questionnaire (25).

3.4.4 Godin leisure-time exercise questionnaire (GLTEQ)

The GLTEQ is a short questionnaire that assesses the number and type of activity bouts (minimum 15 minutes to qualify) regularly performed in a week (Appendix III). The first part of the questionnaire asks how many times in a week a subject performs activities in each of three listed exercise categories: strenuous exercise where the heart beats rapidly (e.g. running, jogging, hockey, football), moderate exercise which is not exhausting (e.g. fast walking, easy bicycling, volleyball), and mild exercise requiring minimal effort (e.g. yoga, archery, bowling). The second part of the questionnaire asks respondents to assign a frequency, by checking one of 3 boxes (often, sometimes, never/rarely), to the regularity that exercise bouts are sustained long enough to work up a sweat or where the heart beats rapidly. In reliability studies of the GLTEQ (36, 38, 39) strenuous exercise scores are the most reliable and scores for light exercise are least reliable (36, 38). Among 53 adults, test and 2 week retest scores showed significant correlations for all types of exercise, strenuous (0.94), moderate (0.46), light (0.48), total (0.74). The score of this questionnaire was determined using the instructions provided by the authors (36).

3.5 Measurement of height and body mass

Barefoot height was measured in duplicate with a wall-mounted stadiometer to the nearest 0.1cm. Body mass was measured in duplicate (in shorts and T-shirt), and recorded at the nearest 0.1 kg using a digital scale.

3.6 Anthropometric procedures

All skinfold measurements were taken in duplicate and measured to the nearest 0.1 mm using a Harpenden skinfold caliper. If duplicate measures differed by 0.5 mm or more, a third measurement was taken. Limb circumference measurements were made in the plane orthogonal to the long axis of the body segment being measured. A flexible standard measuring tape was used for all circumference measurements, which were taken in duplicate (unless values differed by more than 4 mm) and recorded to the nearest 1mm. The mean value (obtained from either 2 or 3 measurements) for each skinfold and circumference measurement was calculated, and this value was used in any prediction equation requiring a single value. A highly trained individual made all measurements, and intraclass correlations between measurement 1 and measurement 2 were calculated to check accuracy.

3.7 Variables of interest

3.7.1 Independent variable: diet

There were two groups in this study. One group was composed of individuals who had been consuming a vegetarian diet for 2 years or more (Veg), and a second group who had consumed an omnivorous diet for 2 years or more (Omni).

3.7.2 Dependent variables

3.7.2.1 Total body skeletal muscle mass

Skeletal muscle mass was measured using Lee's anthropometric prediction equation (13) where SM (kg) = Ht x (0.00744 x CAG^2 + 0.00088 x CTG^2 + 0.00441 x CCG^2) + 2.4 x sex (1 for males) – 0.048 x age + race + 7.8. This equation has an R^2 value (compared to MRI measured muscle mass) of 0.91 and a standard error of 2.2 kg. The equation requires the measurement of both a skinfold and limb circumference from the arm (CAG), thigh (CTG), and medial calf (CCG). The precise location of these sites has been previously defined (40). Use of this prediction equation requires an assigned value for race. For Asian subjects a race value of –2 was assigned, 1.1 for African Canadians, 0 for white or Hispanics. For subjects belonging to a race other than what has been specified, a value of 0 was used. Identification of a subject's race was obtained through the screening questionnaire. The obtained value for total body skeletal muscle mass accounts for body size differences between individuals, as the prediction equation includes a height variable. Height differences between groups were linearly corrected prior to the analysis of this variable.

3.7.2.2 Sum of 12 skinfold-corrected muscle girths

In addition to the anthropometric prediction equation, a sum of skinfold-corrected girths taken from six upper limb and six lower limb sites was measured as an index of muscle. Limb girths and skinfolds were taken from the upper arm, thigh, and calf at sites that have been previously defined (40). These sites have a strong correlation with total body skeletal muscle (13). In addition, a forearm girth was taken at its maximum circumference and a skinfold from the posterior aspect of the forearm at the same level. A cadaver study has shown forearm girth to be a very good predictor of total body skeletal muscle (19). To account for muscle shape, sites located 2 cm above and below each of the mentioned landmarks were also measured. Each corrected girth was then squared and multiplied by stature for dimensional consistency. The sum of these values was calculated.

3.7.2.3 Sum of 6 skinfolds

During the second part of the testing session (anthropometry section) skinfolds were measured. Sites for measurement included the triceps, subscapula, abdominal, front thigh, and suprailium, using landmarks previously defined (40). A medial calf skinfold was also taken, using a landmark described elsewhere (41). A sum of skinfolds ($\sum 6$) was calculated based on the mean value of each skinfold. Skinfold sites were selected to account for major regions of adiposity.

3.7.2.4 Percent fat predicted from anthropometry

Jackson and Pollock's equation (16) for predicting body fat from anthropometry was selected for use in this study. This equation requires the measurement of skinfolds from the chest, axilla, triceps, subscapula, abdomen, suprailium, and front thigh. The procedures and location for taking each of these measurements has been previously described (40). This equation was chosen for a variety of reasons. It has a large number of sites accounting for individual fat distribution differences. It was carried out in a large sample (n = 308) of healthy adult men with a mean age of 33 y, and then cross-validated in another sizable group (n = 95). With few comprehensive fat prediction equations having been generated and cross-validated on young sedentary and healthy men this equation seemed to fit closely with the current sample. As previously mentioned, strong correlations and relatively low standard errors were observed in both the original sample and the cross validation group (16). Values obtained for body density were converted to percent fat using the Siri equation, where % fat = 495/body density – 450 (22).

3.7.2.5 Nutrient intakes from three-day diet records

Three-day intakes of dietary fat, protein, fiber, and total calories were calculated from three-day diet records using The Food Processor 7 software (42).

3.7.2.6 Three-factor eating questionnaire restraint score

Scores of dietary restraint were calculated. See section 3.43 for more detail.

3.7.2.7 Godin leisure-time exercise questionnaire score

See section 3.44 for more detail.

3.8 Statistical analysis

One-way ANOVAs were used to compare group means with respect to the dependent variables. In cases where data were nonparametric, the Mann-Whitney U-test was used as a replacement test to examine group differences. ANCOVA was used to compare muscle differences between groups while controlling for group differences in height. Spearman correlation coefficients were calculated to examine the relationship between TFEQ scores, restraint scores (TFEQ) and GLTEQ scores with each of the fat and muscle variables. Significance was set at the 0.05 level for all statistical tests.

3.9 Statistical power & sample size determination

Limited data is available regarding skeletal muscle mass in young men. For the purpose of the sample size determination, a value of 36kg ± 4kg was used for the Omni group. This was an estimation based on values that have been derived for total skeletal muscle mass in men (13, 43, 44). A mean value of 34kg ± 4kg SMM was assumed for the Veg group. No data have been collected to date that could help with this estimation, so this value was used for sample size determination. A two kilogram difference between the two groups would be an important finding and therefore we will test whether this difference reaches statistical significance. By employing these numbers (36 kg and 34 kg) we can then determine the sample size required for achieving statistical significance. Power was calculated via the UCLA stats page power calculator using mean values for SMM of 36kg ± 4kg for the Omni group, and 34kg ± 4kg for the Veg group. After inserting these values in a one tailed test with a significance level of .05 and a power of .65, the necessary sample size will be n = 30 for the Omni group, and n = 30 for the Veg group. A one tailed test is justified in this case because research has indicated that any between group differences that exist in muscle are unidirectional (4, 5), with omnivores having more muscle than vegetarians. Therefore, by selecting a one tailed test, the statistical power for detecting a difference is enhanced.

3.10 Ethical approval

Ethical approval for all of the procedures previously mentioned was obtained from the University of British Columbia's clinical research ethics board (Appendix II).

4. Results

4.1 Body composition

The results of this study were based on 54 subjects, aged between 20-34. General sample characteristics and body composition results for the two dietary groups are shown in table 4.4.1. Reliability of anthropometric measurements was assessed by calculating the intraclass correlation between the first and second measurements taken for each skinfold and girth measurement. The average intraclass correlations for skinfolds and girths were alpha = 0.9990 and 0.9995 respectively.

Table 4.1.1 Physical characteristics and body composition measurements for vegetarian and omnivorous groups

Variable	Vegetarians (n = 27)	Omnivores (n = 27)	P Value 1 tailed test	 2 tailed test
Age	26.7 ± 3.2	25.8 ± 4.8		0.411
Height (m)	1.768 ± 0.071	1.795 ± 0.064		0.145
Body Mass (kg)	73.0 ± 10.2	77.0 ± 9.9		0.143
Muscle Mass (kg)	30.9 ± 3.5	32.7 ± 4.1	0.049*	0.097
ANCOVA Muscle (kg)	30.7	32.6	0.040*	0.079
Sum of 12 CG (cm^3)	2471207 ± 415931	2683571 ± 413584	0.033*	0.066
% Body Fat	10.5 ± 3.6	12.0 ± 4.5		0.173
Sum of 6 Skinfolds (mm)	70.7 ± 22.7	80.7 ± 29.2		0.168
Years Vegetarian	6.4 ± 5.6	NA	NA	NA

Values are group means ± SD, n = number of subjects.
*P value is significant at the 0.05 level
Muscle Mass = Prior to muscle mass prediction from anthropometry, vegetarians were linearly heightened 2.7cm to account for the between group height differences.
ANCOVA Muscle = Mean muscle mass values generated by ANCOVA controlling for height differences between groups.
Sum of 12 CG = Sum of 12 skinfold-corrected muscle girths

One way ANOVA (1-tailed test) revealed significant differences between Veg and Omni in muscle mass adjusted linearly for group differences in height (Appendix VII).

ANCOVA results (with height as the covariate), corroborated these findings (Appendix X). Similarly, significant group differences were observed between Veg and Omni in a sum of 12 corrected muscle girths. ANOVA results (2-tailed tests) showed no significant group differences in body fat variables ($\Sigma 6$ skinfolds, % fat). Boxplots of body composition results are pictured in Figures 4.1.1- 4.1.4. Figure 4.1.1 illustrates that the middle 50^{th} *percentile* for muscle mass has a similar range between groups, but the Veg group has a significantly lower median value, as a result of a higher frequency of scores at the low end of this range.

Figure 4.1.1 Boxplots of linearly corrected muscle mass of vegetarians and omnivores

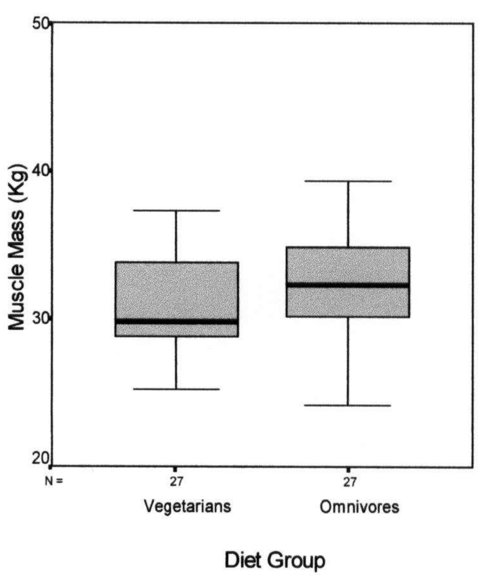


Figure 4.1.2 Boxplots of sum of 12 muscle girths of vegetarians and omnivores

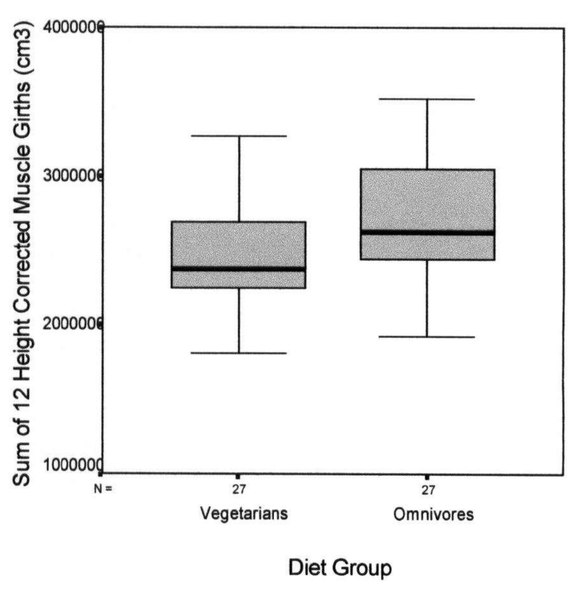


Figure 4.1.3 Boxplots of sum of 6 skinfolds of vegetarians and omnivores

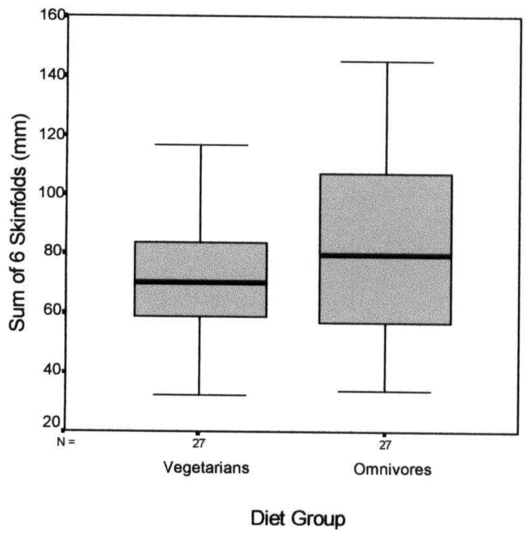
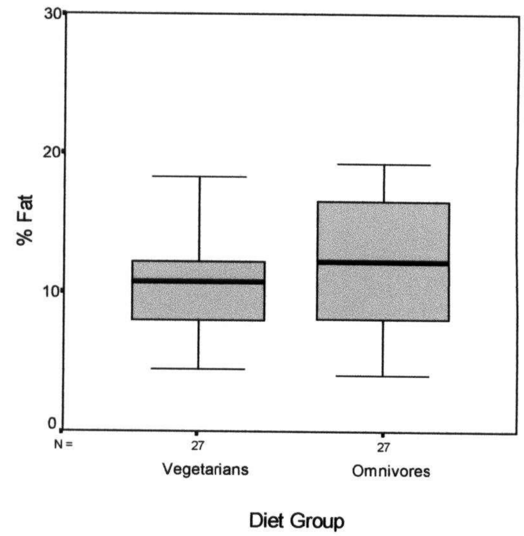


Figure 4.1.4 Boxplots of percent fat of vegetarians and omnivores



Comparing groups on the basis of a sum of 12 corrected muscle girths, yields a more obvious difference (figure 4.1.2). The range of values for Omni is higher than the range observed for Veg.

Body composition variables showed no major departures from normality (table 4.1.2). Histograms for each body composition variable are provided in Appendix V.

Table 4.1.2 Skewness and kurtosis values for body composition variables

	Muscle Mass (kg)	Sum of 12 CG (cm^3)	Sum of 6 SF (mm)	% Fat
Vegetarians				
Skewness	0.45	0.30	0.40	0.61
Kurtosis	-0.80	-0.42	0.20	0.61
Omnivores				
Skewness	0.33	-0.11	-0.87	-1.22
Kurtosis	0.08	-0.75	0.21	0.014

Muscle Mass = Predicted by anthropometric equation
Sum of 12 CG = Sum of 12 skinfold-corrected muscle girths
Sum of 6 SF = Sum of 6 skinfolds

4.2 Questionnaire scores

Questionnaire scores (GLTEQ, TFEQ, Restraint Subscale) violated ANOVA test assumptions for normality. Table 4.2.1 shows values for skewness and kurtosis. Acceptable values for skewness and kurtosis were between +1 and –1. For a graphic illustration of distributions on questionnaire variables, histograms are pictured in Appendix V. As a result of normality violations, the Mann-Whitney U-test (nonparametric test) was used to compare dietary group differences with respect to each of these variables. Table 4.2.2 lists the mean values, test statistics and significance levels for questionnaire scores and reported hours of weekly activity. No significant differences between Veg and Omni men were observed on any of these measures. It should be mentioned that reported number of hours of weekly activity was not in violation of ANOVA test assumptions, but the p value was identical for both the ANOVA test and the Mann-Whitney U-Test so the latter result is shown.

Table 4.2.1 Skewness and kurtosis values for questionnaire results (GLTEQ, TFEQ, TFEQ restraint subscale, reported hours of activity)

	GLTEQ	TFEQ	Restraint Subscale	Activity (hr/wk)
Vegetarians				
Skewness	1.11	1.23	1.75	1.00
Kurtosis	3.34	2.55	5.34	-1.01
Omnivores				
Skewness	0.97	0.91	1.12	-0.83
Kurtosis	0.57	0.22	0.84	-0.33

GLTEQ = Godin Leisure-Time Exercise Questionnaire
Moderate Activity = self-reported hours per week engaged in moderate intensity activities
TFEQ = Three-Factor Eating Questionnaire
Restraint Subscale = dietary restraint subscale score of TFEQ

Table 4.2.2 Questionnaire scores and reported hours of moderate activity for vegetarian and omnivorous groups

Variable	Vegetarians (n = 27)	Omnivores (n = 27)	U-Test	Sig. (2 tailed)
GLTEQ Score	51.8± 27.0	46.8 ± 23.3	307.50	0.324
Moderate Activity (hrs/wk)	4.6 ± 1.8	3.8 ± 1.8	270.00	0.097
TFEQ Score	14.9 ± 5.1	16.7 ± 7.9	354.00	0.855
Dietary Restraint (TFEQ)	5.6 ± 3.5	5.5 ± 4.3	337.50	0.639

Values are group means ± SD, n = number of subjects
GLTEQ = Godin Leisure-Time Exercise Questionnaire
Moderate Activity = self-reported hours per week engaged in moderate intensity activities
TFEQ = Three-Factor Eating Questionnaire
Dietary Restraint (TFEQ) = dietary restraint subscale score of TFEQ
U-Test = Mann-Whitney U-Test statistic

4.3 Correlations between dependent variables

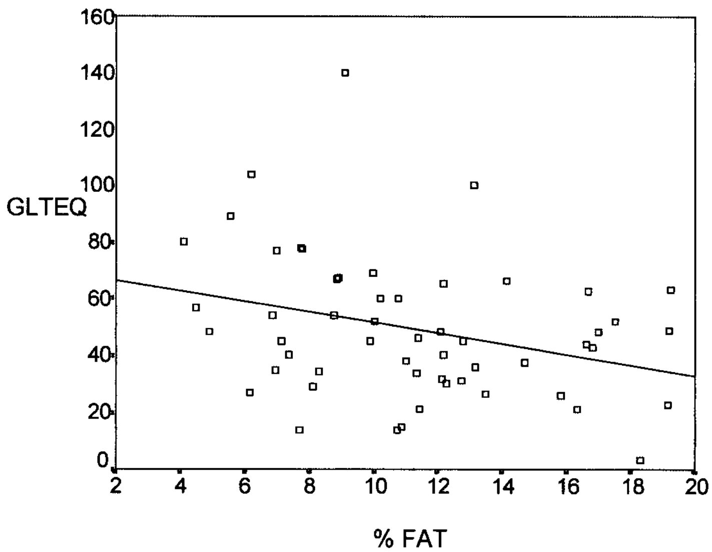
The data were further analyzed to examine relationships between any of the body composition variables and the questionnaire scores (TFEQ Score, Dietary Restraint Score from TFEQ, GLTEQ Score). In this analysis the entire study population was considered as a single group. Spearman correlations were used to account for violations to normality. Table 4.3.1 shows the Spearman correlation coefficients for these relationships. The only significant correlation was between % fat and the GLTEQ score, and this relationship is provided (Figure 4.3.1).

Table 4.3.1 Spearman correlation coefficients of questionnaire scores with body composition variables.

	Correlation Coefficient With		
Variable	Dietary Restraint (TFEQ)	TFEQ Score	GLTEQ Score
Muscle Mass (kg)	-0.051	-0.027	-0.172
Sum of 12 CG (cm^3)	-0.057	-0.052	-0.148
% Fat	-0.199	-0.235	-0.292*
Sum of 6 Skinfolds (mm)	-0.182	-0.226	-0.255

*Correlation is significant at the 0.05 level (2-tailed)
Sum of 12 CG = Sum of 12 skinfold-corrected muscle girths
TFEQ = Three-Factor Eating Questionnaire
Dietary Restraint (TFEQ) = Dietary restraint subscale score of the TFEQ
GLTEQ = Godin Leisure-Time Exercise Questionnaire

Figure 4.3.1 Scatterplot of relationship between GLTEQ score and percent fat



4.4 Dietary intakes

Just as there were violations of normality for questionnaire scores, 3-day intakes of dietary variables were in violation of ANOVA assumptions for normality. As a result of ANOVA violations, the Mann-Whitney U-test was used to compare dietary variables between groups (Appendix VIII). Values for skewness and kurtosis can be seen in Table 4.4.1. Histograms can be viewed in Appendix V.

Table 4.4.1 Skewness and kurtosis values for dietary intake variables by group.

	Calories	Protein	Fiber	Total fat	Sat Fat	Mon fat	Poly fat	P : S
Vegetarians								
Skewness	0.58	0.68	2.08	0.90	1.48	1.12	0.88	0.90
Kurtosis	-0.15	0.26	5.73	1.39	1.89	1.41	0.15	0.56
Omnivores								
Skewness	1.44	1.47	0.87	1.80	2.11	1.33	2.26	2.01
Kurtosis	2.50	2.65	0.54	4.78	7.40	2.22	5.83	5.07

Sat Fat = Saturated fat
Mon Fat = Monounsaturated fat
Poly fat = Polyunsaturated fat
P : S = Ratio of polyunsaturated fat to saturated fat

Results of the Mann-Whitney U-Test (Table 4.4.2) showed that the Veg group consumed significantly more dietary fiber, polyunsaturated fats and a higher ratio of polyunsaturated to saturated fats (P:S), and less saturated fat. No between group differences were observed for 3-day intakes of calories, protein, total fat, or monounsaturated fat.

Table 4.4.2 Three-day dietary intakes compared between dietary groups

Variable	Vegetarians (n = 27)	Omnivores (n = 27)	U-Test	Sig. (2 tailed)
Total Calories	10781 ± 3626	10608 ± 3915	350.0	0.802
Protein (g)	354.5 ± 123.7	452.7 ± 210.0	264.0	0.082
Dietary Fiber (g)	139.8 ± 76.6	92.3 ± 43.3	207.0	0.006**
Total Fat (g)	331.3 ± 136.3	365.8 ± 177.6	333.0	0.586
Saturated Fat (g)	93.8 ± 62.1	129.1 ± 71.4	240.0	0.031*
Monounsaturated Fat (g)	89.5 ± 44.8	101.2 ± 55.0	322.0	0.462
Polyunsaturated Fat (g)	67.5 ± 32.7	42.7 ± 27.5	171.5	0.001**
Poly Fat : Sat Fat	0.97 ± 0.63	0.36 ± 0.19	132.0	0.000**

Values are group means ± SD, n = number of subjects
*P value is significant at the 0.05 level
**P value is significant at the 0.01 level
U-Test = Mann-Whitney U-Test statistic

5. Discussion

A review of the current literature indicated that there was a minimal amount of research on the topic of body composition as it relates to vegetarianism. The study of muscle mass has long suffered from the absence of a practical method for measurement. The intent of this study was to explore this topic in a population that has yet to receive any attention, young men.

5.1 Body composition comparisons between dietary groups

There is limited research on the topic of vegetarianism and its relationship with muscle mass. The first two questions proposed in this study (see section 3.1), concerned whether or not a group of young vegetarian males would differ with respect to muscle mass from a group of young omnivorous males. The present study showed that there was a significant difference between groups in muscle quantity. The Veg group was found to have significantly lower values for predicted skeletal muscle mass (Veg 30.9kg $\pm$ 3.4 vs. Omni 32.7kg $\pm$ 4.1) after vegetarian subjects were linearly heightened 2.7 cm. In the present study, although height was not statistically different between groups, the omnivores were 2.7 cm taller. To account for this small size difference, the heights of vegetarians were linearly scaled to match the omnivores, as previous research has shown that muscle mass increases linearly with height (43). Height was selected as the variable to correct for size differences because it does not interfere with the variable of interest, muscle mass. On the contrary consider correcting muscle mass differences by the more obvious choice of body mass. If correcting by body mass, then any differences in body fat between the groups would obscure the potential for finding any differences in muscle as a percent of body mass. In the present study, because omnivores were slightly fatter (10.5 % vs. 12.0%, although the difference was not statistically significant) any chance of finding omnivores to have a higher percent muscle is confounded by their increased adiposity. Therefore, it was decided that in a between group comparison of muscularity correction for body mass would be misleading. Additional statistical support for this finding of decreased muscle mass among vegetarians was obtained through ANCOVA (with height as the covariate), revealing slightly larger between group differences (Veg 30.7 kg vs. Omni 32.6 kg). Significant group differences in muscle quantity were also observed in comparisons of the sum of 12 corrected muscle girths (Veg 2.5×10^6 $cm^3 \pm 4.2 \times 10^5$ vs. Omni $2.7 \times 10^6 cm^3 \pm 4.1 \times 10^5$).

There has been no previous cross-sectional research on this topic to corroborate our findings. It was hypothesized that differences in muscle would exist between dietary groups, based on the earlier research done in older male populations (4, 5). Previous experimental research has shown that in an elderly male population, consumption of a meat free diet has been inferior to a meat containing diet for gaining muscle and fat free mass with resistance training (4, 5). Although these earlier studies explored diet and the response to training, the central question posed by these studies was similar. Are there muscle differences between a group of men who consume a vegetarian (or meat free) diet compared to a group who consumes an omnivorous one? The answer so far appears to be yes. As the present study is cross-sectional in nature, no causative conclusions can be drawn. However, if a vegetarian diet does have an adverse affect on an individual's muscle building potential, this has important applications for a variety of populations including athletes, dieters, and the elderly.

Discussion of a mechanism that might explain the observed muscle differences is also a matter limited to speculation. Previous authors have suggested the possibility of a diet related hormonal effect to account for muscle differences (5). The present study made no attempt to monitor hormones, and as a result can offer no evidence to support or refute this proposition.

In addition to considering muscle differences, body fatness was also a variable of interest in the present study. Two variables were examined, a sum of 6 skinfolds (accounting for the major areas of fat deposition), and a percent fat derived by predictive equation. It was initially hypothesized that vegetarians would have lower values for each of these variables. Although the Veg group had lower scores for both a sum of 6 skinfolds (Veg 70.7mm ± 22.7 vs. Omni 80.7 ± 29.2) and percent fat (Veg 10.5% ± 3.6 vs. Omni 12.0% ± 4.5) neither achieved statistical significance. It appears as though the small sample size of the present study and the high standard deviations on these measures were limiting factors to detecting a possible difference. This finding agrees with the body of literature which has found either no differences between dietary groups with respect to fatness, or in the cases where there is a difference it is the vegetarians that are leaner (6-10).

5.2 Lifestyle comparisons between dietary groups

Vegetarianism is an unconventional diet, and perhaps an unconventional diet might be related to other unconventional lifestyle factors. A potential explanation for the lower muscle among vegetarians might be that vegetarianism is simply a socially acceptable way for men to diet. If this were true, body composition differences would certainly be expected between a group of vegetarians and omnivores. To test whether eating behaviours and attitudes differed between groups, all participants completed the 51-item Three-Factor Eating Questionnaire (TFEQ) (25). Of the three subscales measured in the TFEQ (restraint, dishinibition, and hunger), dietary restraint (the conscious limitation of food to control weight) was the focus of the present study. A higher score is indicative of greater dietary restraint. Results showed dietary restraint scores to be nearly identical between Veg (5.6 ± 3.5) and Omni (5.5 ± 4.3) groups in this study. Total TFEQ score was also considered with Veg scoring lower than Omni (14.9 ± 5.1 vs. 16.7 ± 7.9), although it was not a significant difference. In past research, a relationship has been identified between male vegetarians and increased dietary restraint (26). These findings are far from unanimous, as research in health conscious women has shown vegetarians to have less dietary restraint than omnivores (24).

Another potential explanation for body composition differences between dietary groups would be different activity levels. If one group is significantly more active, then this could explain differences in muscularity. To test whether groups differed with respect to exercise habits, participants completed the Godin Leisure-Time Exercise Questionnaire. In addition, subjects made an estimation of their participation hours (per week) in moderate intensity physical activities (i.e. recreational jogging, swimming, cycling, rock climbing, volleyball, tennis etc.). The higher the GLTEQ score the higher the activity level of an individual. Results indicated no significant difference between groups on either the GLTEQ (Veg 51.8 ± 27.0 vs. Omni 46.8 ± 23.3) or their hours of estimated activity (Veg 4.6 ± 1.8 vs. Omni 3.8 ± 1.8). However, the possibility still exists that one group was prone to involvement in more muscle promoting activities. These findings, combined with the eating behaviour findings suggest that there is no real difference in exercise or eating behaviours in the sample population involved in this study. Therefore, lifestyle factors are not able to explain the observed differences in muscle.

5.3 Correlations between dependent variables

There was only one significant correlation identified in the present study, existing between GLTEQ score and % fat (r^2 = -0.292). The weak relationship that exists, is not a surprise as GLTEQ is a measure of the amount of activity an individual participates in. It would be expected that as activity level increases body fat would decrease.

5.4 Dietary intake comparisons

The final hypothesis posed in this study concerned whether or not vegetarians and omnivores differed with respect to 3-day dietary intake values. The Veg group were found to consume significantly more dietary fiber (139.8g vs. 92.3g), polyunsaturated fats (67.5g vs. 42.7g) and a higher ratio of polyunsaturated to saturated fats (0.97 vs. 0.36), but less saturated fat (93.8g vs. 129.1g). These findings are in agreement with the limited dietary research that has been conducted on male vegetarians, and found increased fiber (27, 28) and decreased saturated fat (27, 28) levels in comparison to omnivores. No group differences were observed for 3-day intakes of calories, protein, total fats, saturated or monounsaturated fats. Although there was no significant difference observed in protein, it might be suggested that protein differences between Veg (354.5g ± 123.7) and Omni (452.7 ± 210.0) could explain muscularity differences. However, the average daily protein consumption of vegetarians in this study (118.2g) is nearly double the recommended daily allowance of 58-63g for men in their age range (45), and therefore was not believed to have a causal influence.

5.5 Summary and recommendations for future research

Has the present study contributed to a very new body of literature on vegetarianism and body composition? Utilizing a cross-sectional design, the present study has shown significant differences between vegetarians and omnivores with respect to muscle and dietary intakes of fiber and polyunsaturated and saturated fats, but no differences in activity levels, dietary restraint, or body fat levels. These were positive results, as the aim of the present study was to serve as a building block for future research on the topic of body composition and vegetarianism. Before one attempts to answer the question "Why do vegetarians differ with respect to muscle mass?", we must first question whether they are actually different. With this goal being accomplished in the present study, it should be the aim of future studies to answer the question of why they might be different. A recommendation for a future study would be one utilizing a design similar to the earlier Campbell study (5), but performed in a population of younger men. Like the Campbell study (5), a group composed entirely of sedentary omnivores would be randomized into 2 dietary groups. One group continues to consume a meat containing diet, while the other group is selected to consume a LOV diet. Baseline measurements of muscle are taken (ideally using MRI), in addition to fat measurements, and hormone levels (testosterone, free testosterone SHBG). Both groups would then engage in an identical 6-month training program aimed at increasing muscle hypertrophy. All dependent variables are re-measured monthly. In addition to Campbell's framework, the proposed study adds a more accurate means of muscle evaluation, plus hormone measurements and a longer training period. It is felt that a study with these additions might uncover a causal link between vegetarianism and body muscle. Until such a study is completed, we can only speculate about the possibility of a causal link between a vegetarian diet and decreased muscle mass.

6. References

1. National Institute of Nutrition. The Many Faces of Vegetarianism. News Release: Jan 1999.

2. Dwyer JT. Nutritional consequences of vegetarianism. Annu Rev Nutr 1991;11:61-91.

3. Clarys JP, Martin AD, Drinkwater DT. Gross tissue weights in the human body by cadaver dissection. Hum Biol 1984;56:459-473.

4. Campbell WW, Crim MC, Young VR, Joseph LJ, Evans WJ. Effects of resistance training and dietary protein intake on protein metabolism in older adults. Am J Physiol (Endocrinol Metab 31) 1995;268:E1143-E1153.

5. Campbell WW, Barton Jr. ML, Cyr-Campbell D, Davey SL, Beard JL, Parise G, Evans WJ. Effects of an omnivorous diet compared with a lactoovovegetarian diet on resistance-training-induced changes in body composition and skeletal muscle in older men. Am J Clin Nutr 1999;70:1032-1039.

6. Tayter M, Stanek KL. Anthropometric and dietary assessment of omnivore and lacto-ovo-vegetarian children. J Am Diet Assoc 1989;89:1661-1663.

7. Dwyer Jt, Andrew EM, Valadian I, Reed RB. Size, obesity, and leaness in vegetarian preschool children. J Am Diet Assoc 1980;77:434-437.

8. Hebbelinck M, Clarys P, Malsche A. Growth, development, and physical fitness of Flemish vegetarian children, adolescents, and adults. Am J Clin Nutr 1999;70 (suppl):579S-585S.

9. Barr SI, Prior JC, Janelle KC, Lentle BC. Spinal bone mineral density in premenopausal vegetarian and nonvegetarian women: cross-sectional and prospective comparisons. J Am Diet Assoc 1998;98:760-765.

10. Barbosa JC, Shultz TD, Filley SJ, Nieman DC. The relationship among adiposity, diet, and hormone concentrations in vegetarian and nonvegetarian postmenopausal women. Am J Clin Nutr 1990;51:798-803.

11. Parsons TJ, Van Dusseldorp M, Van Der Vliet M, Van De Werken K, Schaafsma G, Van Staveren WA. Reduced bone mass in dutch adolescents fed a macrobiotic diet in early life. J Bone Min Res 1997;12:1486-1494.

12. Nathan I, Hackett AF, Kirby S. A longitudinal study of the growth of matched pairs of vegetarian and omnivorous children, aged 7-11 years, in the North-West of England. Eur J Clin Nutr 1997;51:20-25.

13. Lee RC, Wang Z, Heo M, Ross R, Janssen I, Heymsfield SB. Total-body skeletal muscle mass: development and cross-validation of anthropometric prediction models. Am J Clin Nutr 2000;72:796-803.

14. Dwyer JT, Dietz Jr WH, Andrews EM, Suskind RM. Nutritional status of vegetarian children. Am J Clin Nutr 1982;35:204-216.

15. Howie BJ, Shultz TD. Dietary and hormonal interrelationships among vegetarian Seventh-Day Adventists and nonvegetarian men. Am J Clin Nutr 1985;42:127-134.

16. Jackson AS, Pollock ML. Generalized equations for predicting body density of men. Brit J Nutr 1978;40:497-504.

17. Lukaski H. Estimation of muscle mass. In: A. Roche, S Heymsfield, T. Lohman, ed. Human Body Composition. Champaign Ill: Human Kinetics Publishing, 1996:109-128.

18. Borsook H, Dubnoff JW. The hyrolysis of phosphocreatine and the origin of urinary creatinine. J Biol Chem 1947;168:493-510.

19. Martin AD, Spenst LF, Drinkwater DT, Clarys JP. Anthropometric estimation of muscle mass in men. Med Sci Sports Exerc 1990;22:729-733.

20. Heymsfield SB, McManus C, Smith J, Stevens V, Nixon DW. Anthropometric measurement of muscle mass: revised equations for calculating bone-free arm muscle area. Am J Clin Nutr 1982;36:680-690.

21. Norton K. Anthropometric estimation of body fat. In: Norton K, ed. Anthropometrica. Sydney: University of New South Wales Press, 1996:171-198.

22. Siri WE. Body volume measurement by gas dilution. In: Behnke A, ed. Techniques for measuring body composition. Washington DC: National Academy of Sciences, 1961:108-117.

23. Martin AD, Ross WD, Drinkwater DT, Clarys JP. Prediction of body fat by skinfold caliper: assumptions and cadaver evidence. Int J Obes 1985;9 (Suppl. 1):31-39.

24. Janelle KC, Barr SI. Nutrient Intakes and eating behaviour scores of vegetarian and nonvegetarian women. J Am Diet Assoc 1995;95:180-189.

25. Stunkard AJ, Messick S. The Three-Factor Eating Questionnaire to measure dietary restraint, disinhiition and hunger. J Psychosom Res 1985;29:71-83.

26. Martins Y, Pliner P, O'Connor K. Restrained eating among vegetarians: does a vegetarian eating style mask concerns about weight. Appetite 1999;32:145-154.

27. Key TJA, Roe L, M. Thorogood M, Moore JW, Clark GMG, Wang DY. Testosterone, sex hormone-binding globulin, calculated free testosterone, and estradiol in male begans and omnivores. Brit J Nutr 1990;64:111-119.

28. Belanger A, Locong A, Noel C, Cusan L, Dupont A, Prevost J, Caron S, Sevigny J. Influence of diet on plasma steroid and sex plasma binding globulin levels in adult men. J Steroid Biochem 1989;32:829-833.

29. Tesar R, Notelovitz M, Shim E, Kauwell G, Brown J. Axial and peripheral bone density and nutrient intakes of postmenopausal vegetarian and omnivorous women. Am J Clin Nutr 1992;56:699-704.

30. Lloyd T, Schaeffer JM, Walker MA, Demers LM. Urinary hormonal concentrations and spinal bone densities of premenopausal vegetarian and nonvegetarian women. Am J Clin Nutr 1991;54:1005-1010.

31. Woo J, Kwok T, Ho SC, Sham A, Lau E. Nutritional staus of elderly chinese vegetarians. Age and Ageing 1998;27:455-461.

32. Loebel CC, Kraemer WJ. A brief review: testosterone and resistance exercise in men. J Strength Cond Res 1998;12:57-63.

33. Vermeulen A. Physiology of the testosterone-binding globulin in man. Ann NY Acad Sci 1988;538:103-111.

34. Longcope C, Geldman HA, Mckinlay JB, Araujo AB. Diet and sex hormone-binding globulin. J Clin Endocrinol Metab 2000;85:293-296.

35. Raben A, Kiens B, Richter EA, Rasmussen LB, Svenstrup B, Micic S, Bennett P. Serum sex hormones and endurance performance after a lacto-ovo vegetarian and mixed diet. Med Sci Sports Exerc 1992;24:1290-1297.

36. Godin G, Shephard RJ. A simple method to assess exercise behaviour in the community. Can J Appl Sport Sci 1985;10:141-146.

37. Nelson M. Methods for data collection at an individual level. In: Staveren WAV, ed. Manual on methodology for food consumption studies. New York: Oxford University Press:64-74.

38. Jacobs DRJ, Ainsworth BE, Hartman TJ, Leon AS. A simultaneous evaluation of 10 community used physical activity questionnaires. Med Sci Sports Exerc 1993;25:81-91.

39. Sallis JF, Buono MJ, Roby JJ, Micale FG, Nelson JA. Seven-day recall and other physical activity self-reports in children and adolescents. Med Sci Sports Exerc 1993;25:99-108.

40. Lohman TC, Roche AF, Martorell R. Anthropometric standaridization reference manual. Champaing. IL: Human kinetics, 1998.

41. Behnke AR, Wilmore JH. Evaluation and regulation of body build and composition. Englewood Cliffs: Prentice Hall, 1974.

42. Esha Research. The food processor nutrition and fitness software. 7.6 ed. Salem OR, 2001.

43. Janssen I, Heymsfield SB, Wang Z, Ross R. Skeletal muscle mass and distribution in 468 men and women aged 18-88 yr. J Appl Physiol 2000;89:81-88.

44. Wang SM, Baumgartner R, Burastero S, Pierson Jr. RN, Heymsfield SB. Total body skeletal muscle mass measured directly by computerized axial tomography: results in healthy men. Clin Res 1992;40:A642.

45. National Academy of Sciences. Recommended Dietary Allowances 10th ed. Advanced Nutrition and Human Metabolism 3rd ed. Belmont Ca: Wadsworth/Thomson Learning, 1989:Inside front cover.

7. Appendices

Appendix III: Questionnaires

Screening Questionnaire

Name:

Age (years):

1. In the last two years, have you consumed meat (red meat, white meat, fish) more than once a month? Y or N

b) If you answered no to question 1, how many years have you been consuming a vegetarian diet? _______

c) If you answered yes to question 1, how many times a week do you consume meat? _______. How many years have you been consuming a meat containing diet? ________.

2. Do you participate in resistance training exercise? Y or N

b) If so, how many times per week on average? ______

3. On average, how many hours of moderate intensity physical activity do you perform in a week? (i.e. recreational jogging, swimming, cycling, rock climbing, volleyball, tennis, etc) _______

b) In what activities is the majority of this time spent? __________________________

4. Do you smoke? Y or N

5. Are you presently on, or have you been on any medication in the past year that may have an affect on your muscle or fat levels? Y or N

6. Place a checkmark beside one of the following.
Are you African Canadian______, Asian_____, Caucasian_____, Hispanic_____, Other______.

The Three-Factor Eating Questionnaire

Part 1

Instructions: Please circle the response that best applies to you.

1a. (For Meat eaters) When I smell a sizzling steak or see a juicy piece of meat, I find it very difficult to keep from eating, even if I have just finished eating a meal. ....**True** **False**

1b. (For Vegetarians) When I smell freshly baked bread I find it very difficult to keep from eating, even if I have just finished a meal. ....**True** **False**

2. I usually eat too much at social occasions, like parties and picnics. ....**True** **False**

3. I am usually so hungry that I eat more than three times a day. ....**True** **False**

4. When I have eaten my quota of calories, I am usually good about not eating any more. ....**True** **False**

5. Dieting is so hard for me because I just get too hungry. ....**True** **False**

6. I deliberately take small helpings as a means of controlling my weight. ....**True** **False**

7. Sometimes things just taste so good that I keep on eating even when I am no longer hungry..........**True** **False**

8. Since I am often hungry, I sometimes wish that while I am eating, an expert would tell me that I have had enough or that I can have something more to eat. ....**True** **False**

9. When I feel anxious, I find myself eating. ....**True** **False**

10. Life is too short to worry about dieting. .... **True** **False**

11. Since my weight goes up and down, I have gone on reducing diets more than once. ....**True** **False**

12. I often feel so hungry that I just have to eat something. ....**True** **False**

13. When I am with someone who is overeating, I usually overeat too. ....**True** **False**

14. I have a pretty good idea of the number of calories in common food. ....**True** **False**

15. Sometimes when I start eating, I just can't seem to stop. ....**True** **False**

16. It is not difficult for me to leave something on my plate. ....**True** **False**

17. At certain times of the day, I get hungry because I have gotten used to eating then. .... **True** **False**

18. While on a diet, if I eat food that is not allowed, I consciously eat less for a period of time to make up for it. ....**True** **False**

19. Being with someone who is eating often makes me hungry enough to eat also. ....**True** **False**

20. When I feel blue, I often overeat. ....**True** **False**

21. I enjoy eating too much to spoil it by counting calories or watching my weight. ....**True** **False**

22. When I see a real delicacy, I often get so hungry that I have to eat right away. ....**True** **False**

23. I often stop eating when I am not really full as a conscious means of limiting the amount that I eat. ....**True** **False**

24. I get so hungry that my stomach often seems like a bottomless pit. ....**True** **False**

25. My weight has hardly changed at all in the last ten years. ....**True** **False**

26. I am always hungry so it is hard for me to stop eating before I finish the food on my plate.........**True** **False**

27. When I feel lonely, I console myself by eating. ....**True** **False**

28. I consciously hold back at meals in order not to gain weight. ....**True** **False**

29. I sometimes get very hungry late in the evening or at night. ....**True** **False**

30. I eat anything I want, any time I want. ....**True** **False**

31. Without even thinking about it, I take a long time to eat. ....**True** **False**

32. I count calories as a conscious means of controlling my weight. ....**True** **False**

33. I do not eat some foods because they make me fat. ....**True** **False**

34. I am always hungry enough to eat at any time. ....**True** **False**

35. I pay a great deal of attention to changes in my figure. ....**True** **False**

36. While on a diet, if I eat a food that is not allowed, I often then splurge and eat other high calorie foods. ....**True** **False**

Part 2

Instructions: Please answer the following questions by circling the number above the response that is appropriate to you.

37. How often are you dieting in a conscious effort to control your weight?

1	2	3	4
rarely	**sometimes**	**usually**	**always**

38. Would a weight fluctuation of 5lbs affect the way you live your life?

1	2	3	4
not at all	**slightly**	**moderately**	**very much**

39. How ofen do you feel hungry?

1	2	3	4
only at mealtimes	sometimes between meals	often between meals	almost always

40. Do your feelings of guilt about overeating help you control your food intake?

1	2	3	4
never	**rarely**	**often**	**always**

41. How difficult would it be for you to stop eating halfway through dinner and not eat for the next four hours?

1	2	3	4
easy	**slightly difficult**	**moderately difficult**	**very difficult**

42. How conscious are you of what you are eating?

1	2	3	4
not at all	**slightly**	**moderately**	**extremely**

43. How frequently do you avoid "stocking up" on tempting foods?

1	2	3	4
almost never	**seldom**	**usually**	**almost always**

44. How likely are you to shop for low calorie foods?

1	2	3	4
unlikely	**slightly unlikely**	**moderately likely**	**very likely**

45. Do you eat sensibly in front of others and splurge alone?

1	2	3	4
never	**rarely**	**often**	**always**

46. How likely are you to consciously eat slowly in order to cut down on how much you eat?

1	2	3	4
unlikely	**slightly likely**	**moderately likely**	**very likely**

47. How frequently do you skip dessert because you are no longer hungry?

1	2	3	4
almost never	**seldom**	**at least once a week**	**almost every day**

48. How likely are you to consciously eat less than you want?

1	2	3	4
unlikely	**slightly likely**	**moderately likely**	**very likely**

49. Do you go on eating binges though you are not hungry?

1	2	3	4
never	**rarely**	**sometimes**	**at least once a week**

50. On a scale of 0 to 5, where 0 means no restraint in eating (eating whatever you want, whenever you want it) and 5 means total restraint (constantly limiting food intake and never "giving in"), what number would you give yourself.

0
eat whatever you want, whenever you want it

1
usually eat whatever you want, whenever you want it

2
often eat whatever you want, whenever you want it

3
often limit food intake, but often "give in"

4
usually limit food intake, rarely "give in"

5
constantly limiting food intake, never "giving in"

51. To what extent does this statement describe your eating behavior? "I start dieting in the morning, but because of any number of things that happen during the day, by evening I have given up and eat what I want, promising myself to start dieting again tomorrow.

1	2	3	4
not like me	**little like me**	**pretty good description of me**	**describes me perfectly**

Godin Leisure-Time Exercise Questionnaire

Considering a **7-Day period** (a week), how many times on the average do you do the following kinds of exercise for **more than 15 minutes** during your **free time** (write on each line the appropriate number). Include the average duration of your exercise bouts.

	Times per week (more than 15 mins)	Avg Duration
a) STRENUOUS EXERCISE (HEART BEATS RAPIDLY) (i.e. running, jogging, hockey, football, soccer, squash, basketball, cross country skiing, judo, roller skating, vigorous swimming, vigorous long distance cycling)	______	______
b) MODERATE EXERCISE (NOT EXHAUSTING) (i.e. fast walking, baseball, tennis, easy bicycling, volleyball, badminton, easy swimming, alpine skiing, popular and folk dancing)	______	______
c) MILD EXERCISE (MINIMAL EFFORT) (i.e. yoga, archery, fishing from river band, bowling, horseshoes, golf, snow-mobiling, easy walking)	______	______

2. Considering a 7-Day period (a week), during your leisure-time, how often do you engage in any regular activity long enough to work up a sweat (heart beats rapidly)?

OFTEN	SOMETIMES	NEVER/RARELY
1. ☐	2. ☐	3. ☐

Appendix IV: Anthropometric Proforma

Name (last, given)															
Date															
Birthdate								**Subject #**							
Height & Weight															
1) Stature (cm)															
2) Body Mass (kg)															
Skinfolds															
3) Biceps															
2 cm above biceps															
2 cm below biceps															
4) Triceps															
2 cm above triceps															
2 cm below triceps															
5)Forearm															
2 cm above forearm															
2 cm below forearm															
6) Subscapular															
7) Supra-ilium															
8) Chest															
9) Axilla															
10) Front thigh															
2 cm above thigh															
2 cm below thigh															
11) Medial calf															
2 cm above calf															
2 cm below calf															
12) Abdomen															
Girths															
13) Biceps															
2 cm above biceps															
2 cm below biceps															
14) forearm															
2 cm above forearm															
2 cm below forearm															
15) Mid-thigh															
2 cm above mid-thigh															
2 cm below mid-thigh															
16) Calf															
2 cm above calf															
2 cm below calf															

Appendix V: Distribution of Dependent Variables

Figure 1: Vegetarian Muscle Mass (Kg)

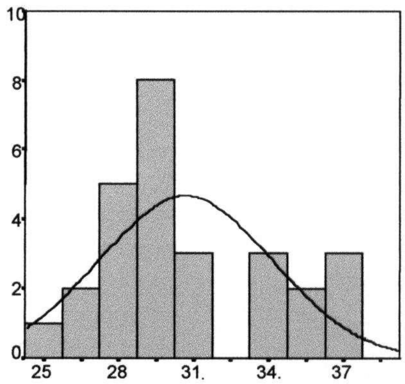


Figure 2: Omnivore Muscle Mass (Kg)

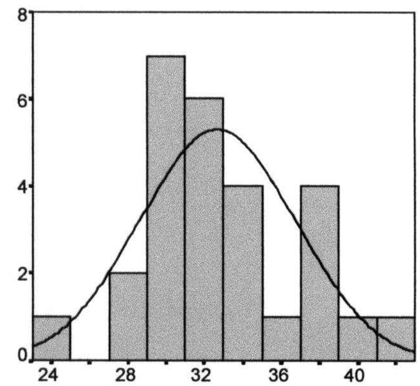


Figure 3: Vegetarian Σ12 CG (cm^3)

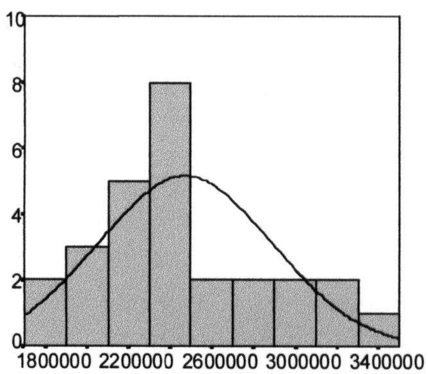


Figure 4: Omnivore Σ12 CG (cm^3)

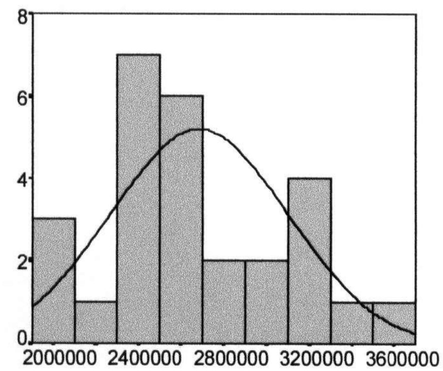


Figure 5: Vegetarian % Fat

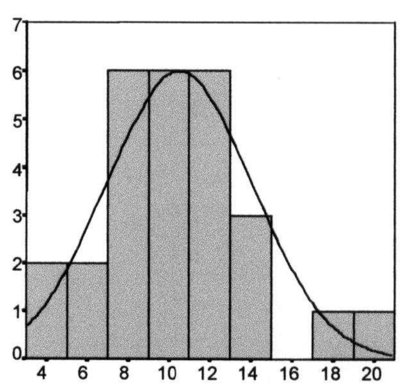


Figure 6: Omnivore % Fat

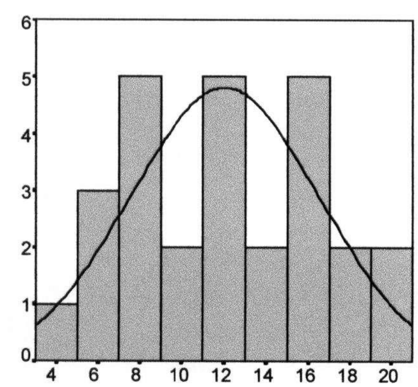


Figure 7: Vegetarian Σ6 Skinfolds (mm)

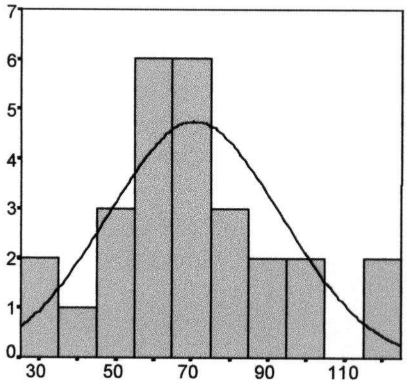


Figure 8: Omnivore Σ6 Skinfolds (mm)

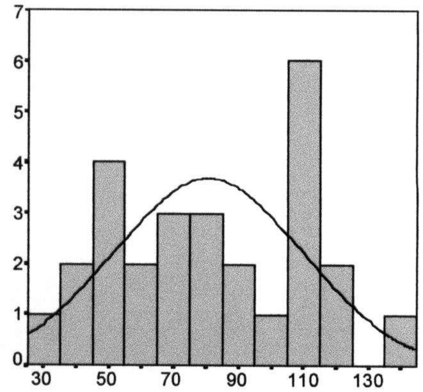


Figure 9: Vegetarian GLTEQ Score

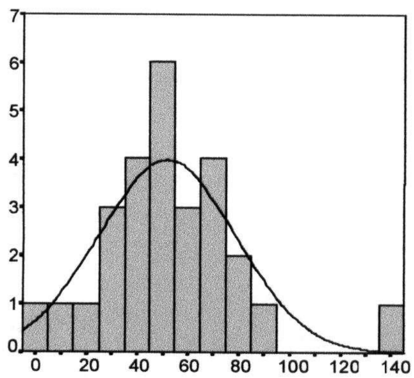


Figure 10: Omnivore GLTEQ Score

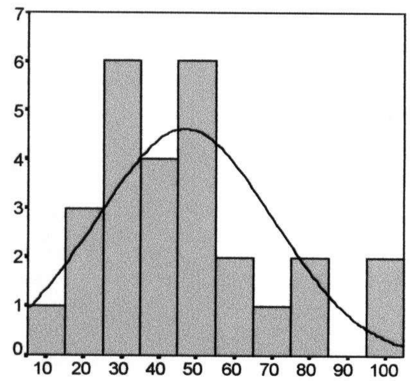


Figure 11: Vegetarian Dietary Restraint

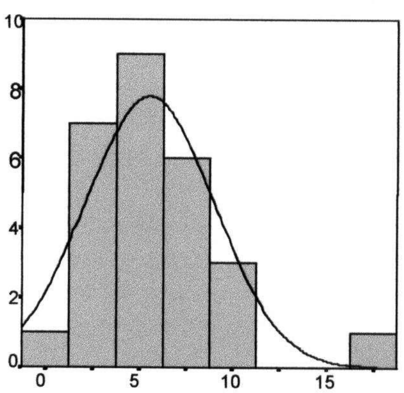


Figure 12: Omnivore Dietary Restraint

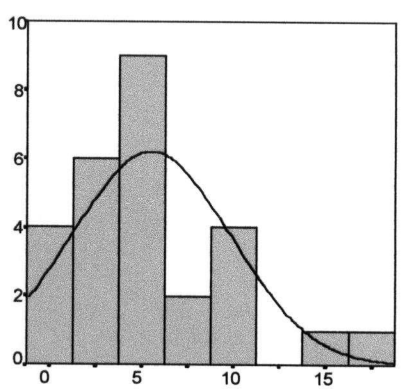


Figure 13: Vegetarian TFEQ Score

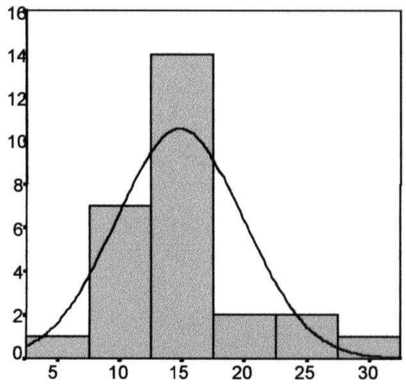


Figure 14: Omnivore TFEQ Score

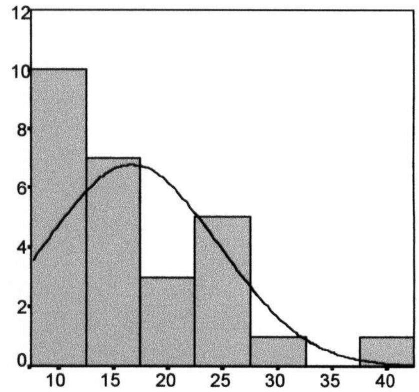


Figure 15: Vegetarian Activity (hr/week)

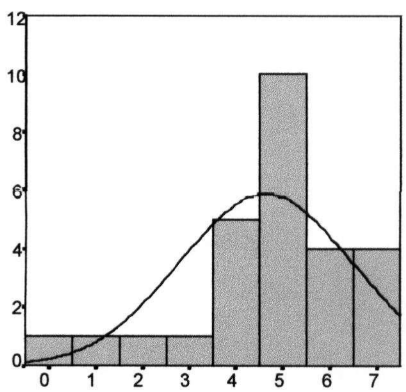


Figure 16: Omnivore Activity (hr/week)

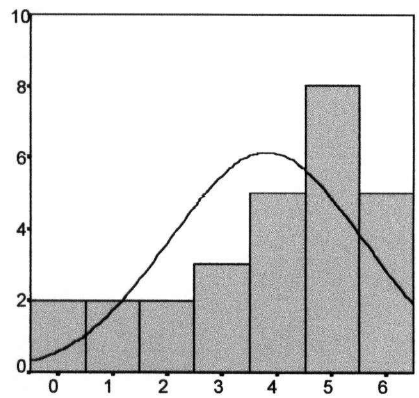


Figure 17: Vegetarian Calories

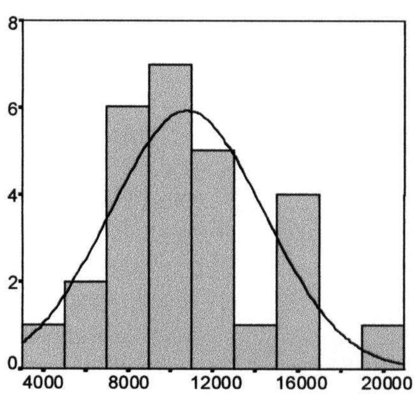


Figure 18: Omnivore Calories

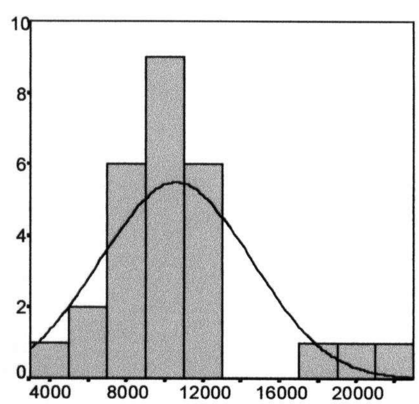


Figure 19: Vegetarian Protein (g)

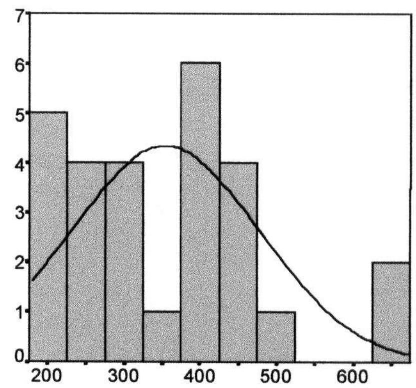


Figure 20: Omnivore Protein (g)

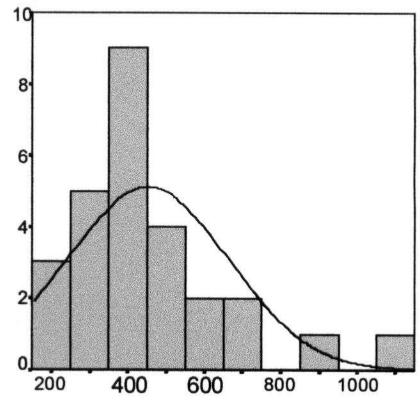


Figure 21: Vegetarian Fiber (g)

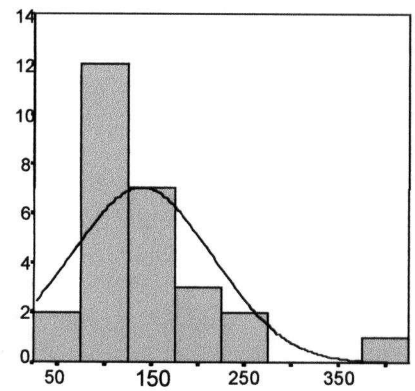


Figure 22: Omnivore Fiber (g)

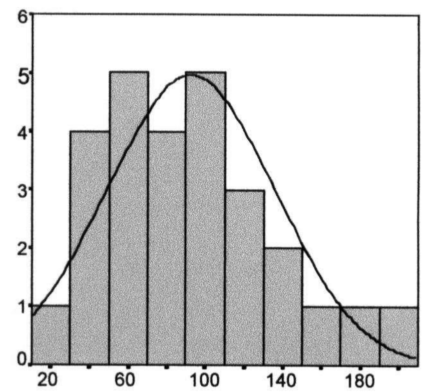


Figure 23: Vegetarian Total Fat (g)

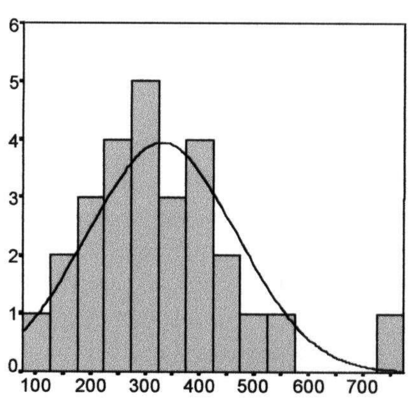


Figure 24: Omnivore Total Fat (g)

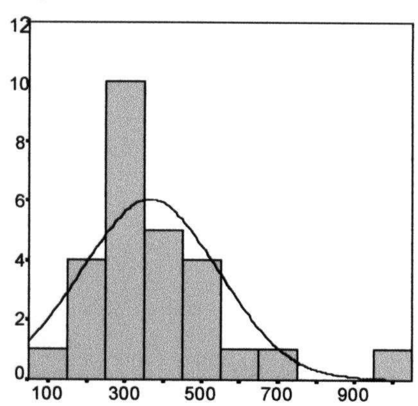


Figure 25: Vegetarian Sat. Fat (g)

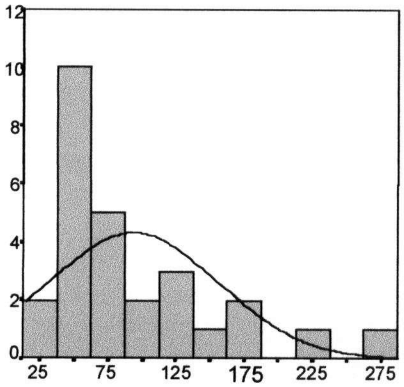


Figure 26: Omnivore Sat. Fat (g)

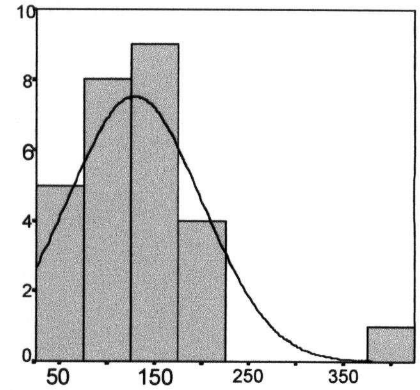


Figure 27: Vegetarian Mono. Fat (g)

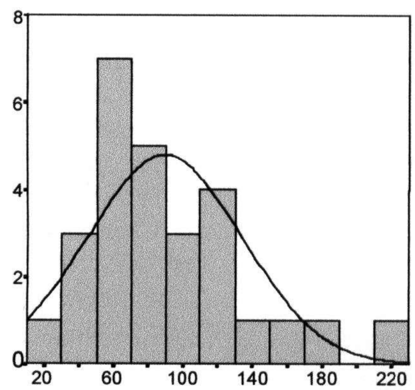


Figure 28: Omnivore Mono. Fat (g)

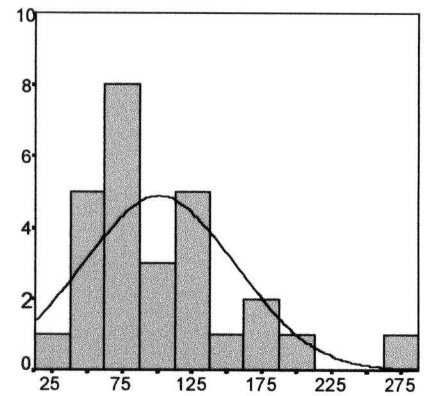


Figure 29: Vegetarian Poly. Fat Intake (g)

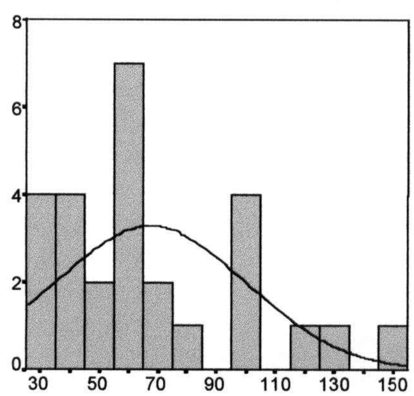


Figure 30: Omnivore Poly. Fat Intake (g)

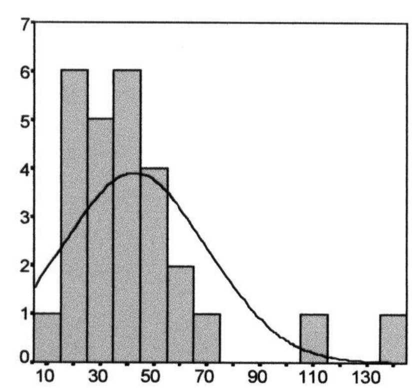


Figure 31: Vegetarian P : S Ratio

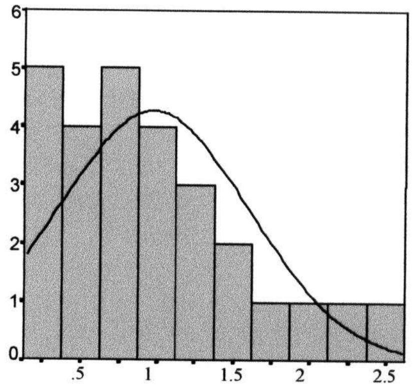
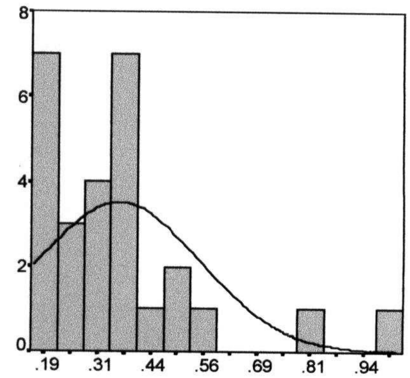


Figure 32: Omnivore P:S Ratio



AppendixVI: Instructions For 3-Day Diet Records

An accurate dietary intake record can provide valuable information about the nutritional content of an individual's usual diet. Please try and maintain your normal eating patterns in terms of content and quantity of foods eaten during this 3-day period.

Please keep a record of **everything** you eat or drink on the attached forms for 3 days in a row (two weekdays and one weekend day). **Please be as specific as possible.**

*To ensure accuracy please try to record immediately after eating.

*The more accurate you record; the more meaningful the analysis.

Be sure to include:

1. **ALL FOODS AND DRINKS** consumed including snacks, soft drinks, alcohol, cream and sugar in coffee/tea, butter/sauces on vegetables, jams, relishes, candies, butter/margarine/mayonnaise on sandwiches, salad dressing. Break combination foods down into their constituents (e.g. ham and cheese omelette= 3 eggs + 1 oz. Cheddar cheese + 1 slice Oscar Meyer Packaged ham Slices + 1 tsp butter in pan).

2. **THE AMOUNT OF FOOD** that was consumed. It is extremely important that accurate measurements be recorded. Please use the measuring cups and spoons provided to measure the volumes of foods consumed whenever possible.

* Use the **VOLUME** measures such as cups, tablespoons (Tbs.), teaspoons (Tsp.) or millilitres (ml) for soups, pasta, cereals, rice, other grains, small or cut vegetables, cut fruit, tinned foods, drinks, sauces, salad dressings, butter, mayonnaise, margarine, jams, peanut butter etc. Please be as accurate as possible. For example record whether a tablespoon is 'heaping' or 'level'.

Appendix VII: One Way ANOVA comparison of means

Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum
AGE	1.00	27	26.7037	3.20834	.61745	25.4345	27.9729	20.00	32.00
	2.00	27	25.7778	4.83841	.93115	23.8638	27.6918	20.00	34.00
	Total	54	26.2407	4.09295	.55698	25.1236	27.3579	20.00	34.00
HEIGHT	1.00	27	1.76822	.070671	.013601	1.74027	1.79618	1.655	1.955
	2.00	27	1.79537	.064081	.012332	1.77002	1.82072	1.631	1.917
	Total	54	1.78180	.068208	.009282	1.76318	1.80041	1.631	1.955
WEIGHT	1.00	27	72.9926	10.15022	1.95341	68.9773	77.0079	59.30	96.60
	2.00	27	77.0444	9.86923	1.89934	73.1403	80.9486	59.60	102.60
	Total	54	75.0185	10.12449	1.37777	72.2551	77.7820	59.30	102.60
MUSCMASS	1.00	27	30.9330	3.45494	.66490	29.5662	32.2997	25.23	37.39
	2.00	27	32.6689	4.06025	.78140	31.0627	34.2751	24.15	41.90
	Total	54	31.8009	3.83543	.52194	30.7541	32.8478	24.15	41.90
SUM12CGB	1.00	27	2471207	415931.28969	80046.01	2306669.715	2635743.591	1809113	3434090
	2.00	27	2683571	413584.70636	79594.41	2519962.268	2847179.590	1923126	3520751
	Total	54	2577389	424578.83087	57777.86	2461501.078	2693276.504	1809113	3520751
PERCFAT	1.00	27	10.4974	3.58599	.69012	9.0788	11.9160	4.50	19.27
	2.00	27	12.0207	4.46554	.85939	10.2542	13.7873	4.09	19.21
	Total	54	11.2591	4.08434	.55581	10.1443	12.3739	4.09	19.27
SUM6SF	1.00	27	70.7333	22.66359	4.36161	61.7679	79.6988	32.00	123.20
	2.00	27	80.6852	29.19867	5.61929	69.1346	92.2358	33.80	144.70
	Total	54	75.7093	26.37117	3.58866	68.5113	82.9072	32.00	144.70

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
AGE	Between Groups	11.574	1	11.574	.687	.411
	Within Groups	876.296	52	16.852		
	Total	887.870	53			
HEIGHT	Between Groups	.010	1	.010	2.187	.145
	Within Groups	.237	52	.005		
	Total	.247	53			
WEIGHT	Between Groups	221.636	1	221.636	2.212	.143
	Within Groups	5211.145	52	100.214		
	Total	5432.781	53			
MUSCMASS	Between Groups	40.681	1	40.681	2.863	.097
	Within Groups	738.978	52	14.211		
	Total	779.659	53			
SUM12CGB	Between Groups	6.09E+11	1	6.088E+11	3.539	.066
	Within Groups	8.95E+12	52	1.720E+11		
	Total	9.55E+12	53			
PERCFAT	Between Groups	31.327	1	31.327	1.910	.173
	Within Groups	852.810	52	16.400		
	Total	884.137	53			
SUM6SF	Between Groups	1337.031	1	1337.031	1.957	.168
	Within Groups	35521.214	52	683.100		
	Total	36858.245	53			

Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
GLTEQ	1.00	27	51.7778	27.02183	5.20035	41.0883	62.4673	3.00	140.00
	2.00	27	46.8333	23.31804	4.48756	37.6090	56.0576	14.00	104.00
	Total	54	49.3056	25.12298	3.41881	42.4483	56.1628	3.00	140.00
RESTRAIN	1.00	27	5.5556	3.45669	.66524	4.1881	6.9230	1.00	18.00
	2.00	27	5.5185	4.33563	.83439	3.8034	7.2336	.00	17.00
	Total	54	5.5370	3.88375	.52851	4.4770	6.5971	.00	18.00
TFEQ	1.00	27	14.8519	5.09678	.98088	12.8356	16.8681	5.00	30.00
	2.00	27	16.6667	7.92270	1.52472	13.5325	19.8008	8.00	38.00
	Total	54	15.7593	6.66145	.90651	13.9410	17.5775	5.00	38.00
ACTIVITY	1.00	27	4.6296	1.82711	.35163	3.9069	5.3524	.00	7.00
	2.00	27	3.8085	1.75114	.33701	3.1158	4.5012	.00	6.00
	Total	54	4.2191	1.82036	.24772	3.7222	4.7159	.00	7.00
CALORIES	1.00	27	10780.85	3626.15352	697.85357	9346.3948	12215.3119	4304.18	19210.17
	2.00	27	10608.12	3914.82386	753.40820	9059.4691	12156.7746	4692.61	22133.05
	Total	54	10694.49	3738.50061	508.74549	9674.0734	11714.9018	4304.18	22133.05
PROTEIN	1.00	27	354.5389	123.71721	23.80939	305.5980	403.4798	183.62	642.61
	2.00	27	452.6711	209.95578	40.40601	369.6154	535.7268	190.18	1106.86
	Total	54	403.6050	177.72546	24.18537	355.0953	452.1147	183.62	1106.86
FIBER	1.00	27	139.8137	76.63467	14.74835	109.4980	170.1294	60.00	418.46
	2.00	27	92.3381	43.28275	8.32977	75.2161	109.4602	26.93	206.05
	Total	54	116.0759	66.13751	9.00018	98.0239	134.1280	26.93	418.46
TOTFAT	1.00	27	331.2996	136.24622	26.22060	277.4024	385.1968	106.15	726.71
	2.00	27	365.7841	177.58103	34.17548	295.5354	436.0328	120.79	984.28
	Total	54	348.5419	157.73176	21.46457	305.4894	391.5943	106.15	984.28
SATFAT	1.00	27	93.7493	62.10149	11.95144	69.1827	118.3158	24.09	275.03
	2.00	27	129.0722	71.41882	13.74456	100.8199	157.3246	28.64	400.75
	Total	54	111.4107	68.64352	9.34120	92.6747	130.1468	24.09	400.75
MONOFAT	1.00	27	89.4463	44.79619	8.62103	71.7255	107.1671	25.20	217.00
	2.00	27	101.1489	54.96715	10.57843	79.4046	122.8932	34.08	271.94
	Total	54	95.2976	50.01492	6.80617	81.6461	108.9490	25.20	271.94
POLYFAT	1.00	27	67.5107	32.68529	6.29029	54.5809	80.4406	27.98	149.26
	2.00	27	42.7419	27.50983	5.29427	31.8593	53.6244	13.22	138.20
	Total	54	55.1263	32.42853	4.41296	46.2750	63.9776	13.22	149.26
PUFTOSAT	1.00	27	.9744	.62948	.12114	.7254	1.2234	.17	2.62
	2.00	27	.3628	.19139	.03683	.2871	.4385	.16	1.02
	Total	54	.6686	.55464	.07548	.5172	.8200	.16	2.62

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
GLTEQ	Between Groups	330.042	1	330.042	.518	.475
	Within Groups	33121.667	52	636.955		
	Total	33451.708	53			
RESTRAIN	Between Groups	.019	1	.019	.001	.972
	Within Groups	799.407	52	15.373		
	Total	799.426	53			
TFEQ	Between Groups	44.463	1	44.463	1.002	.321
	Within Groups	2307.407	52	44.373		
	Total	2351.870	53			
ACTIVITY	Between Groups	9.102	1	9.102	2.842	.098
	Within Groups	166.525	52	3.202		
	Total	175.627	53			
CALORIES	Between Groups	402788.2	1	402788.223	.028	.867
	Within Groups	7.40E+08	52	14237417.58		
	Total	7.41E+08	53			
PROTEIN	Between Groups	130004.1	1	130004.096	4.378	.041
	Within Groups	1544072	52	29693.689		
	Total	1674076	53			
FIBER	Between Groups	30428.033	1	30428.033	7.856	.007
	Within Groups	201403.0	52	3873.135		
	Total	231831.0	53			
TOTFAT	Between Groups	16053.888	1	16053.888	.641	.427
	Within Groups	1302549	52	25049.026		
	Total	1318603	53			
SATFAT	Between Groups	16844.108	1	16844.108	3.761	.058
	Within Groups	232888.3	52	4478.621		
	Total	249732.4	53			
MONOFAT	Between Groups	1848.834	1	1848.834	.735	.395
	Within Groups	130730.2	52	2514.043		
	Total	132579.1	53			
POLYFAT	Between Groups	8282.221	1	8282.221	9.076	.004
	Within Groups	47453.094	52	912.559		
	Total	55735.315	53			
PUFTOSAT	Between Groups	5.050	1	5.050	23.331	.000
	Within Groups	11.255	52	.216		
	Total	16.304	53			

Appendix VIII: Mann–Whitney U-Tests

Ranks

	DIETGRP	N	Mean Rank	Sum of Ranks
GLTEQ	1.00	27	29.61	799.50
	2.00	27	25.39	685.50
	Total	54		
ACTIVITY	1.00	27	31.00	837.00
	2.00	27	24.00	648.00
	Total	54		
TFEQ	1.00	27	27.11	732.00
	2.00	27	27.89	753.00
	Total	54		
RESTRAIN	1.00	27	28.50	769.50
	2.00	27	26.50	715.50
	Total	54		

Test Statistics[a]

	GLTEQ	ACTIVITY	TFEQ	RESTRAIN
Mann-Whitney U	307.500	270.000	354.000	337.500
Wilcoxon W	685.500	648.000	732.000	715.500
Z	-.986	-1.657	-.182	-.470
Asymp. Sig. (2-tailed)	.324	.097	.855	.639

a. Grouping Variable: DIETGRP

Ranks

	DIETGRP	N	Mean Rank	Sum of Ranks
CALORIES	1.00	27	28.04	757.00
	2.00	27	26.96	728.00
	Total	54		
PROTEIN	1.00	27	23.78	642.00
	2.00	27	31.22	843.00
	Total	54		
FIBER	1.00	27	33.33	900.00
	2.00	27	21.67	585.00
	Total	54		
TOTFAT	1.00	27	26.33	711.00
	2.00	27	28.67	774.00
	Total	54		
SATFAT	1.00	27	22.89	618.00
	2.00	27	32.11	867.00
	Total	54		
MONOFAT	1.00	27	25.93	700.00
	2.00	27	29.07	785.00
	Total	54		
POLYFAT	1.00	27	34.65	935.50
	2.00	27	20.35	549.50
	Total	54		
PUFTOSAT	1.00	27	36.11	975.00
	2.00	27	18.89	510.00
	Total	54		

Test Statistics[a]

	CALORIES	PROTEIN	FIBER	TOTFAT	SATFAT	MONOFAT	POLYFAT	PUFTOSAT
Mann-Whitney U	350.000	264.000	207.000	333.000	240.000	322.000	171.500	132.000
Wilcoxon W	728.000	642.000	585.000	711.000	618.000	700.000	549.500	510.000
Z	-.251	-1.739	-2.725	-.545	-2.154	-.735	-3.339	-4.022
Asymp. Sig. (2-tailed)	.802	.082	.006	.586	.031	.462	.001	.000

a. Grouping Variable: DIETGRP

Appendix IX: Spearman correlation coefficients

Correlations

			MUSCMASS	SUM12CGB	PERCFAT	SUM6SF	GLTEQ	RESTRAIN	TFEQ
Spearman's rho	MUSCMASS	Correlation Coefficie	1.000	.960**	-.100	-.076	-.172	-.051	-.027
		Sig. (2-tailed)	.	.000	.473	.585	.214	.716	.846
		N	54	54	54	54	54	54	54
	SUM12CGB	Correlation Coefficie	.960**	1.000	.006	.032	-.148	-.057	-.052
		Sig. (2-tailed)	.000	.	.964	.818	.286	.680	.710
		N	54	54	54	54	54	54	54
	PERCFAT	Correlation Coefficie	-.100	.006	1.000	.984**	-.292*	-.199	-.235
		Sig. (2-tailed)	.473	.964	.	.000	.032	.150	.087
		N	54	54	54	54	54	54	54
	SUM6SF	Correlation Coefficie	-.076	.032	.984**	1.000	-.255	-.182	-.226
		Sig. (2-tailed)	.585	.818	.000	.	.063	.187	.100
		N	54	54	54	54	54	54	54
	GLTEQ	Correlation Coefficie	-.172	-.148	-.292*	-.255	1.000	.048	.024
		Sig. (2-tailed)	.214	.286	.032	.063	.	.728	.864
		N	54	54	54	54	54	54	54
	RESTRAIN	Correlation Coefficie	-.051	-.057	-.199	-.182	.048	1.000	.610**
		Sig. (2-tailed)	.716	.680	.150	.187	.728	.	.000
		N	54	54	54	54	54	54	54
	TFEQ	Correlation Coefficie	-.027	-.052	-.235	-.226	.024	.610**	1.000
		Sig. (2-tailed)	.846	.710	.087	.100	.864	.000	.
		N	54	54	54	54	54	54	54

**. Correlation is significant at the .01 level (2-tailed).

*. Correlation is significant at the .05 level (2-tailed).

Appendix X: ANCOVA comparison of muscle mass

Univariate Analysis of Variance

Between-Subjects Factors

		Value Label	N
DIETGRP	1.00	Vegetarian	27
	2.00	Omnivores	27

Descriptive Statistics

Dependent Variable: MUSCLE

DIETGRP	Mean	Std. Deviation	N
Vegetarian	30.5985	3.41132	27
Omnivores	32.6689	4.06025	27
Total	31.6337	3.85848	54

Tests of Between-Subjects Effects

Dependent Variable: MUSCLE

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	70.875[a]	2	35.438	2.517	.091
Intercept	25.260	1	25.260	1.794	.186
HEIGHT	13.009	1	13.009	.924	.341
DIETGRP	45.258	1	45.258	3.214	.079
Error	718.183	51	14.082		
Total	54826.384	54			
Corrected Total	789.059	53			

a. R Squared = .090 (Adjusted R Squared = .054)

Estimated Marginal Means

1. Grand Mean

Dependent Variable: MUSCLE

Mean	Std. Error	95% Confidence Interval	
		Lower Bound	Upper Bound
31.634[a]	.511	30.609	32.659

a. Evaluated at covariates appeared in the model: HEIGHT = 1.7818.

2. DIETGRP

Estimates

Dependent Variable: MUSCLE

DIETGRP	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Vegetarian	30.699[a]	.730	29.234	32.164
Omnivores	32.568[a]	.730	31.103	34.033

a. Evaluated at covariates appeared in the model: HEIGHT = 1.7818.

Pairwise Comparisons

Dependent Variable: MUSCLE

(I) DIETGRP	(J) DIETGRP	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
					Lower Bound	Upper Bound
Vegetarian	Omnivores	-1.869	1.043	.079	-3.962	.224
Omnivores	Vegetarian	1.869	1.043	.079	-.224	3.962

Based on estimated marginal means

a. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Univariate Tests

Dependent Variable: MUSCLE

	Sum of Squares	df	Mean Square	F	Sig.
Contrast	45.258	1	45.258	3.214	.079
Error	718.183	51	14.082		

The F tests the effect of DIETGRP. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.