COGNITIVE DIETARY RESTRAINT, FOOD INTAKE AND CORTISOL EXCRETION IN PREMENOPAUSAL WOMEN

by

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ABSTRACT

In order to achieve or maintain a desired body weight many women consciously try to limit their food intake. This is referred to as *dietary restraint* or *cognitive dietary restraint*. Currently the instrument most commonly used to assess dietary restraint is the restraint scale of the Three-Factor Eating Questionnaire (TFEQ). Previous studies have found women with high restraint scores to be similar to those with low restraint scores in terms of age, Body Mass Index (BMI), and energy intake. Where a difference has been found is in menstrual cycle, and particularly ovulatory, characteristics. While the mediating mechanism for this association is not known we have hypothesized that women with high restraint scores may experience more stress as a result of monitoring their food intake. Stress, whether physiological or psychological, activates the hypothalamic-pituitary-adrenal axis resulting in an elevation in serum cortisol and consequently, in urinary cortisol excretion. Higher levels of cortisol are associated with a decrease in reproductive hormones and also with accelerated bone loss.

This cross-sectional study was designed to determine whether relationships exist among dietary restraint, food intake, cortisol excretion and bone mineral density (BMD) in premenopausal women. To address this purpose a two-part study was designed. In Part One, women completed a survey instrument which included the TFEQ, Eating Disorder Inventory (EDI), Rosenberg's Self-esteem Scale and Perceived Stress Scale as well as information on physical, lifestyle and menstrual cycle characteristics. Individuals from Part One were recruited for Part Two on the basis of having low or high restraint scores and a number of other inclusion/exclusion criteria. Eligible participants were 20-35 y, weight stable, had a BMI between 18 and 25 kg/m^2, exercised $\leq$ 7 hr/wk, were regularly menstruating and not using oral contraceptives. These individuals completed 3-day food records, collected a 24-

hour urine specimen on a day in which all food was provided to them and their intakes recorded, and had their body composition and BMD assessed by DEXA.

Participants (n = 666) in Part One were grouped on the basis of restraint scores into low, medium or high restraint groups. The 3 groups were similar in average age, height, weight and BMI, but women in the high restraint group had higher 'highest' BMIs, exercised more (hr/wk) and were more likely to report following vegetarian diets. Also, a greater proportion of women with high restraint scores reported presently trying to lose weight, had ever tried to lose weight, had a history of eating disorders and had experienced weight fluctuations. A significant difference was found in menstrual cycle regularity with 34% of women with high restraint scores reporting irregular cycles compared with about 17% of women with low or medium restraint scores. Scores on the TFEQ hunger scale and EDI maturity fears scale did not differ among groups, but women in the high restraint group had higher scores than those in the low restraint group on all other psychometric scales. Overall, Part One provides a broad profile of the study population from which Part Two participants were recruited.

Participants (n = 62) in Part Two were also compared on the basis of high or low restraint scores. Again, age, height, weight and BMI were similar. Both 3-day reported and 24-hour documented energy and fat intakes were lower in the high restraint group, but other nutrient intakes, including calcium, were similar. Exercise level was higher in the high restraint group although the inclusion criterion was set at $\leq$ 7 hr/wk. The 24-hour urinary excretion of cortisol in women with high scores for restraint was significantly greater than in women with low scores for restraint. There were no associations between cortisol excretion and energy or nutrient intakes or exercise level. Characteristics of bone did not differ between restraint groups but further analysis using exercise as a covariate revealed lower

values for bone mineral content (BMC) in the high restraint group. Differences were found in BMD and BMC between women grouped as minimal (0-< 2 hr/wk) or moderate (2-7 hr/wk) exercisers with the latter having higher values. Later analysis of only women who reported exercising moderately revealed lower values for total body BMC and spinal BMC in women with high compared to low restraint scores.

The finding that urinary cortisol excretion was higher in women with high scores for dietary restraint than those with low scores is unique and supports our hypothesis that dietary restraint is a stressor with corresponding physiological responses from the neuroendocrine system. Higher cortisol excretion has long term implications for bone health; accordingly our results suggest that dietary restraint may not be innocuous. Our study concurs with other cross-sectional studies in finding a difference in BMC and BMD between minimal and moderate exercisers. What our results add is the finding that within women grouped as moderate exercisers, high levels of dietary restraint may be a limiting factor in the maximization or maintenance of bone mass, possibly through associated higher cortisol levels. Prospective studies are needed to determine whether the cross-sectional associations among dietary restraint, cortisol, moderate exercise and bone mineral characteristics persist over time.

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CHAPTER 1:

INTRODUCTION

1.1 Background

In order to achieve or maintain a desired body weight, many women consciously try to limit their food intake. This is referred to as *dietary restraint* or *cognitive dietary restraint*. The concept of restrained eating was originally introduced to define a type of eating behaviour that was governed by cognitive processes rather than by physiological mechanisms such as hunger and satiety (Herman CP & Mack D, 1975).

Of the several scales that have been developed to measure dietary restraint, the 21-item restraint scale of the Three-Factor Eating Questionnaire (TFEQ), (Stunkard AJ & Messick S, 1985) is currently recognized as the most appropriate tool for the assessment of cognitive dietary restraint. Other scales have been more concerned with a combination of restraint and overeating (Laessle RG et al, 1989a). Typically women with high scores on the restraint scale are very *aware* of the amount and type of food they consume, although studies have shown they may not actually eat less.

Previous studies have found women with high scores for dietary restraint to be similar to those with low scores for dietary restraint in terms of age, Body Mass Index (BMI, kg/m^2), and energy intake (Lautenbacher S et al, 1992; Barr SI et al, 1994a; Barr SI et al, 1994b). Where a difference has been found has been in menstrual cycle, and particularly ovulatory, characteristics (Schweiger U et al, 1992; Barr SI et al, 1994a; Barr SI et al, 1994b). In three separate studies involving different subject groups, more ovulatory disturbances were found in women with high scores for dietary restraint compared to women with low scores for restraint. These differences included shortening of cycle length, luteal phase length, and the

proportion of anovulatory cycles (Schweiger U et al, 1992; Barr SI et al, 1994a; Barr SI et al, 1994b).

The mediating mechanism between dietary restraint and ovulatory disturbances is not known, but women with high scores for restraint may experience more stress related to food intake than women with low scores for restraint. At the neuroendocrine level, higher stress triggers the release of corticotropin releasing hormone (CRH) from the hypothalamus which leads to the release of cortisol from the adrenal cortex (Rivier C et al, 1986). If higher stress does occur in relation to dietary restraint an elevation in cortisol levels would be a likely consequence. Higher levels of cortisol are associated with increases in reproductive disturbances due to the inhibitory effect of CRH on the hypothalamic hormones required for normal menstrual cycle function (Barbarino A et al, 1989; Biller BM et al, 1990). Therefore, if dietary restraint led to stress-related hypercortisolemia and increased urinary cortisol excretion, women with high restraint scores would be more likely to experience associated reproductive changes.

Only one study has explored a possible relationship between cortisol levels or excretion and dietary restraint (Pirke KM et al, 1990). This study measured serum cortisol at 30 minute intervals from 11:00 P.M. to 7:00 A.M.. The overnight study protocol may not have been appropriate if an increase in cortisol corresponds with an increase in stress related to food intake. It is unlikely that group differences would be observed during a time period when food consumption would not occur.

While a potential relationship between dietary restraint and cortisol has not been adequately explored, there is known to be a relationship between clinical eating disorders and high cortisol. Studies have found that elevated cortisol levels are significantly more common in women with clinical eating disorders than in those without (Devlin MJ et al, 1989;

Schweiger U et al, 1992). Hypercortisolemia is closely associated with amenorrhea, or the absence of menstruation, in women with anorexia nervosa (Biller BM et al, 1990). In fact, amenorrhea (no menstrual flow for $\geq$ 3 months), is one of the diagnostic criteria for anorexia nervosa (American Psychiatric Association, 1987). Menstrual cycle disturbances are common in normal weight women with bulimia nervosa and even in women dieting for the achievement of a healthy body weight (Pirke KM et al, 1985; Pirke KM et al, 1987; Pirke KM et al, 1989).

Menstrual cycle abnormalities such as those observed in women with clinical eating disorders have been associated with lower bone mineral density (Yeager KK et al, 1993; Carmichael KA & Carmichael DH, 1995). The severity of apparent bone loss increases with the degree of cycle disturbance. At the extreme end, amenorrhea associated with anorexia nervosa is related to significantly lower bone mineral density and subsequent risk of osteoporotic fractures (Carmichael KA & Carmichael DH, 1995). At the lesser end, in well nourished active women, subclinical menstrual cycle disturbances including anovulation, were associated with a loss in spinal bone mineral density over a one year period (Prior JC et al, 1990).

Bone loss is a well known consequence of low or decreased levels of reproductive hormones regardless of whether these reproductive changes are related to clinical eating disorders, cessation of ovarian function or hypothalamic disturbances (Cann CE et al, 1984; Davies MC et al, 1990; Drinkwater BL et al, 1984; Marcus R et al, 1985). Reproductive hormones, especially estrogen and progesterone, are important in skeletal maturation, the achievement of peak bone mass and the prevention of bone loss. As stated earlier, research has shown that the production of reproductive hormones is negatively impacted by elevated levels of cortisol. Higher cortisol is associated with bone loss not only through its indirect

impact on menstrual cycle function but also through direct effects on bone and mineral metabolism (Canalis E, 1996). Studies suggest that cortisol inhibits bone formation and enhances bone resorption (Lukert BP & Raisz LG, 1990). Exogenous glucocorticoids decrease calcium absorption from the intestine through direct effects on intestinal cell metabolic functions (Hahn TJ et al, 1981). Lower calcium absorption leads to a decrease in serum calcium to which the parathyroid gland responds by increasing parathyroid hormone (PTH) activity. PTH increases resorption of bone to normalize serum calcium levels, ultimately leading to increased renal calcium excretion. It has been reported that osteoporosis occurs in 30-50% of persons who require long-term cortisol therapy (Hahn TJ, 1978; Adinoff AD & Hollister JR, 1983). Therefore, it is possible that more modest increases in circulating levels of cortisol could have long-term implications for bone health.

The relationships among cortisol, clinical eating disorders, menstrual cycle and ovulatory disturbances, and bone health have been documented. The relationship between dietary restraint and menstrual cycle and ovulatory disturbances has also been documented in several studies. What remains to be investigated are the relationships between dietary restraint and cortisol, and dietary restraint and bone health. The existing data suggest that if women with high scores for dietary restraint have higher circulating levels of cortisol, causing increased excretion, than women with low scores for dietary restraint, the former group may be at risk in terms of bone health.

1.2 Purpose of the Study

The primary purpose of this cross-sectional study was to determine whether an association exists between cognitive dietary restraint and cortisol excretion. As a measure of cortisol production, twenty-four hour urinary cortisol excretion was compared between

women with high scores on the restraint scale of the TFEQ and women with low scores on the restraint scale.

In some (Tuschl RJ et al, 1990a; Laessle RG et al, 1989b), but not all (Schweiger U et al, 1992; Barr SI et al, 1994a; Barr SI et al, 1994b) studies, women with high scores for restraint differed from those with low scores for restraint with respect to total energy intake, macronutrient intakes and long term food preferences. In order to quantify and qualify any differences in energy and macronutrient intakes in the present study, participants completed 3-day food records. In addition, all food and beverages were supplied and intakes recorded during the 24-hour urine collection period.

While it is apparent that restrained eating may be a consequence of current cultural ideals for a slim, athletic figure it is not known why some women respond more to social pressures than others. To provide a broader profile of women with high scores for restraint compared to those with low scores, participants also completed several scales assessing various eating attitudes, eating behaviours and personality characteristics. This broad profile also included additional information on physical characteristics, exercise habits, dieting behaviour, menstrual cycle characteristics and other lifestyle factors. Only one study has directly examined the possible link between dietary restraint and bone mineral density (BMD) (Barr SI et al, 1994a). In Barr's study, spinal BMD, as assessed by quantitative computerized tomography (QCT), was similar between women grouped in the upper and lower tertiles for dietary restraint. The latter study was limited by a small sample size which included only 9 women in each of the upper and lower restraint groups making the detection of a difference unlikely as there is substantial inter-individual variability in BMD. The present study assessed body composition and bone status by dual energy x-ray absorptiometry (DEXA). The urinary calcium/creatinine excretion ratio was also calculated

for use as a comparative indicator of bone metabolism between the two groups. The main objectives of this study were:

1. To compare the 24-hour urinary excretion of cortisol of women with low scores for dietary restraint and women with high scores for dietary restraint.
2. To compare energy and nutrient intakes from 3-day food records and a 24-hour documented intake period of women with low and high scores for dietary restraint.
3. To compare bone mineral densities (BMD), bone mineral content (BMC) and body composition of women with low and high scores for dietary restraint.
4. To compare scores on selected scales assessing eating attitudes and personality characteristics of women with low and high scores for dietary restraint.
5. To compare exercise level and lifestyle variables of women with low and high scores for dietary restraint.

To address these objectives a two-part study was designed. In Part One women completed a survey instrument which included scales related to eating attitudes, eating behaviour and personality as well as information on physical, lifestyle and menstrual cycle characteristics. This questionnaire was also used to recruit participants for Part Two of the study. Participants in Part Two completed a 3-day food record, collected a 24-hour urine specimen and had their body composition analysed by DEXA. The methods, results and discussion sections of Part One and Part Two are presented separately following the literature review.

1.3 Hypotheses (Null)

1.3.1 Part One Hypotheses

1. The age, physical and lifestyle characteristics will not differ among women with low, medium and high scores for dietary restraint.

2. Weight fluctuation and dieting history will not differ among women with low, medium and high scores for dietary restraint.

3. Self-reported menstrual cycle characteristics will not differ among women with low, medium and high scores for dietary restraint.

4. Scores on the Three-Factor Eating Questionnaire subscales, the Perceived Stress Scale, Rosenberg's Self-esteem Scale and the Eating Disorder Inventory subscales will not differ among women with low, medium and high scores for dietary restraint.

1.3.2 Part Two Hypotheses

1. Neither the 24-hour urinary excretion of cortisol nor the urinary cortisol/creatinine ratio will differ between women with low scores for dietary restraint and women with high scores for dietary restraint.

2. Neither the 24-hour urinary excretion of calcium nor the calcium/creatinine ratio will differ between women with low and high scores for dietary restraint

3. There will be no differences in the energy, macronutrient, calcium or fibre intakes of women with low and high scores for dietary restraint when assessed by 3-day dietary intake records or during a 24-hour documented intake period.

4. There will be no differences in the total body or spinal bone mineral density (BMD), bone mineral content (BMC) or body composition of women with low or high scores for dietary restraint when assessed by dual energy x-ray absorptiometry (DEXA).

5. Bone characteristics will not differ according to exercise level or other lifestyle variables.

6. The demographic characteristics of women with low and high scores for dietary restraint will not differ.

CHAPTER 2:

LITERATURE REVIEW

2.1 Introduction

The present study was designed to investigate whether a relationship exists between cognitive dietary restraint and cortisol excretion due to the known association between dietary restraint and menstrual cycle, including ovulatory, disturbances. A relationship between high cortisol levels and menstrual cycle disturbances has been established and both factors negatively impact on bone health. If cortisol levels are higher in women with high restraint scores it would suggest a mechanism for the association between high dietary restraint and menstrual cycle disturbances. The long-term consequences of dietary restraint have not been investigated, however, higher cortisol levels in women with high restraint scores may have implications for bone health.

The concept of restrained eating was originally introduced to define a type of eating behavior that was governed by cognitive processes rather than by physiological mechanisms such as hunger and satiety. Individuals exhibiting dietary restraint[1] attempt to limit their food intake in order to achieve or maintain a desired body weight (Lautenbacher S et al, 1992).

In this review of the literature, early theories regarding eating behaviour are examined in section 2.2. Section 2.3 is an overview of the early studies on dietary restraint, including those which assessed the response to a pre-load in restrained and unrestrained eaters, and those assessing relationships between restraint, and anxiety, cognition, and alcohol. Several scales have been developed over the years to assess dietary restraint. Section 2.4 covers the

[1] The terminology used to define women with high or low restraint scores has changed over the years. Earlier studies defined women as 'restrained eaters' while currently women are described as 'having high (or low) scores for restraint'. Throughout this literature review the description used in the particular study will be used.

Restraint Scale, the Three-Factor Eating Questionnaire, the Dutch Eating Questionnaire and a comparison of these three scales.

Section 2.5 evaluates the physical characteristics, body satisfaction, quantitative and qualitative dietary composition of women grouped according to whether they had high or low restraint scores. Studies which have examined the impact of dietary restraint on the menstrual cycle are reviewed in section 2.6, followed by an assessment of the impact of dietary restraint on the neuroendocrine system in section 2.7.

Section 2.8 is an overview of the effect of cortisol on bone health through both direct as well as indirect mechanisms. Indirect effects include those on sex hormones, calcium homeostasis, and other hormones. The final section (2.9) briefly discusses the potential implications of dietary restraint for bone health through its impact on the menstrual cycle and cortisol production.

2.2 Early Investigations Into Eating Behaviour

Restrained eating theory developed from earlier work done by Schachter (Schachter S, 1968) and Nisbett (Nisbett RE, 1972), who had attempted to identify specific characteristics which would differentiate between obese and nonobese individuals. Schachter hypothesized that the dietary intake of obese individuals was governed more by external cues such as the sight, smell and taste of food, while normal weight individuals were more responsive to internal physiological cues originating in the hypothalamic, gastric and circulatory systems (Schachter S, 1971). In a series of experiments, Schachter made several observations concerning differences in the eating behaviour of obese individuals compared to normal weight individuals (Schachter S, 1967; Schachter S, 1971; Schachter S et al, 1968).

Obese individuals were observed to eat more food at a given setting and to consume it more rapidly than normal weight subjects (Schachter S, 1971). When obese and normal weight subjects participated in a supposed taste test, the obese subjects consumed an equal amount of a sample food regardless of whether they had eaten immediately before or not (Schachter S et al, 1968). Normal weight subjects ate significantly less of the sample food if they had recently consumed food than if they had not. The behaviour of the obese individuals, therefore, appeared to have little to do with the actual state of the stomach or glucose homeostasis. Schachter also manipulated physiological state by injecting subjects with epinephrine or placebo and no effects were observed in the eating behaviour of obese subjects after the stimuli, while normal weight participants reduced their food intake (Schachter S et al, 1968). These and other experiments led Schachter to conclude that obese individuals are externally controlled, or stimulus bound.

Nisbett proposed an alternative theory around the same time (Nisbett RE, 1972) which suggested that an individual's eating behaviour was governed by an internal *set point*. He hypothesized that individuals have a fixed number of fat cells in their body and will eat an amount which is appropriate for maintaining the size of these cells. The theory suggests that when an individual loses weight only the size of the fat cells is reduced and not the actual number of cells, resulting in signals being conveyed to the hypothalamus. Subsequent behavioural changes occur to restore the cell size, thereby maintaining the set point (Nisbett RE, 1972). Nisbett further proposed that the difference between an individual's current weight and their set point accounted for the observed behavioural differences which had led to Schachter's external-internal model. He suggested that when an individual is below their set point they are more responsive to external cues. According to the theory, one's set point is biologically pre-determined through genetics and/or early childhood nutritional

experiences. This does not necessarily determine whether one is of normal body weight or not, as some individuals may resist the urges of hypothalamic and gastric messengers and maintain their weight at a level lower than their set point demands. Accordingly, in today's western society where the prevailing concept of beauty includes a slim, fit body, there would be increased pressure on individuals with higher set points to resist eating the amount required for set point maintenance.

2.3 Early Studies on Dietary Restraint

Based on the observations of Schachter and Nisbett, Herman and Mack (Herman CP & Mack D, 1975) hypothesized that individuals who restricted their energy intake in order to maintain a sub-set point weight would exhibit an eating behaviour style that differed from that of individuals who were not restricting energy, in the event that self-imposed dietary restraint could be removed. Herman and Mack reasoned that the same pattern would be exhibited by dieters (restrained eaters) regardless of whether they were obese or of normal weight. In order to quantify the extent to which individuals had concerns about their weight and were restricting their food intake, Herman and Mack developed a 10-item questionnaire which became known as the 'Restraint Scale' (Herman CP & Mack D, 1975).

Herman and Mack (Herman CP & Mack D, 1975) designed several studies using the Restraint Scale to test their hypotheses regarding restrained eaters. In particular, the amount of food consumed by individuals grouped as restrained or unrestrained was measured after prior consumption of varying quantities of food (a pre-load). Restrained eaters were found to consume *more* food after a pre-load than without, while unrestrained eaters consumed less food following a pre-load. The authors concluded that differences in eating behaviour could not be generalized to differences between obese and nonobese individuals but that restrained eaters differed from unrestrained regardless of their weight. Their assumption was that a pre-

load somehow acted directly on the *restraint mechanism* and that restrained individuals *counterregulate* by eating more than unrestrained individuals who regulate their food consumption in a more appropriate manner. It appeared that among restrained individuals, the pre-load had removed self-imposed cognitive dietary restrictions and internal and/or external pressures to eat had taken over. This removal of dietary restraint and subsequent increase in food intake later became known as *disinhibition*, and in some scales is assessed separately from restraint.

A further study by Herman and Polivy (Herman CP & Polivy J, 1975) was undertaken to determine the impact of anxiety on food intake in restrained and unrestrained women. Restrained women tended to eat more after being exposed to a high anxiety situation than a low anxiety situation while unrestrained women ate significantly less when anxious. In a further investigation of the effect of dysphoric mood on dietary restraint, Polivy and Herman (Polivy J & Herman CP, 1976) observed that clinically depressed patients classified as unrestrained eaters lost weight, whereas restrained eaters gained weight after the onset of depression. According to their analysis, negative emotions serve to disrupt the chronic self-control of the restrained eater, and, therefore, lead to increased food consumption. In contrast, in the unrestrained eater the physiological correlates of emotional distress tend to inhibit appetite.

Polivy (Polivy J, 1976) undertook to determine the extent to which cognition rather than actual calorie (energy) content plays a part in the different eating behaviours observed in restrained and unrestrained eaters. She observed that restrained eaters ate in response to their perception of the energy value of a pre-load, and if they perceived themselves as having already eaten excessively they increased their food intake substantially. Unrestrained

subjects ate about the same amount after a pre-load regardless of whether they believed it to be highly caloric or not.

In a further investigation, Polivy and Herman (Polivy J & Herman CP, 1976) examined the food consumption pattern of restrained and unrestrained subjects after the ingestion of alcohol, which is believed to cause disinhibition. Their results were not as straightforward as anticipated, but ultimately, it was found that alcohol proved to be a disinhibitor for restrained eaters only when the subjects were aware that they were consuming alcohol. When restrained subjects were unaware that the beverage they consumed was alcohol, the pharmacological effect of alcohol alone did not bring about the disinhibition response. Therefore, cognitive factors again played an important role.

In summary, the previous studies focused on the impact of various situations on the dietary intake of subjects classified as restrained or unrestrained eaters by the Restraint Scale (Herman CP & Mack D, 1975). The ingestion of a pre-load, dysphoric mood such as depression or anxiety, and the known ingestion of alcohol all resulted in a lifting of self-imposed dietary restraint among restrained eaters. Dietary restraint was now believed to be a more valid predictor of eating behaviour in a given situation than body weight (Herman CP & Mack D, 1975).

2.4 The Assessment of Dietary Restraint

The aforementioned studies used variations of the 10-item Restraint Scale developed by Herman and Mack (Herman CP & Mack D, 1975) to differentiate between restrained and unrestrained eating patterns. The scale represented a continuum, with restrained individuals who are highly conscious of their dietary consumption and carefully monitor food intake on one end, and unrestrained individuals who exhibit little concern about their dietary intake on the other. A concern arose about the bifactorial aspect of the Restraint Scale as it included

questions dealing with weight fluctuations (items 2, 3, 4, and 10) as well as questions related more to dieting (items 1, 5, 6, 7, 8, and 9) (Herman CP & Mack D, 1975; Drewnowski A et al, 1982). Drewnowski labelled these two factors Weight History and Dietary Concern. The premise behind the inclusion of the weight history items (Herman CP & Mack D, 1975) was that individuals who practised dietary restraint would be prone to periods of overeating (become disinhibited) and would experience weight changes on a regular basis. The questions, "How often are you dieting?" and "What is the maximum amount of weight that you have lost in one week?" accounted for almost 70% of the variance in total scores. It appears that the use of the total score on the Restraint Scale can sometimes fail to separate dieting from weight fluctuation.

Lowe (Lowe MR, 1984) designed a study to further investigate the problems found by Drewnowski with the validity of the Restraint Scale. He found that high restraint normal weight subjects had a greater history of being overweight suggesting that these individuals may behave like the obese due to their having retained characteristics associated with their prior obesity, rather than present levels of cognitive restraint. It is quite possible that these normal weight restrained eaters have been successful in their dieting and are maintaining their body weight at a sub set point level.

A similar construct to Herman and Mack's restrained eating was developed by a German group, who referred to this characteristic as *latent obesity*. Similar to Nisbett's set point theory, Pudel (Pudel V, 1975) suggested that within a group of normal weight individuals there likely existed a group who were biologically programmed to be overweight but managed to maintain a normal weight through restricting their dietary intake. This theory resulted from observations of the rate of consumption of a test meal in obese and nonobese subjects. The rate of eating in the nonobese subjects typically slowed during a meal, while

that of obese subjects did not. However, a subgroup of nonobese subjects ate at the same rate as obese subjects (Meyer JE & Pudel VE, 1977). A 40-item questionnaire was developed which enabled the authors to differentiate normal weight individuals who did not slow their rate of eating during a meal from those who did.

Stunkard and Messick (Stunkard AJ & Messick S, 1985) utilized questions from Pudel's Latent Obesity Questionnaire and from Herman and Mack's Restraint Scale in combination with 17 newly created items to construct a new instrument for the study of eating behaviours. Based on factor analysis, Stunkard and Messick discovered three separate factors embedded within their proposed new questionnaire. The three components were identified as 1) cognitive control of eating behaviour, 2) disinhibition of control, and 3) susceptibility to hunger. Based on the findings of Drewnowski (Drewnowski A et al, 1982), the four questions from the Restraint Scale which assessed weight fluctuation were eliminated. According to Stunkard and Messick, any potential benefit in including these four items was outweighed by the disadvantages (Stunkard AJ & Messick S, 1985). Herman and Mack had incorporated the concept of disinhibition into their restraint theory and it was an integral part of their Restraint Scale. By separating disinhibition from dietary restraint in Stunkard and Messick's new scale, disinhibition rather than restraint was identified as the underlying mechanism for the weight gain previously observed by Polivy and Herman in depressed subjects (Polivy J & Herman CP, 1976).

In a further study by Marcus et al (Marcus MD et al, 1985), the new questionnaire was administered to a group of obese women of whom 44% reported problems with bulimia. Binge severity correlated with the disinhibition factor of the new questionnaire but not with the factor relating to dietary restraint, again supporting the concept that disinhibition was not an essential component of the dietary restraint concept. Stunkard and Messick (Stunkard AJ

& Messick S, 1985) pointed out the potential for different forms of treatment based on the three newly-identified factors. Their questionnaire was called the 'Three-Factor Eating Questionnaire (TFEQ) to Measure Dietary Restraint, Disinhibition and Hunger'.

Coincidentally a group of researchers in The Netherlands also found the Restraint Scale of Herman and Mack and the latent obesity scale of Pudel (Pudel VE, 1978), to be multifactorial and set about constructing a new scale (Van Strien T et al, 1986). The main purpose of their investigation was to develop a questionnaire containing three scales designed to differentiate between restrained, emotional and external eating. This questionnaire was called the 'Dutch Eating Behaviour Questionnaire (DEBQ) for Assessment of Restrained, Emotional, and External Eating Behaviour'.

The issue of which quesionnaire was the most appropriate for measuring dietary restraint emerged. As previously stated, the Restraint Scale has been identified as having two underlying factors; Weight History and Dietary Concern. An article by Heatherton et al (Heatherton TF et al, 1988) sought to counter the criticisms of the Restraint Scale and to examine the alternatives. These authors justified the inclusion of disinhibition within dietary restraint with the argument that few dieters succeed in maintaining their restraint and typically experience periods of disinhibition; therefore, it is appropriate to pair the two concepts. Their intent was to identify dieters. They are in agreement that the *truly* restrained eater who doesn't experience periods of disinhibition is not identified by the Restraint Scale.

Westenhoeffer (Westenhoeffer J, 1991) administered the TFEQ to a very large number of subjects (n = 54,525) and actually found restraint with low disinhibition to be more prevalent than restraint with high disinhibition, in contrast to the belief of Heatherton et al (Heatherton TF et al, 1988). The emphasis on weight fluctuation in the Restraint Scale may also yield higher scores from obese individuals who are not necessarily restrained but

who experience greater variability in weight as a consequence of being overweight (Ruderman AJ, 1986; Drewnowski A et al, 1982; Blanchard FA & Frost RO, 1983). Heatherton et al (Heatherton TF et al, 1988) analyzed the TFEQ and DEBQ and again it became a question of whether one is measuring restraint or restraint in combination with disinhibition. They also questioned the criticism of the bifactorial aspect of the Restraint Scale when both the TFEQ and the DEBQ measure more than one factor. However, Heatherton concluded that this did not appear to be a problem for the latter two scales, as their components are clearly divided allowing for easy analysis.

Another interesting problem with the Restraint Scale was identified by Wardle (Wardle J, 1986). She points out that in the Restraint Scale, the Weight History items demand specific information about weight variation. Such information is most readily available to those individuals who have greater concern about their weight. In a previous study, Wardle (Wardle J, 1980) reported the completion of only 76% of questionnaires, often because of failure to complete the items regarding weight. This could result in an over-estimation of restraint in the population and a biased subject group.

Subsequently, Laessle et al (Laessle RG et al, 1989a) compared the validity of the three scales for assessing dietary restraint by relating these scales to self-reported energy intake and other measures associated with disordered eating and figure consciousness. The factor analysis employed in this study showed mean daily energy intake to be negatively correlated with the restraint scales of the TFEQ and the DEBQ but not with the Restraint Scale. The Restraint Scale was identified as being a useful tool for the measurement of disinhibition and weight fluctuation in experimental procedures. The Restraint Scale would also be useful in the study of eating disorders as binge eating may be considered an extreme form of disinhibited eating. The biological and psychobiological consequences of restricting

energy intake on an ongoing basis were emphasized. In particular, the authors mentioned a reduction in the activity of the sympathetic nervous system and disturbances of menstrual cycle function as potential consequences of dieting behaviour.

A study by Lowe and Kleifield (Lowe MR & Kleifield EI, 1988) investigated the role of cognitive dietary restraint in the regulation of eating using the TFEQ restraint scale, an Eating Inventory (this included pertinent weight history information), and the Restraint Scale for assessment purposes. The results indicated that the restraint scale of the TFEQ was unrelated to excessive eating. This is consistent with other research into binge eating, as previously mentioned (Marcus MD et al, 1985). Interestingly the Restraint Scale was not related to excessive eating either, which the authors interpreted as indicating that a large percentage of subjects in the study may have belonged to the group of dieters who do not become vulnerable to periods of overeating (women who are successful at dieting).

The Restraint Scale has been successful in identifying those on a diet who are prone to becoming disinhibited under certain experimental conditions such as the consumption of a pre-load, the known ingestion of alcohol, or situations which induce a dysphoric mood. It does not necessarily identify restrained eaters who are successful in maintaining their diet and who are not prone to the weight fluctuations brought on by bouts of overeating combined with periods of energy restriction. The restraint scale of the TFEQ is a more appropriate tool for identifying individuals who are successful at dieting. The disinhibition scale of the TFEQ would serve to identify those less successful at dieting. The scales of the TFEQ provide a different profile than the DEBQ and one that may be more useful in separating individuals who are prone to overeating under certain circumstances from those who are not. Currently the restraint scale of the TFEQ is the most frequently used assessment tool in the study of

dietary restraint and the body of literature investigating the differences between women with high or low scores is more extensive than for the DEBQ.

2.5 Characteristics of Women with Elevated Restraint Scores

2.5.1 Dietary Composition – Quantitative Aspects

Over the years many studies have been conducted in an attempt to identify the various psychological, physiological and anatomical characteristics of restrained eaters and the biological consequences that may result from this type of eating behaviour. Because most of the earlier data were obtained under laboratory conditions, Laessle, et al (Laessle RG et al, 1989b) chose to investigate the everyday eating behaviour of restrained and unrestrained eaters with respect to total energy intake, macronutrient composition, and long term food preference. Group differences in biochemical indices of nutritional status were also examined. The restraint scale of the TFEQ was used to assess dietary restraint in 60 young German women, with the group median score differentiating restrained from unrestrained eaters. The mean score for the group regarded as restrained eaters was 10.4 ± 3.3 compared with 2.8 ± 1.3 for the group regarded as unrestrained eaters. Disinhibition scores were significantly higher in the restrained group. Reported energy consumption, as determined from 7-day diet records, was significantly lower in the restrained group than the unrestrained group (1956 ± 348 kcal/d vs. 2338 ± 442 kcal/d). Variability of daily energy intake was also examined, and the average minimum daily energy intake was also lower in the restrained vs. the unrestrained group (1274 kcal/d vs. 1701 kcal/d). During interviews, restrained eaters stated that on several days each month they severely restricted energy intake, in some cases totally abstaining from food. Protein intake as a percentage of energy was higher in the restrained group but no significant differences were found for carbohydrate or fat intakes as a

percentage of energy. Restrained subjects did attempt to restrict their intake of foods which are generally perceived to be higher in energy content.

The data (Laessle RG et al, 1989b) also indicated a strong negative correlation between restraint score and reported energy intake. This correlation was also found when 24-hour diet recall and the DEBQ were used in a previous study (Wardle J & Beales S, 1987). Plasma levels of triiodothyronine and glucose were not decreased in restrained subjects as might be expected in undernourished individuals, although an increase was observed in their triglyceride levels. The physical characteristics of the subjects provided for some interesting speculation in that the calculated BMI, maximum BMI and minimum BMI were higher in the restrained subjects compared to the unrestrained subjects. The question arose as to whether restrained eaters may be underreporting or alternatively, whether they may actually need less energy than unrestrained eaters. Others have reported that frequent dieting may actually cause a decrease in energy expenditure (Brownell KD et al, 1986; Hill AJ & Blundell JE, 1990). Alternatively, it is possible that restrained eaters may have genetically lower energy requirements and, therefore, be maintaining a lower energy intake than normal to prevent weight gain. Twenty-three percent of the restrained subjects in this study reported more than nine previous dieting periods with a weight loss of at least 4 kg per episode. Further studies examining the energy intake of restrained subjects who have not undergone periods of weight fluctuation would help to determine the impact of this variable.

The doubly-labelled water method was used to clarify whether restrained eaters do underestimate their energy intake on self-report measures, or actually have a lower energy requirement due to a decrease in energy expenditure (Tuschl RJ et al, 1990a). Women participants were age 18-30 y and of normal body weight (BMI = 18-24 kg/m^2). Exclusion criteria included: excessive exercise, being on a diet, having lost > 4 kg in the past 30 days,

and a history of clinical eating disorders. Subjects completed the TFEQ restraint scale and those who scored ≤ 3 were classified as unrestrained eaters while those who scored ≥ 10 were classified as restrained. Again, the BMI was higher (21.1 kg/m^2 vs. 20.0 kg/m^2, $P = 0.03$) and the self-reported daily energy intake lower (2057 kcal/d vs. 2300 kcal/d) in the restrained eaters compared to the unrestrained eaters. After adjusting for body composition and height, the actual basal energy expenditure of restrained eaters was determined to be 620 kcal less than that of the unrestrained group. Therefore, when reported energy intake was also adjusted for body composition and weight, it was determined that restrained eaters were meeting their daily energy requirements, but those requirements were significantly lower than those of unrestrained eaters. This has important implications in several areas. For one, it was now apparent that restrained eaters do not consistently underreport dietary intake to a greater extent than unrestrained eaters. It was believed that in order to maintain a higher BMI, periods of overeating must be interspersed with periods of lower energy intake. If energy expenditure is actually lower in restrained eaters then the reported energy intake would be sufficient and overeating unnecessary. Lower energy requirements may be the result of a biological predisposition and, therefore, dietary restraint would be necessary to maintain a normal body weight. Alternatively, a lower energy expenditure may be an adaptive mechanism to restrained eating over a longer period of time (Apfelbaum M, 1978). A recent study (Leibel RL et al, 1995) found that a reduction in energy expenditure accompanied weight loss, and an increase in energy expenditure accompanied weight gain; these metabolic changes occurred in both obese and nonobese subjects. Although this was a very thorough study, it is unknown whether these changes would persist over time as assessments were carried out immediately after weight change.

A study which excluded women who had any weight loss during the previous four months, still found restrained eaters reported consuming 23% less energy than unrestrained eaters (Schweiger U et al, 1992). It should be noted that a lower energy intake has not been observed in all studies as Barr (Barr SI et al, 1994a) did not find a significant difference in reported energy intake in women in the upper tertile of scores for dietary restraint vs. those in the lower tertile. The women who participated in Barr's study had a higher average activity level than normal with 32% training for a marathon and 33% running between 24 and 79 km/wk. This higher expenditure of energy may have negated the need to restrict dietary energy. Women with high restraint scores in Barr's study had elevated BMI's compared with women with low restraint scores, although the difference was not significant. She also excluded women who had experienced a weight change > 2.5 kg in the previous year. Laessle et al (Laessle RG et al, 1989b) only excluded those women who had been on an intense weight losing diet in the past month and Tuschl et al (Tuschl RJ et al, 1990a) excluded only those who had lost > 4 kg in the past month. These differences may explain the difference in results between Barr and Laessle's findings.

The results of the study by Tuschl et al (Tuschl RJ et al, 1990a) were important in demonstrating that differences in energy expenditure may be the reason for lower reported energy consumption among women with high restraint scores, yet the particular component of energy expenditure responsible cannot be ascertained from their data. Total energy expenditure is composed of basal (or resting) metabolic expenditure (BME), diet induced thermogenesis (DIT) and physical activity. In following up on their previous research Platte et al (Platte P et al, 1996) investigated the components of energy expenditure in women with high and low restraint scores. They tested the hypothesis that restrained eaters had reduced resting metabolic rate (RMR) and/or DIT and whether weight cycling caused the effect. In

addressing the first hypothesis, 12 women with high restraint scores and 12 women with low restraint scores were studied with regard to RMR and DIT by indirect calorimetry using a ventilated hood system. RMR was found to be significantly lower in the high restraint group although they were similar to the low restraint group in body size and composition. DIT did not differ between the two groups. Also of interest is that the measured RMR in the unrestrained group was the same as predicted on the basis of height and weight (using the Harris Benedict equation), yet this was not so in the restrained group where measured RMR was less than predicted.

Next, the authors studied two groups of women with high restraint scores who varied in whether they were weight cyclers or not. Twelve women were categorized as weight cyclers and 12 as weight holders. Again, RMR and DIT were determined from indirect calorimetry and in this case the two groups were similar in both components of energy expenditure. Both groups of women had significantly lower RMR than predicted from height and weight, in concordance with earlier findings regarding women with high restraint scores. These two studies demonstrated that weight cycling was not associated with decreased RMR in restrained eaters but restrained eaters as a group had lower RMR than unrestrained eaters. This may be the factor which predisposed them to a higher body weight and may not reflect dieting-induced alterations in metabolic rate. While these studies cannot identify whether lower RMR in women with high restraint scores is the result or cause of their eating attitudes or behaviour, they do support earlier findings and clarify the component of total energy expenditure which contributes to the difference. Whatever the cause, having a lower energy expenditure could make further weight loss more difficult to achieve and continued dietary restraint necessary to at least maintain body weight and prevent weight gain.

2.5.2 Physical Characteristics of Restrained Eaters

As already stated, several studies have noted differences in the BMI values of restrained eaters compared to unrestrained eaters. In two of these studies (Tuschl RJ et al, 1990a; Tuschl RJ et al, 1990b) the mean BMI was significantly higher in the former group. Other studies have not found significance in the differences but have still noted elevated values for restrained eaters (Schweiger U et al, 1992; Lautenbacher S et al, 1992; Barr SI et al, 1994a; Laessle RG et al, 1989b). What is also of interest is the reports of subjects' former maximum BMI's. Tuschl et al (Tuschl RJ et al, 1990a), reported restrained eaters had significantly higher maximum BMI values than unrestrained eaters (22.5 ± 1.5 kg/m^2 vs. 20.7 ± 1.5 kg/m^2, $P < 0.01$). Others have reported elevated maximum BMI values but nonsignificant differences (Schweiger U et al, 1992; Lautenbacher S et al, 1992; Laessle RG et al, 1989b). These data suggest that although BMI may remain higher in restrained eaters, they could still be below their biologically optimal, or genetically prescribed weight. As previously stated, Lowe and Kleifield, (Lowe MR & Kleifield EI, 1988) also discussed the possibility that a subset of dieters exists who are maintaining their weight at levels well below their greatest weight.

2.5.3 Body Dissatisfaction

Restrained eaters are more dissatisfied with their bodies than unrestrained eaters even when there is only a minimal difference in body measures between the two groups (Lautenbacher S et al, 1992). Furthermore when BMI was statistically controlled for in a multiple regression model, the percentage of body fat in restrained women accounted for no additional variance in restraint score although on its own it was a significant predictor of this variable (Davis C et al, 1993). In other words, if BMI is held constant, percentage body fat is not associated with the degree of restrained eating. If body fat is held constant, the degree to

which subjects' BMI differs is significantly related to the degree of restraint. Variability in BMI when body fat is held constant is the result of the contribution made by fat free tissues such as muscle and bone. Therefore, anatomical factors which are beyond the dieters' control may be contributing a greater amount to women's dissatisfaction with their bodies than body fat.

A further study by Davis et al (Davis C et al, 1993) replicated previous findings and extended them to demonstrate that frame size, independent of other effects, accounted for a significant portion of the variance in dietary restraint. BMI and frame size both correlated positively with weight dissatisfaction. Restrained eaters were clearly more dissatisfied with their bodies than unrestrained eaters, also exhibiting significantly more emotional reactivity and greater focus on their bodies. In a study which assessed nutrient intakes and eating behaviour scores of vegetarian and nonvegetarian women, Barr (Barr SI et al, 1994b) also reported a relationship between dietary restraint and BMI but did not detect an association between dietary restraint and percentage body fat.

2.5.4 Dietary Composition – Qualitative Aspects

It has been reported that restrained eaters (Tuschl RJ et al, 1990a) consume a significantly lower percentage of energy as fat and alcohol and a greater percentage of energy as carbohydrate than unrestrained eaters. A further study looked at the qualitative choices made by restrained vs. unrestrained eaters (Tuschl RJ et al, 1990b). When self-reported food choice frequencies for basic food stuffs, snacks, fats and dairy products were compared, no differences were found. However, restrained eaters specifically avoided fat and selected low fat products with a much higher frequency than unrestrained eaters. Because low fat products are frequently less flavourful and, therefore, less emotionally satisfying than higher

fat foods it had previously been proposed that this type of dietary restriction may lead to a level of frustration that could precipitate binge eating (Herman CP & Polivy J, 1988).

Other studies have also reported no difference on the basis of restraint in terms of percentage of energy as fat, protein and carbohydrate (Schweiger U et al, 1992; Barr SI et al, 1994a). However, a previously mentioned study identified percentage of energy as protein being significantly higher (Laessle RG et al, 1989b) in restrained subjects. Restrained subjects showed a heightened frequency of the use of artificial sweeteners compared to unrestrained subjects (Tuschl RJ et al, 1990b). Other authors (Blundell JE et al, 1988; Rogers PJ et al, 1988) have suggested that by uncoupling sweet taste and energy through the frequent use of artificial sweeteners, an impairment in the satiety process may result. An impairment in the satiety process was also believed to be a contributor to overeating. But, overeating to the degree which constitutes binging does not seem to be a necessary consequence of dietary restraint (Marcus MD et al, 1985; Lowe MR & Kleifield EI, 1988).

2.6 Dietary Restraint and the Menstrual Cycle

Investigations into the consequences of dietary restraint inevitably led researchers to examine the impact of altered eating behaviour on menstrual function. More extreme eating disorders have long been associated with menstrual cycle abnormalities (Marshall JC & Kelch RP, 1979; Doerr P et al, 1980). In fact, amenorrhea, or the absence of at least three consecutive menstrual cycles, is an obligatory symptom for the diagnosis of anorexia nervosa (American Psychiatric Association, 1987). It is a consequence of hypothalamic dysfunction and is characterized by very low level secretion of gonadotropic hormones, similar to that observed in childhood or early puberty. Generally, loss of menstrual function was attributed to a decrease in body weight, and in particular it was believed that women required a critical amount of body fat in order to maintain regular menstrual cycles (Frisch RE & McArthur

JW, 1974). While elevated rates of menstrual dysfunction have also been observed in nonclinical samples such as low weight ballet dancers (Garner DM et al, 1983) and distance runners (Feicht CB et al, 1978), low body weight does not appear to be a necessary factor as disturbances in the menstrual cycle have also been found in normal weight women with bulimia (Pirke KM et al, 1987).

In one of the original papers describing bulimia nervosa, amenorrhea was reported in 39.3% of bulimic patients (Russell GF, 1979). While this overt form of menstrual cycle disturbance is easily diagnosed, it later became apparent that there was also a high prevalence of less obvious disturbances including anovulatory cycles and shortened luteal phase length cycles in women with bulimia nervosa. Johnson et al (Johnson WG et al, 1983) found amenorrhea to be present in 20% of normal weight women with bulimia and menstrual irregularity in another 20%. In anorexic patients who returned to normal body weight, menstrual function did not return to normal within one year. Under experimental conditions of complete food absence, 3 out of 5 normal weight women showed a regression to an infantile luteinizing hormone (LH) secretory pattern (Fichter MM & Pirke KM, 1984). This result was found after a relatively short period of time (14-23 d), and an average weight loss of 8 kg.

Under conditions of less severe, although still highly limited energy restriction in normal weight women, ovulatory function has been consistently altered. In a study assessing the impact of 1000 kcal/d *ad libitum* feeding over a six week period there was no decrease observed in LH levels. But, in 6 subjects with previously normal luteal phase hormones, 3 did not have normal range progesterone levels during the diet period (Pirke KM et al, 1985).

In a study contrasting dietary content within an energy deprivation study, 7 out of 9 subjects developed luteal-phase disturbances while on a 1000 kcal/d vegetarian high-

carbohydrate diet as compared to only 2 out of 9 subjects on a 1000 kcal/d mixed, high-protein diet (Pirke KM et al, 1986). Estradiol and progesterone levels were significantly lower in the luteal phase in women assigned to the vegetarian diet. Subjects in both groups lost an average of 1 kg/wk.

Maturation of the hypothalamic-pituitary-ovarian axis is another important variable. When 22 healthy, normal weight women were observed through a control cycle and a 1000 kcal/d, high-carbohydrate, vegetarian diet cycle, luteal-phase disturbances were considerably more prevalent in women aged 19-24 y compared to those aged 25-30 y (Schweiger U et al, 1987). The extent of weight loss was another co-factor in ovulatory disturbances with a greater weight loss associated with a higher rate of disturbance.

Pirke et al (Pirke KM et al, 1989) examined the mechanism through which dieting may cause menstrual irregularities in normal weight women. Thirteen regularly menstruating, ovulatory, normal weight young women, with no history of eating disorders consumed a vegetarian, 800 kcal/d diet for one menstrual cycle, resulting in a weight loss of 1 kg/wk. BMI at the end of the diet cycle was equivalent to 99% of ideal body weight. Participants had previously been observed during a control cycle during which ovulation was confirmed in all 13 subjects through ultrasonic examination of follicular growth and endometrial changes. Only 2 subjects maintained ovulatory cycles with a normal length luteal phase during the vegetarian diet phase. Of the remaining 11 subjects, 7 showed impaired follicular development and the 4 with apparently normal follicular development had impaired progesterone secretion during the luteal phase.

The low energy, vegetarian diet was also associated with pituitary hormone changes (Pirke KM et al, 1989). Alterations of the secretion of LH were observed during the follicular phase of the diet cycle, with mean concentration being significantly lower. As

there were a variety of factors being manipulated in this study, including energy intake, dietary content and body weight, it is difficult to reach any conclusion as to the extent to which each, or all of these changes may play a role in altering ovulatory function. Ovarian function may be sensitive to an altered dietary composition as well as to alterations in energy intake.

In several of these studies, vegetarian diets have been implicated as potentially affecting the menstrual cycle. When past and present menstrual history was compared in vegetarian and nonvegetarian women without energy manipulation, vegetarian women reported a significantly greater frequency of cycle irregularity (3-10 menses/y) compared with nonvegetarians (Pedersen AB et al, 1991). In a later study by Barr et al (Barr SI et al, 1994b), healthy vegetarian women were actually observed to have fewer subclinical ovulatory disturbances than nonvegetarian women. Several factors may account for this difference in results.

First, in several studies (Pirke KM et al, 1989; Pirke KM et al, 1986; Schweiger U et al, 1987), consuming a vegetarian diet led to alterations in dietary content resulting in a sharp decrease in fat content and an increase in carbohydrate and fibre content. Rose (Rose DP et al, 1991) studied the impact of a 50% increase in dietary fibre on serum estrogen concentration. When supplemented with wheat bran fibre, significant reductions in serum estrone and estradiol were observed. Earlier, Rose (Rose DP et al, 1987) had observed that a 20% reduction in daily fat also led to a reduction in estrogen levels. Therefore, the observed menstrual cycle irregularities in the aforementioned studies may have been part of a physiological adaptation to a new diet. Barr's study only included women who had consumed a vegetarian diet for at least two years and excluded women with eating disorders. Huse and Lucas (Huse DM & Lucas AR, 1984) noted that a greater percentage of women

with anorexia nervosa reported following a vegetarian diet compared with other women. It is quite likely that women with eating disorders may adopt such a diet as a way of limiting their energy intake, as animal products are believed to be higher in fat and energy content. Pedersen's study doesn't mention the exclusion of women with clinical eating disorders which may have been more prevalent in the vegetarian group, biasing the results. In addition, women in the nonvegetarian group reported having used oral contraceptives for a longer period of time which may have contributed to self-reported cycle regularity. Pedersen relied on retrospective data while the studies by Pirke et al and Schweiger et al were experimental conditions of a control cycle vs. a diet cycle (cross-over design). On the other hand, Barr's study was prospective in design (over six menstrual cycles) and did not involve the manipulation of subjects' diet either in quantity or quality.

In another study to determine whether short-term energy deprivation affects sex-hormone patterns, 2 of 6 subjects became anovulatory and amenorrheic when only energy content of the diet was manipulated (Kurzer MS & Calloway DH, 1986). During the low-energy diet phase the energy content of the diet was 41% of the control phase. Each phase covered one menstrual cycle. Again, adaptation to the new diet may have caused the irregularities in menstrual cycle pattern.

It was apparent from these studies that a greatly diminished energy intake could potentially impact on menstrual function in normal weight women. This affect was more pronounced in younger women and also if the weight loss occurred rapidly (Schweiger U et al, 1987).

Low body weight, anorexia nervosa, bulimia nervosa, intense exercise, very low energy diets and rapid weight loss have all been implicated in menstrual cycle dysfunction. As bulimic patients are frequently of normal weight, these findings cannot be explained by

low body weight alone. An interesting observation was made by a group of researchers in the process of selecting a control group for a study on anorexic and bulimic women (Kreipe RE et al, 1989). A subset of women who scored high on the Eating Attitudes Test (used in the diagnosis of anorexia nervosa), yet exhibited no symptoms of eating disorders, reported a history of menstrual cycle disturbances. These women were assessed as having subclinical eating disorders (SED's). Further studies on this group compared their menstrual histories to those of a control group and a group diagnosed with clinical eating disorders. Abnormal menstrual function, including amenorrhea and oligomenorrhea characterized 93.4% of the women with SED's. All of the women in this group reported having experienced weight fluctuations of at least 10% of ideal body weight, although over what time frame was not clear. As weight loss has previously been shown to affect menstrual function, this makes the results more difficult to interpret. Another problem with this study, as identified by the authors, was the potential for recruitment bias as the study was titled 'Thoughts and Feelings about Body Image'.

Kriepe and colleagues persisted with a second study titled more ambiguously, 'Construct Validation' which was reported in the same paper (Kreipe RE et al, 1989). Again, subjects were divided into the same three groups. Although only 7 subjects were in the normal weight SED group, 100% reported a history of secondary amenorrhea or other menstrual irregularities. Only 15% of the controls (n = 20) reported abnormal menstrual histories. Unlike the women with SED's reported in the previous study, weight fluctuation was not a factor in this group. There were many potential confounders in these two studies, including small sample size, use of retrospective menstrual history only, lack of measurement of exercise level or dietary intake, and data were not reported on oral contraceptive use or

other hormone therapy. However, the results do suggest that a continuum may exist in disorder eating behaviour with corresponding alterations in menstrual cycle function.

In a more controlled study, Schweiger et al (Schweiger U et al, 1992) undertook to determine whether menstrual cycle disturbances were associated with restrained patterns of eating. Dietary restraint was assessed both by the TFEQ and the DEBQ with subjects who scored above the 75th percentile of scores established in a population of young German women classified as restrained, and those below the 50th percentile classified as unrestrained. Participants also completed the Eating Attitudes Test. Subjects (n = 57) were of normal body weight (BMI = 18-24 kg/m^2), age 18-24 y, had menstrual cycles of normal length, no recent history of weight loss, were not using oral contraceptives or other medication, and did not participate in endurance exercise or avoid any major food groups. Both restrained and unrestrained groups were similar in terms of demographic data with a trend towards a higher maximum BMI in the restrained subjects. Although no difference was found in terms of present BMI, age, weight and activity level, the restrained subjects reported a 23% lower energy intake than unrestrained subjects as monitored by nutritional diaries. As previously stated, restrained eaters have not been found to consistently underreport as lower energy expenditures have been confirmed by the doubly-labelled water method (Tuschl RJ et al, 1990a). The duration of the menstrual cycle was significantly shorter for restrained women and only 2 of the 9 women in this group had cycles that satisfied the standard menstrual cycle hormonal profile (serum estradiol max. of $\geq$ 440 pmol/L, serum progesterone max. $\geq$ 19 nmol/L, and luteal phase length of $\geq$ 9 days). Eleven of the 13 unrestrained subjects satisfied the standard criteria. Luteal phase length was significantly shorter in the restrained group and the mean progesterone concentration significantly lower. In both subject groups energy intake was higher during the last week of the cycle than during the first week.

Energy expenditure in the luteal phase of ovulatory cycles has also been reported to be higher by Barr et al (Barr SI et al, 1995). This may be partially due to the thermic effect of progesterone production (Webb P, 1986). Shortening the luteal phase, and, therefore, decreasing overall progesterone production, may be an adaptive mechanism by which the body copes with a lower energy intake.

Barr et al (Barr SI et al, 1994a) also assessed dietary restraint and menstrual cycle characteristics in normal weight women whose habits included a wide range of activity levels. Exclusion criteria included a history of eating disorders, compulsive exercising as well as weight fluctuation of > 2.5 kg in the past year. Participants had demonstrated a normal cycle length as well as a normal length luteal phase for two consecutive cycles prior to participation in an earlier study (Prior JC et al, 1990). At the five year follow-up, participants completed the TFEQ and were grouped according to whether they had restraint scores in the upper or lower tertile of the restraint scale. From quantitative basal temperature analysis, luteal phase length was determined to be significantly shorter in women with high restraint scores irrespective of age and exercise level. The exclusion of women who experienced weight fluctuation was important as it eliminated the possibility of weight-cycling as the cause of menstrual irregularities in restrained subjects.

In the previously mentioned study by Barr et al (Barr SI et al, 1994b), in which menstrual cycles were prospectively documented over six months, cycle disturbances in vegetarian and nonvegetarian women were compared and dietary restraint was also assessed. Women with high restraint scores had significantly fewer ovulatory cycles, a shorter mean luteal phase length and a lower mean luteal phase index (luteal phase length/cycle length) compared with women with low restraint scores. An association was not found between

vegetarian diets and ovulatory cycle changes. Instead, dietary restraint proved to be a better predictor of ovulatory disturbances than did the type of diet.

2.7 Dietary Restraint and the Neuroendocrine System

Little research has focused directly on the potential effect of dietary restraint on the neuroendocrine system. It was previously believed that menstrual cycle irregularities associated with eating disorders and endurance exercise were the result of weight cycling, low body weight, low percentage body fat or a low energy intake (Pirke KM et al, 1985; Pirke KM et al, 1987; Fichter MM et al, 1986; Fichter MM et al, 1988; Fichter MM & Pirke KM, 1989). As the results from Schweiger (Schweiger U et al, 1992) and Barr's (Barr SI et al, 1994a; Barr SI et al, 1994b) studies indicate, dietary restraint may impair ovulatory function irrespective of these other variables.

Dietary restraint appears to impact most on the luteal phase of the menstrual cycle. The luteal phase of the normal menstrual cycle is characterized by the secretion of progesterone from the corpus luteum. The corpus luteum is anatomically derived from the post-ovulatory follicle. Normal corpus luteum function is dependent upon, among other things, sufficient circulating levels of luteinizing hormone (Soules MR et al, 1989). Luteinizing hormone (LH) is released in a pulsatile fashion from the anterior pituitary in response to gonadotropin hormone releasing hormone (GnRH) release from the hypothalamus into the hypophysial-portal circulation.

When ovulatory function is disrupted, stress appears to be the intervening factor whether it is psychological, physiological or nutritional. Stress is a known inhibitor of ovarian steroid secretion. Rivier et al (Rivier C et al, 1986) exposed male rats to electroshock and found plasma LH levels were significantly reduced. When a corticotropin-releasing hormone (CRH) antagonist was administered, the inhibitory effect of stress on LH

concentration was prevented. CRH is released from the hypothalamus in response to stress (Naylor AM et al, 1990). Animal studies have found that CRH decreases plasma LH (Rivier C & Vale W, 1984) by inhibiting the release of GnRH into the hypophysial-portal circulation (Petraglia F et al, 1987). In rats the intracerebroventricular administration of CRH resulted in a reduction of immunoreactive GnRH and LH (Petraglia F et al, 1987). In addition, Petraglia et al (Petraglia F et al, 1986) determined that endogenous opioid peptides may act in concert with CRH in modulating the stress induced changes in LH secretion. When they treated previously stressed rats with opiate antagonists, LH levels were normalized. This may be species specific, as similar experiments on sheep actually found an increase in LH after the administration of CRH (Naylor AM et al, 1990).

A study of regularly menstruating volunteers sought to confirm the inhibitory effect of CRH on gonadotropin secretion and also to investigate the effect of an opiate antagonist on the action of CRH (Barbarino A et al, 1989). A significant decline in LH levels were observed 30 minutes after initiation of an intravenous infusion of CRH. The opiate antagonist, naloxone, reversed the inhibitory effect of CRH on LH concentration. CRH did not affect the pituitary response to GnRH suggesting that the inhibitory effect must be exerted at a higher level, presumably directly on GnRH secretion. Again opioids appear to play a role in modulating the CRH effect on LH release. Unfortunately, these results were not confirmed in a later study by Fischer et al (Fischer UG et al, 1992). Under similar experimental conditions to those reported in the previous study there was no observable decline in mid-luteal LH concentration after the intravenous administration of CRH. The difference between these results and those of the animal experiments may be due to the intracerebroventricular administration of CRH in the animal studies compared with the intravenous infusion into the forearm of the human studies. As it is believed that CRH

inhibits LH through its action on GnRH in the hypothalamus, the concentration levels could be considerably different depending on where the hormone was administered. However, this does not explain the positive results of Barbarino et al (Barbarino A et al, 1989).

CRH triggers the release of adrenocorticotropic hormone (ACTH) from the anterior pituitary (Naylor AM et al, 1990). ACTH stimulates the release of cortisol from the adrenal gland into circulation. Cortisol has direct negative feedback on the hypothalamus to decrease the formation of CRH and on the anterior pituitary gland to decrease the formation of ACTH. Anorexia nervosa patients often have elevated levels of plasma cortisol, and failure of suppression of plasma ACTH and cortisol levels by dexamethasone (Frankel RJ & Jenkins JS, 1975; Warren MP & Vande Wiele RL, 1973) indicating a disturbance of normal hypothalamic control. Hypercortisolism was reported by Suh et al (Suh BY et al, 1988) in women with functional hypothalamic amenorrhea (FHA). In a later study (Berga SL et al, 1989) by the same group, the hypothalamic-pituitary function of 15 women with FHA and 16 women without FHA were compared by analysis of 24-hour secretory patterns of LH, FSH, cortisol, GH, PRL, and TSH. In this study, women with eating disorders, affective disorders or depression were excluded. Mean cortisol levels in the women with FHA were again significantly higher than in the controls (275 ± 29 nmol/L vs. 212 ± 33 nmol/L). LH and FSH were significantly lower in women with FHA compared with controls.

If the stress of dietary restraint were to cause an increase in CRH levels, then higher circulating levels of cortisol should follow. To date only one study has measured cortisol in women classified as restrained eaters and compared these values to those of women classified as unrestrained eaters. Pirke et al (Pirke KM et al, 1990) studied 22 healthy young women, aged 18-24 y with a BMI between 18 and 24 kg/m^2. Women were classified as restrained (n = 9) if they scored above the 75^{th} percentile on the TFEQ restraint scale and

unrestrained (n = 13) if they scored below the 50th percentile. Blood was sampled at 30 minute intervals from an indwelling catheter inserted into a participant's forearm vein during an overnight study period. Cortisol levels did not differ between the two groups. This does not seem surprising as stress induced by dietary restraint would presumably be related to food intake which occurs during awake hours not during sleep. Decisions around food related behaviours such as shopping, meal planning and preparation, as well as how much and when to eat, are an integral part of most peoples' daily lives. If indeed women with high restraint scores are trying to restrict food intake to regulate body weight, as suggested by their higher former BMIs and lower mean energy intake, then this could be an ongoing source of stress. Controlling weight by constantly monitoring food intake is potentially stressful, and virtually any type of physical or mental stress results in elevation of cortisol concentrations in blood.

Although the above study did not find a difference in cortisol levels between women grouped as restrained vs. unrestrained eaters, they did report higher insulin levels in the restrained eaters compared with unrestrained eaters (Pirke KM et al, 1990). The gonadotropic function of insulin was discussed in a paper by Poretsky and Kalin (Poretsky L & Kalin M, 1987). It has been observed that insulin dependent diabetes, which is characterized by low blood insulin levels (insulinopenia), is also associated with alterations in menstrual cycle function. Specifically, insulinopenia is associated with primary amenorrhea, late menarche, anovulation, low pregnancy rate and early menopause. From a review of *in vivo* studies as well as clinical observations, the authors conclude that physiologically normal levels of insulin are necessary for the ovary to reach full steroidogenic potential. High insulin levels and insulin resistance states are associated with anovulation and androgen excess (polycystic ovary disease). Potential mechanisms include

direct effects on steroidogenic enzymes, possible modulation of FSH or LH receptor number, or a cooperative interaction with FSH or LH. Further research into this area is necessary to clarify the role of insulin in reproductive function.

In a review paper by DeCree (De Cree C, 1990) the possibility of endogenous opioid peptides provoking menstrual irregularities in women athletes was discussed. Significantly higher levels of β-endorphin have been observed in female athletes both pre and post competition (Farrell PA et al, 1982; Carr, 1981). It was concluded that β-endorphin may decrease LH levels by suppressing hypothalamic GnRH.

The control of the menstrual cycle is one of the most complex physiological processes in humans. Studies have shown that CRH inhibits GnRH which leads to a decrease in LH and, therefore, negatively affects the development of the corpus luteum and subsequent progesterone secretion. The subclinical ovulatory disturbances seen in women with high restraint scores may be the result of food related stress leading to higher levels of CRH. There may also be effects of other hormones such as opioids or insulin involved in the observed ovulatory differences.

2.8 Cortisol and Bone Health

The physiological consequences of higher circulating levels of cortisol include, but are not restricted to, menstrual cycle disturbances. In 1932, Harvey Cushing noted that an excess of glucocorticoids, secondary to pituitary tumours producing ACTH, led to osteoporosis. Cortisol is the primary glucocorticoid produced in the adrenal gland of humans. Because of the rarity of what became known as the Cushing Syndrome, glucocorticoid-induced bone loss did not become a problem until these hormones began to be used therapeutically in diseases such as rheumatoid arthritis, chronic active hepatitis, inflammatory bowel disease, and asthma. Rapid bone loss leading to vertebral and other

fractures became recognized as a common side effect of cortisol treatment (Hahn TJ et al, 1974). The bone loss preferentially involves trabecular bone especially in the spine and ribs (Baylink DJ, 1983).

Glucocorticoid-induced bone loss involves a number of mechanisms which adversely affect calcium homeostasis and inhibit bone formation. In a recent review article Reid (Reid IR, 1997) noted that glucocorticoids negatively impact on the skeleton through effects on bone formation, bone resorption, calcium entry into the body in the gut and exit from the body in the renal tubule, and alterations in sex hormones.

2.8.1 Effects on Sex Hormones

As has been shown by the studies described in the previous section, higher levels of glucocorticoids may lead to a reduction in sex hormone production through an inhibitory effect at the hypothalamic level. In addition to the effects on LH, glucocorticoids have been shown to inhibit follicle stimulating hormone (FSH) induced estrogen production in cultured rat granulosa cells (Hsueh AJ & Erickson GF, 1978). Circulating levels of adrenal androstenedione are also reduced due to the effect of a suppression of ACTH by higher levels of cortisol with adrenal atrophy as a consequence (Lukert BP & Raisz LG, 1990). Estrone levels go down as lower levels of adrenal androgens are available to provide a substrate for aromatization which produces estrone (Longcope C, 1986).

The relationship between reproductive hormones and bone health is widely recognized (Barr SI & Prior JC, 1993). Estrogens and androgens are important in the skeletal maturation of growing individuals and in the prevention of bone loss (Lindsay R et al, 1976; Prior JC et al, 1994). Decreasing estrogen levels at menopause are causally associated with an increase in bone turnover and resorption, which in turn, leads to an increased susceptibility of bone to fractures. This is confirmed by the fact that estrogen therapy has a

significant effect on the prevention of bone loss (Riggs BL & Melton LJ, 1992). The presence of a low concentration of estrogen receptors has been demonstrated in human osteoblastic cells (Eriksen EF et al, 1988) and estrogen treatment indirectly decreases bone resorption, suggesting that estrogen exerts effects and plays important roles in bone turnover (Riggs BL & Melton LJ, 1992). However, the cellular and molecular mechanisms of estrogen action on bone have not been clearly elucidated (Kassem M et al, 1996).

The hormone most impacted by a reduction in luteal phase length is progesterone (Prior JC et al, 1990). There is increasing evidence for a direct, osteoblast receptor mediated role for endogenous progesterone in mineral and skeletal metabolism (Prior JC, 1990). Bowman (Bowman BM & Miller SC, 1996) used a rat model to compare skeletal changes in a low estrogen/low progesterone state with those in a low estrogen/high progesterone state. Cancellous bone was maintained in the high progesterone group but not in the low progesterone group. In Prior's earlier review of the role of progesterone as a bone-tropic hormone, she examined the experimental, epidemiological, and clinical data and concluded that progesterone has a positive role in bone formation. *In vitro* studies suggest that progesterone competes with glucocorticoids at osteoblast binding sites decreasing glucocorticoid inhibition of bone formation and possibly interfering with glucocorticoid-related bone resorption. Progestagen treatment of three different metabolic bone conditions; glucocorticoid-induced osteoporosis, primary hyperparathyroidism and heparin-induced osteporosis resulted in an increase in bone mineral content (Prior JC, 1990). Prior and colleagues later reported the results of a one year randomized double-blind, placebo controlled trial using cyclic medroxyprogesterone, with or without calcium supplementation (Prior JC et al, 1994). Participants in the study were premenopausal, age 21-45 y, physically active and experiencing amenorrhea, oligomenorrhea, anovulation, or short luteal phase

cycles. Women in the cyclic medroxyprogesterone intervention group had significant gains in spinal bone mineral density (BMD) while women in the placebo controlled group lost bone. Calcium supplements did not significantly affect the results.

2.8.2 Effects on Calcium Homeostasis

Glucocorticoids decrease net intestinal calcium absorption in both humans and animals. Several mechanisms have been proposed for the impaired absorption including a decrease in the synthesis of calcium binding protein, decreased active cellular transport, decreased release of calcium from mitochondria and various vitamin D related mechanisms. While the contribution of altered vitamin D status has been studied extensively, the findings are inconclusive (Hahn TJ et al, 1981; Hahn TJ, 1980). Cortisol may diminish the synthesis of the active form of vitamin D (Reid IR, 1997) and may also antagonize the action of this metabolite (Lukert BP & Raisz LG, 1990).

The renal loss of calcium is enhanced by cortisol (Reid IR, 1997). Fasting urinary calcium excretion is elevated in non-patient subjects receiving glucocorticoids and patients on long term glucocorticoid therapy. Hypercalcuria is probably due to both increased skeletal mobilization of calcium and decreased renal tubular reabsorption (Lukert BP & Raisz LG, 1990). The net effect of a decrease in intestinal absorption of calcium and increased urinary excretion is negative calcium balance.

2.8.3 Effects on Other Hormones

A decrease in serum ionized calcium levels from negative calcium balance leads to the release of parathyroid hormone (PTH) from the parathyroid gland. PTH acts to normalize serum calcium by accelerating the removal of calcium from bone by at least two

processes. It stimulates osteolysis by surface osteocytes and also stimulates osteoclasts to resorb completely mineralized bone (Walsh CA et al, 1995).

Insulin-like growth factor-1 (IGF-1) is a growth hormone dependent polypeptide which is synthesized by skeletal cells and known to stimulate skeletal growth. Glucocorticoids inhibit the synthesis of IGF-1 as well as its binding protein (IGFBP) in osteoblast cultures (Lukert BP & Raisz LG, 1990).

2.8.4 Direct Effects on Bone

Bone resorption is stimulated *in vivo* by glucocorticoids, possibly as a result of the hyperparathyroidism which results from a decrease in calcium absorption (Canalis E, 1993). It is unlikely that this is the sole cause because trabecular bone loss is characteristic of glucocorticoid induced osteoporosis and not of primary hyperparathyroidism. Glucocorticoids can also enhance macrophage attachment to bone leading to increased resorption by altering cell surface oligosaccharides (Lukert BP & Raisz LG, 1990; Reid IR, 1997).

While physiologic concentrations of glucocorticoids enhance the function of differentiating osteoblasts, prolonged exposure and pharmacological dosages inhibit synthetic processes. Osteoblast-like cells have glucocorticoid receptors and glucocorticoid binding may modulate the cells' response to PTH, 1,25-$(OH)_2D$, prostaglandins, and growth factors. Glucocorticoid-enhanced sensitivity of osteoblasts to PTH inhibits both the synthesis of collagen by these cells and their replication and differentiation. Collagenase production has also been shown to be increased by cortisol. Synthesis of other components of bone matrix, such as mucopolysaccharides is decreased in bone cultures exposed to cortisol (Lukert BP & Raisz LG, 1990; Reid IR, 1997).

In summary, high levels of glucocorticoids, of which the dominant physiological form is cortisol, have a pronounced effect on bone remodelling and calcium balance both directly and indirectly through a diversity of mechanisms. The net result is an increase in bone loss.

2.9 Dietary Restraint and Bone Health

In reviewing the literature, it appears that only one study has assessed the relationship between dietary restraint and bone health (Barr SI et al, 1994a) and, as this was not the primary purpose of the study, it was not powered to detect a difference in bone. Barr's cross-sectional study assessed the relationship between dietary restraint and menstrual cycle characteristics and also measured spinal BMD. BDM was found values were similar between women with high restraint scores (n = 9) and those with low restraint scores (n = 9). It is likely that a greater number of subjects would be needed to detect a significant difference in BMD between women with high and low restraint scores. As noted earlier, women with high restraint scores were more likely to experience subclinical ovulatory disturbances compared with women with low restraint scores.

It has long been recognized that severe disruptions in menstrual cycle function, such as those seen in association with anorexia nervosa and intense endurance exercise (Fisher EC et al, 1986), are associated with lower BMD (Cann CE et al, 1984; Davies MC et al, 1990; Drinkwater BL et al, 1984; Marcus R et al, 1985; Fisher EC et al, 1986; Nelson ME et al, 1986). It has also been observed that collegiate women athletes with irregular menses during adolescence have decreased BMD (Lloyd T et al, 1988), but it is only recently that an association has been found between subclinical menstrual disorders and spinal BMD (Prior JC et al, 1990). A group of 66 women who had two consecutive menstrual cycles documented as ovulatory prior to their enrollment in the study, were observed over a one

year period. It is interesting to note that during the two month period when cycles were assessed, 32 of 113 women screened (28%) did not meet the criteria for normal ovulation with a normal length luteal phase. During the one year experimental period, menstrual cycle data, basal temperature and physical activity level were recorded daily. Spinal cancellous BDM by QCT, serum hormone levels and body morphology were assessed in the first and last cycle of the study period. A significant decrease in spinal BMD was associated with ovulatory disturbances which included anovulation and short luteal phase lengths. These findings were irrespective of exercise level. The implication from this study is that inadequate production of progesterone, the primary hormone of the luteal phase, leads to a net increase in bone loss.

Relating Prior's findings back to studies in which associations were found between dietary restraint and subclinical menstrual cycle disturbances (Schweiger U et al, 1992; Barr SI et al, 1994a; Barr SI et al, 1994b) suggests that women with high restraint scores may be more susceptible to lower BMD and, therefore, at an increased risk for osteoporosis. As stated, there were too few participants in Barr's study (Barr SI et al, 1994a) to detect a significant difference in BMD.

It should be noted that a more recent study (Waller K et al, 1996) did not find a relationship between luteal phase abnormalities and BMD loss although the subjects in this study differed in several ways from those in Prior's study. In particular, the mean weight and percentage body fat of women in Waller's study was 67.3 kg and 30.6% vs. 58.2 kg and 19.6% in Prior's study. As noted, in Prior's study, ovulation was determined prior to enrollment and participants were then followed prospectively for one year. In Waller's study, subject's menstrual cycles were monitored for six months and the single BMD measurement was performed between four months and one year later. In addition, these two

studies used different methods for measurement of BMD (QCT vs. DEXA in the latter) and for the assessment of menstrual cycle data. Waller found only 7 of 53 women had luteal phase abnormalities vs. 53 of 66 women in Prior's study. No association was found between luteal phase abnormalities and BMD in Waller's study. A further study (De Souza MJ et al, 1997) found BMD to be unaffected by decreased progesterone production associated with short and inadequate luteal phases in exercising women, although Petit et al (Petit MA et al, 1998) have questioned the research design and sample size used in the latter study. As pointed out by Petit, there is a need for further studies which are adequately powered, documenting changes in BMD over several years utilizing both DEXA and QCT technologies, and documenting ovulatory and cycle characteristics over at least six months. In addition, while the effect of moderate exercise on subclinical menstrual disturbances has not been fully clarified (Prior JC et al, 1990; De Souza MJ et al, 1998), exercise should be carefully monitored in future studies assessing the menstrual cycle and bone health.

In summary, relationships between cognitive dietary restraint and bone health have not been established but there appears to be sufficient justification for research into this area. Dietary restraint has been associated with menstrual cycle, including ovulatory, disturbances, and such disturbances have been associated with an increase in bone loss. There may be many factors which mediate the observed relationships and future studies would require appropriate control.

CHAPTER 3:

STUDY OVERVIEW

3.1 Study Design

This study was comprised of two parts. Part One consisted of the development and distribution of a questionnaire which focused on women's eating attitudes and behaviours as well as physical, lifestyle and menstrual cycle characteristics (Appendix 1). The questionnaire was pre-tested on a group of 8 women students at Simon Fraser University (Appendix 2). Subsequently, the revised questionnaire was completed by women students at the University of British Columbia. A recruitment form ('Interested In More?') for women interested in Part Two of the study was included at the back of the questionnaire (Appendix 3).

Part Two was a cross-sectional study of women grouped according to their scores on the TFEQ restraint scale. Women who completed the recruitment form from Part One and met the specified inclusion criteria were invited to participate further. These women were interviewed and asked to complete the following study requirements:

a.) complete a second copy of the questionnaire;

b.) have anthropometric measurements taken;

c.) provide a 3-day food record;

d.) provide a 24-hour urine collection on a day when all food and beverages were supplied and intake recorded;

e.) keep a menstrual cycle diary (optional).

After these aspects of the study were completed, participants had their body composition and bone mineral density assessed by dual energy x-ray absorptiometry

(DEXA). The methods, results and discussion sections of Part One and Part Two of the study are presented separately.

Ethical approval for this study was received from the University of British Columbia's Screening Committee for Research and Other studies Involving Human Subjects (Appendix 4).

CHAPTER 4:

PART ONE

4.1 Rationale

Women with varying scores for dietary restraint have previously been characterized according to a number of physical and lifestyle variables but many of these studies had small numbers of subjects and often provided only a limited amount of information. In the present study, a more extensive questionnaire was developed and distributed to a large group of university women in order to provide a broader profile of women grouped according to restraint scale scores. From the group of women who completed the questionnaire in Part One of this study, a subgroup was selected who met the inclusion criteria for Part Two.

4.2 Objectives and Hypotheses

4.2.1 Objectives

1. To further characterize women with low, medium and high scores for dietary restraint.
2. To select a group of women for a more in depth study of women with high and low restraint scores.

4.2.2 Hypotheses

1. The age, physical and lifestyle characteristics will not differ among women with low, medium and high scores for dietary restraint.
2. Weight fluctuation and dieting history will not differ among women with low, medium and high scores for dietary restraint.
3. Self-reported menstrual cycle characteristics will not differ among women with low, medium and high scores for dietary restraint.

4. Scores on the Three-Factor Eating Questionnaire subscales, the Perceived Stress Scale, Rosenberg's Self-esteem Scale and the Eating Disorder Inventory subscales will not differ among women with low, medium and high scores for dietary restraint.

4.3 Methods

4.3.1 Subjects

Female U.B.C. students were recruited during classes in biochemistry, human nutrition, psychology, family science, nursing and human kinetics. They each received a questionnaire to take home and return to class during the following week. There were no exclusion criteria for participation in Part One of the study.

4.3.2 Questionnaire

The questionnaire was designed to take approximately 20 minutes to complete. It included previously validated, standardized scales designed to assess eating attitudes, eating behaviours and psychometric characteristics. It also included questions on age, height, weight, dieting history, menstrual cycle history, exercise, special diets (e.g. vegetarian), vitamin, mineral and medication use.

4.3.2.1 Eating attitudes and eating behaviours

a.) Three-Factor Eating Questionnaire (TFEQ)

The 51-item Three-Factor Eating Questionnaire (Stunkard AJ & Messick S, 1985) was used to assess three dimensions of human eating behaviour: 1) cognitive restraint of eating, 2) disinhibition and 3) hunger. The cognitive restraint scale (21 items) measures the intent to control food intake in order to achieve or maintain a desired body weight. The disinhibition scale (16 items) assesses overeating and binge eating in response to a variety of situations associated with loss of control of food intake. The hunger scale (14 items)

measures perceived hunger. The individual scale items are presented in Appendixes 5, 6 and 7.

To make the TFEQ suitable for individuals who don't consume meat, the first item was altered from, "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 a meal", to "When I smell my favourite food, I find it very difficult to keep from eating, even if I have just finished a meal".

The first 36 items direct respondents to circle "true" or "false" in accordance with their perception of the statement. The following 15 items are presented in a Likert style format with four possible responses with the exception of item 50 (six possibilities). Responses to items on the TFEQ were scored according to the instructions provided by Stunkard and Messick (Stunkard AJ & Messick S, 1985) and summed to obtain scores for restraint, disinhibition and hunger. Participants were grouped according to their total score on the 21-item restraint scale based on quartiles established in a previous study (unpublished). For the present study, participants with restraint scores which fell in the 2nd or 3rd quartiles of the latter study were grouped as 'women with medium restraint scores'. Women with scores falling in the lower quartile for restraint were grouped as 'women with low restraint scores' and women with restraint scores in the upper quartile as 'women with high restraint scores'. The actual numerical groupings are described under statistical analysis.

b.) The Eating Disorders Inventory (EDI)

The Eating Disorders Inventory (Garner DM et al, 1983) is a widely used self-report measure designed to assess psychological characteristics and symptoms commonly associated with anorexia nervosa and bulimia nervosa. It consists of 64 statements that form eight subscales. Three of the subscales (drive for thinness, bulimia, and body dissatisfaction) assess attitudes and behaviours towards weight, body shape and eating. The other five

subscales measure more general psychological characteristics of individuals with eating disorders. These scales are ineffectiveness, perfectionism, interpersonal distrust, interoceptive awareness, and maturity fears. Rationale for the use of the EDI and other scales as well as descriptions of the scales comprising the EDI are presented in Appendix 8.

All items on the EDI are presented in a six point format. Participants circle the most applicable response from the following options: "always", "usually", "often", "sometimes", "rarely", or "never". The EDI was scored according to instructions provided in the EDI 2 Professional Manual (Garner DM & Olmstead MP, 1991). Higher scores on the individual subscales are considered to be more pathological in terms of eating behaviour.

4.3.2.2 Other psychometric scales

a.) The Perceived Stress Scale (PSS)

The Perceived Stress Scale (Cohen S et al, 1983) measures the extent to which situations in one's life are appraised as stressful. It consists of 14 statements asking about the participants' feelings and thoughts during the last month. In each case the possible responses refer to *how often* the individual felt or thought a certain way. Choices are presented in a five point scale with the following alternatives: "never", "almost never", "sometimes", "fairly often", or "very often". Items were scored and totalled according to instructions provided by the authors, with higher scores reflecting higher perceived stress.

b.) Rosenberg's Self-esteem Scale (RSES)

Rosenberg's Self-esteem Scale is a widely used measure of self-esteem (Rosenberg M, 1965). It consists of 10 items on a four point Likert-type scale with responses ranging from "strongly agree" to "strongly disagree". Higher scores indicate *lower* self-esteem.

4.3.3.3 Physical measurements

Participants reported their present height and weight as well as their highest and lowest adult weights. They were also asked "at what weight do you feel your best" which was subsequently referred to as their 'best' weight. From these values BMI, highest BMI, lowest BMI, and best BMI were calculated in kg/m^2.

4.3.3.4 Dieting history

Participants were asked whether they were currently trying to lose weight or had ever tried to lose weight. Weight fluctuation was determined by the number of times that > 5 lbs was lost in the past two years. Women were also asked whether they had ever been diagnosed with or treated for an eating disorder.

4.3.3.5 Menstrual cycle characteristics

Participants were asked whether they were currently having menstrual cycles and if so, whether their cycles were irregular or regular. They were also asked the average length of their cycle and whether they were presently, or had in the past six months, used oral contraceptives. Lastly, they were asked the date their last menstrual cycle began and the date on which the questionnaire was completed. From these dates their 'cycle day' was calculated and used for further analysis.

4.3.3.6 Lifestyle characteristics

Lifestyle information included questions regarding alcohol and coffee or tea consumption, cigarette usage, vitamin, mineral and medication use as well as hours of exercise/wk and type of exercise. Participants identified whether they were following lacto-ovo vegetarian, vegan or other special diets.

4.3.3 Statistical Analysis

All data were entered into a computer file (SPSS Data Entry, 1996; SPSS Inc., Chicago) and analyzed using programs available in SPSS, for Windows, Version 7.5, SPSS Inc., Chicago IL. A printout of the data file was verified against the original data to detect coding errors, which were corrected prior to statistical analyses.

As described, responses to the standard questionnaires (TFEQ, EDI, PSS, and RSES) were scored according to the instructions provided by the authors and summed to obtain scores for the various subscales. Descriptive statistics were calculated for all variables. Pearson correlation analysis was used to examine univariate associations among variables. Participants were grouped in three different ways and group comparisons were made in terms of all variables.

1. Grouping according to TFEQ restraint scale scores.

Low restraint = score 0-5 on TFEQ restraint scale

Medium restraint = score 6-12 on TFEQ restraint scale

High restraint = score 13-21 on TFEQ restraint scale

2. Grouping according to menstrual cycle regularity.

Participants who were not using oral contraceptives and were having menstrual cycles were grouped according to whether they reported their menstrual cycles to be regular or irregular.

3. Grouping according to vegetarian or nonvegetarian subgroup.

Participants were grouped as vegetarian if they responded "yes" to a question asking whether they were currently following either a lacto-ovo vegetarian or vegan diet. All others were grouped as nonvegetarians.

Group comparisons among the low, medium and high restraint groups were made by ANOVA. When significant F ratios were present Duncan's multiple range test was used to determine which means were significantly different. For group comparison between women who reported menstruating regularly and irregularly, and women who followed vegetarian and nonvegetarian diets, unpaired t-tests were used. For comparisons of population proportions, chi-square was used. All comparisons were two tailed, and were evaluated at a significance level of $P < 0.05$ except where multiple comparisons were made in which case a more conservative P value was used (0.01).

4.4 Results

4.4.1 All Participants

4.4.1.1 Physical characteristics

Of 1350 questionnaires distributed 761 (56%) were returned of which 666 (49%) were complete and usable for analysis (a printing error resulted in the loss of 95). Physical characteristics of all women who completed the questionnaire are presented in Table 1 (n = 666). Participants were all university students with a mean age of 21.6 ± 4.2 y

Table 1. Physical characteristics of all participants (n = 666)

Characteristic	Mean (± SD)	Range
Height (cm)	164.5 ± 7.1	140.0-188.0
Weight (kg)	57.2 ± 9.6	36.0-113.4
BMI (kg/m^2)	21.1 ± 3.0	14.8-42.7
Highest BMI (kg/m^2)[a]	22.5 ± 3.7	15.3-45.7
Lowest BMI (kg/m^2)[b]	19.7 ± 2.5	14.4-31.7
Best BMI (kg/m^2)[c]	20.1 ± 2.1	14.6-31.7

[a] Calculated from weight given as 'highest adult weight'.
[b] Calculated from weight given as 'lowest adult weight'.
[c] Calculated from weight given as 'best adult weight'.

range, 17-73 y). The range in most variables was broad due to the large number of participants. Best BMI, calculated from the weight given as 'best weight', was significantly lower than BMI calculated from self-reported present weight ($P < 0.001$).

4.4.1.2 Lifestyle characteristics

Lifestyle characteristics of all participants are presented in Table 2. Intake of caffeinated beverages (coffee or tea) ranged from 0 to 7 cups/d and alcohol intake ranged from 0 to 25 drinks/wk. Fifty-four percent of women reported abstaining from alcohol completely and 44% reported light alcohol consumption (1-7 drinks/wk). Only 2% reported consuming > 7 drinks/wk.

Table 2. Lifestyle characteristics of all participants

Characteristic	n = 666
Coffee or tea (cups/d)[a]	1.0 ± 1.1
Alcohol (drinks/wk)[a]	1.2 ± 2.1
Exercise (hr/wk)[a]	3.7 ± 4.0
Cigarette smokers	6.3%
Vegetarian	7.8%
Using vitamin/mineral supplements	35.7%

[a] Mean ± SD.

Hours of weekly exercise (defined as activity of sufficient intensity to raise one's heart rate) ranged from 0 to 42 hr/wk. Ten percent of women reported 0 hr/wk of exercise. Over 75% reported light to moderate exercise (≤ 7 hr/wk) and less than 15% reported exercising > 7 hr/wk.

Fewer than 10% of women smoked cigarettes (n = 42) or stated they were lacto-ovo vegetarians or vegans (n = 52). Over one-third of women (n = 238) reported currently using vitamin or mineral supplements.

4.4.1.3 Weight fluctuation and dieting history

Weight fluctuation and dieting history are presented in Table 3. Almost three-quarters of women reported having ever tried to lose weight while over 40% were presently trying to lose weight. Of women who responded to the question, "Have you ever been diagnosed with or treated for an eating disorder?", fewer than 5% said "yes".

Table 3. Weight fluctuation and dieting history of all participants (n = 666)

Characteristic	n	
Presently trying to lose weight	661	42.7%
Ever tried to lose weight	661	73.0%
History of eating disorders[a]	575	4.2%
Weight fluctuation[b,c]	639	1.48 ± 1.95

[a] Previously diagnosed with or treated for an eating disorder.
[b] Mean ± SD.
[c] Number of times > 5 lbs lost during the past two years.

Weight fluctuation was defined as the number of times > 5 lbs was lost during the previous two years. Responses ranged from 0 to 30 times with 206 women responding 0 times, 318 reporting 1–2 times and 115 reporting a weight loss of > 5 lbs more than twice. Twenty-seven women did not respond to the question. Reasons for weight loss were not requested.

4.4.1.4 Menstrual cycle characteristics

Of the 666 women who completed the questionnaire, 640 reported having menstrual cycles (96%). Of these women, 166 (26%) reported using oral contraceptives and were excluded from the following analysis. Table 4 presents the menstrual cycle characteristics of the 474 women not using oral contraceptives and shows that just over 20% reported their cycles to be irregular. Menstrual cycle length was reported by 420 participants and ranged from 18 to 56 days. Three hundred and ninety-nine women (95%) reported their average

Table 4. Menstrual cycle characteristics (n = 474)[a]

Characteristic	n	
Irregularly cycling	97	20.5%
Menstrual cycle length (d)[b]	420	29.3 ± 4.0

[a] Participants not using oral contraceptives and having menstrual cycles.
[b] Mean ± SD.

cycle length to be between 21 and 35 days. Interestingly, almost 50% of women reported cycle lengths of either 28 or 30 days, compared to only 5% reporting 29 day cycles.

Seventeen women (4%) reported their average cycle length to be > 35 days and four women (1%) reported cycles of < 21 days. Fifty-four women did not know the average length of their menstrual cycle or did not respond to the question.

4.4.1.5 Eating behaviour, eating attitudes and psychometric subscales

Participants' scores on the Three-Factor Eating Questionnaire (TFEQ) subscales, Perceived Stress Scale, Rosenberg's Self-esteem Scale and the eight Eating Disorder Inventory (EDI) subscales are presented in Table 5. Cronbach's alpha has also been listed for all scales. Five hundred and ninety-six women completed the 21-item restraint scale of the TFEQ. Several statements on the restraint scale proved to be problematic resulting in an overall response rate of 89.5%. In particular, statements that were presumptive regarding past dieting history had lower response rates (e.g. items 5 and 18). Appendix 5 lists the items comprising the TFEQ restraint scale and the percentage of women who provided responses to each item. Approximately 32% (n = 189) of women had restraint scores ≤ 5, suggestive of low intent to control food intake. Slightly more than 24% (n = 145) of women had scores ≥ 13, suggestive of high intent to control food intake. The remaining women (44%) had scores for dietary restraint between 6 and 12 (n = 262).

Table 5. TFEQ[a] subscale, Perceived Stress Scale[b], Rosenberg's Self-esteem Scale[c], EDI[d] subscale scores for all participants

	n	Mean (± SD)	Range	Chronbach's α
TFEQ restraint	596	8.6 ± 5.3	0-21	0.88
TFEQ disinhibition	604	6.2 ± 3.7	0-16	0.81
TFEQ hunger	605	6.4 ± 3.1	0-14	0.74
Perceived stress	661	26.1 ± 7.6	5-53	0.86
Self-esteem	654	1.4 ± 1.6	0-6	0.73
EDI drive for thinness	289	4.4 ± 5.4	0-20	0.89
EDI bulimia	281	1.2 ± 2.2	0-13	0.70
EDI body dissatisfaction	282	9.2 ± 7.9	0-27	0.92
EDI ineffectiveness	285	2.8 ± 4.4	0-23	0.88
EDI perfectionism	289	5.9 ± 4.2	0-18	0.76
EDI interpersonal distrust	291	2.1 ± 2.7	0-14	0.72
EDI interoceptive awareness	278	2.3 ± 3.6	0-24	0.80
EDI maturity fears	289	3.5 ± 4.2	0-20	0.83

[a] TFEQ = Three-Factor Eating Questionnaire (Stunkard AJ & Messick S, 1985).
[b] Perceived Stress Scale (Cohen S et al, 1983).
[c] Rosenberg's Self-esteem Scale (Rosenberg M, 1965). Lower scores reflect higher self-esteem.
[d] EDI = Eating Disorder Inventory (Garner DM & Olmstead MP, 1984).

A total of 604 women completed all 16 items of the disinhibition scale of the TFEQ. The presumption of past dieting resulted in item 36 of the disinhibition scale having a response rate of 95%. Appendix 6 lists the items that comprise the disinhibition scale and their response rates. The 26-item hunger scale of the TFEQ was completed by 605 women. Appendix 7 lists the hunger scale items and their response rates.

Women were grouped according to whether they completed the TFEQ during the early (days 1-12), mid (days 13-16) or latter part of their menstrual cycle (days 17-36). No differences were found in mean scores on the TFEQ restraint, disinhibition or hunger scales according to time of the cycle.

Scores on the eight subscales of the Eating Disorder Inventory (EDI) were available for only 291 participants due to a printing error. Mean scores on all EDI subscales were comparable to norms (Appendix 9) reported by Garner (Garner DM & Olmstead MP, 1991) for nonpatient college women (n = 205).

Bivariate associations among the three subscales of the Three-Factor Eating Questionnaire (TFEQ) are presented in Table 6. Disinhibition scores were significantly correlated with scores on both the restraint scale and the hunger scale.

Table 6. Correlation coefficients[a] among the TFEQ[b] subscales

	n	TFEQ restraint	n	TFEQ disinhibition
TFEQ disinhibition	569	0.35[c]		
TFEQ hunger	566	0.10	569	0.47[c]

[a] Pearson correlation coefficients are shown; all significance levels were 2-tailed.
[b] TFEQ = Three-Factor Eating Questionnaire (Stunkard AJ & Messick S, 1985).
[c] $P < 0.001$.

Correlation coefficients between the subscales of the TFEQ and age, physical characteristics and lifestyles variables are presented in Table 7. Restraint scale scores were positively correlated with highest BMI, weight fluctuation and exercise. Disinhibition scale scores were positively correlated with weight, BMI, highest BMI, lowest BMI and weight fluctuation. The hunger scale was negatively correlated with age.

Bivariate analyses were conducted to identify associations among the TFEQ subscales, the Perceived Stress Scale and Rosenberg's Self-esteem Scale (Table 8). The TFEQ restraint scale was positively correlated with the Perceived Stress Scale and Rosenberg's Self-esteem Scale with the latter indicating lower self-esteem. The disinhibition scale was correlated positively with the Perceived Stress Scale and Rosenberg's Self-esteem

Table 7. Correlation coefficients[a] among the TFEQ[b] subscales, age, physical characteristics and lifestyle variables

	n	Restraint	n	Disinhibition	n	Hunger
Age (y)	600	0.04	601	-0.03	604	-0.15[c]
Height (cm)	599	0.02	599	0.00	602	0.07
Weight (kg)	593	0.07	594	0.23[c]	597	0.09
BMI (kg/m^2)	592	0.08	592	0.28[c]	595	0.07
Highest BMI (kg/m^2)[d]	592	0.20[c]	592	0.33[c]	596	0.09
Lowest BMI (kg/m^2)[e]	592	0.08	590	0.18[c]	593	0.04
Best BMI (kg/m^2)[f]	584	-0.02	581	0.09	586	0.02
Weight fluctuation[g]	577	0.20[c]	576	0.27[c]	604	0.13
Coffee or tea (cups/d)	600	0.10	601	0.10	604	0.05
Alcohol (drinks/wk)	594	-0.02	602	0.03	604	0.08
Exercise (hr/wk)	597	0.14[c]	598	-0.01	601	0.04
Menstrual cycle length (d)	526	0.03	527	0.00	528	0.00

[a] Pearson correlation coefficients are shown; all significance levels were 2-tailed.
[b] TFEQ = Three-Factor Eating Questionnaire (Stunkard AJ & Messick S, 1985).
[c] $P < 0.01$.
[d] Calculated from weight given as 'highest adult weight'.
[e] Calculated from weight given as 'lowest adult weight'.
[f] Calculated from weight given as 'best adult weight'.
[g] Number of times > 5 lbs lost during the past two years.

Table 8. Correlation coefficients[a] among the TFEQ[b] subscales, Perceived Stress Scale[c] and Rosenberg's Self-esteem Scale[d]

	n	TFEQ restraint	N	TFEQ disinhibition	n	TFEQ hunger
Perceived stress	592	0.22[e]	600	0.34[e]	602	–0.23[e]
Self-esteem	584	0.27[e]	598	0.33[e]	599	0.28[e]

[a] Pearson correlation coefficients are shown; all significance levels were 2-tailed.
[b] TFEQ = Three-Factor Eating Questionnaire (Stunkard AJ & Messick S, 1985).
[c] Perceived Stress Scale (Cohen S et al, 1983).
[d] Rosenberg's Self-esteem Scale (Rosenberg M, 1965). Lower scores reflect higher self-esteem.
[e] $P < 0.001$.

Scale. Finally, Rosenberg's Self-esteem Scale and the Perceived Stress Scale were correlated (not shown in Table 8, $r = 0.597$, $P < 0.001$).

Bivariate correlations between the subscales of the TFEQ and the subscales of the EDI are presented in Table 9. The TFEQ subscales were positively correlated with all EDI subscales except perfectionism and interpersonal distrust. The EDI maturity fears subscale was positively correlated with the TFEQ disinhibition and hunger scales but not the restraint scale. The strongest correlation between the various subscales was between the TFEQ restraint scale and the EDI drive for thinness scale ($r = 0.69$, $P < 0.001$).

Table 9. Correlation coefficients[a] between TFEQ[b] subscales and EDI[c] subscales

	n	Restraint	n	Disinhibition	n	Hunger
EDI drive for thinness	265	0.69[d]	264	0.54[d]	263	0.31[d]
EDI bulimia	261	0.34[d]	261	0.60[d]	261	0.38[d]
EDI body dissatisfaction	265	0.43[c]	265	0.53[d]	263	0.28[d]
EDI ineffectiveness	263	0.24[d]	262	0.32[d]	261	0.27[d]
EDI perfectionism	264	0.16	264	0.15	262	0.16
EDI interpersonal distrust	266	0.18	266	0.14	264	0.08
EDI interoceptive awareness	255	0.34[d]	256	0.29[d]	254	0.22[d]
EDI maturity fears	264	0.12	264	0.22[d]	262	0.21[d]

[a] Pearson correlation coefficients are shown; all significance levels were 2-tailed.
[b] TFEQ = Three-Factor Eating Questionnaire (Stunkard AJ & Messick S, 1985).
[c] EDI = Eating Disorder Inventory (Garner DM & Olmstead MP, 1984).
[d] $P < 0.001$.

4.4.2 Participants Grouped According to TFEQ Restraint Scores

As previously described, participants were grouped according to their scores on the Three-Factor Eating Questionnaire (TFEQ) restraint scale. Percentages of participants according to restraint score groupings are presented in Figure 1. Just under 32% (n = 189) of

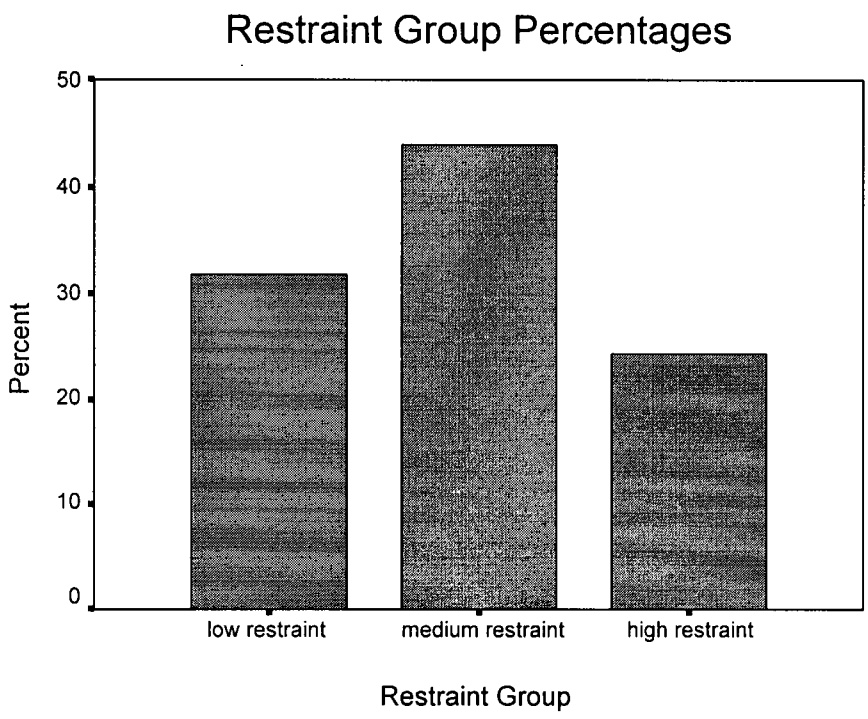

Figure 1. Percentages of women classified as having low (Three-Factor Eating Questionnaire {TFEQ} restraint score ≤ 5), medium (TFEQ restraint score 6-12), or high (TFEQ restraint score ≥ 13) cognitive dietary restraint.

women had low scores for restraint, 44% (n = 262) had medium restraint scores, and 24% (n = 145) had high restraint scores.

4.4.2.1 Physical characteristics

Physical characteristics of women grouped according to their TFEQ restraint scale scores are presented in Table 10. Age, height, weight, BMI (kg/m^2) and best BMI were similar among the three groups. Highest BMI was higher in women grouped as having high or medium scores for restraint when compared to women in the low restraint group. Lowest BMI differed only between women with low scores and those with medium scores for restraint with the former group having lower values.

Table 10. Physical characteristics (mean ± SD) of women with low, medium and high scores for dietary restraint

Characteristic	Low restraint[a] (n = 189)	Medium restraint[b] (n = 262)	High restraint[c] (n = 145)	P value
Age (y)	21.2 ± 3.3	21.6 ± 3.4	21.7 ± 5.2	0.328
Height (cm)	164.7 ± 7.4	164.5 ± 6.6	164.9 ± 8.1	0.893
Weight (kg)	56.4 ± 10.9	57.8 ± 9.3	57.8 ± 9.0	0.260
BMI (kg/m^2)	20.8 ± 3.8	21.3 ± 2.6	21.2 ± 2.6	0.221
Highest BMI (kg/m^2)[d]	21.9 ± 4.1[e]	22.7 ± 3.3[f]	23.3 ± 4.0[f]	0.002
Lowest BMI (kg/m^2)[g]	19.4 ± 2.8[e]	20.0 ± 2.4[f]	19.8 ± 2.2[e,f]	0.023
Best BMI (kg/m^2)[h]	20.0 ± 2.3	20.2 ± 1.9	19.8 ± 1.9	0.085

[a] Score 0-5 on the Three-Factor Eating Questionnaire (TFEQ) restraint scale (Stunkard AJ & Messick S, 1985).
[b] Score 6-12 on TFEQ restraint scale.
[c] Score 13-21 on TFEQ restraint scale.
[d] Calculated from weight given as 'highest adult weight'.
[e,f] Means differ significantly between values in rows not sharing a common superscript (by one-way ANOVA and Duncan's multiple range test).
[g] Calculated from weight given as 'lowest adult weight'.
[h] Calculated from weight given as 'best adult weight'.

4.4.2.2 Lifestyle characteristics

Other lifestyle characteristics of participants grouped according to restraint scores are presented in Table 11. Caffeinated (coffee or tea) and alcoholic beverage intakes did not differ among groups nor did the use of vitamin or mineral supplements. Compared to women with low and medium scores for restraint, women with high restraint scores reported more hours of weekly exercise and were more likely to smoke although the group difference was not significant. Finally, the likelihood of following a lacto-ovo or vegan diet increased significantly as the level of dietary restraint increased.

4.4.2.3 Weight fluctuation and dieting history

Weight fluctuation and dieting history of participants grouped according to restraint scores are presented in Table 12. In response to the question, "Are you presently trying to lose weight?" a significant difference was found among restraint groups with over 80% of

Table 11. Lifestyle characteristics of women with low, medium and high scores for dietary restraint

Characteristic	Low restraint[a] (n = 189)	Medium restraint[b] (n = 262)	High restraint[c] (n = 145)	P value
Coffee or tea (cups/d)[d]	0.9 ± 1.0	1.0 ± 1.1	1.2 ± 1.2	0.071
Alcohol (drinks/wk)[d]	1.3 ± 2.1	1.0 ± 1.6	1.2 ± 2.0	0.244
Exercise (hr/wk)[d]	3.2 ± 3.5[e]	3.5 ± 3.1[e]	4.6 ± 5.3[f]	0.027
Cigarette smokers	5.9%	4.6%	10.4%	0.071
Vegetarian	3.7%	7.3%	14.5%[g]	0.001
Using vitamin/mineral supplements	35.8%	35.5%	36.4%	0.986

[a] Score 0-5 on the Three-Factor Eating Questionnaire (TFEQ) restraint scale (Stunkard AJ & Messick S, 1985).
[b] Score 6-12 on TFEQ restraint scale.
[c] Score 13-21 on TFEQ restraint scale.
[d] Mean ± SD.
[e,f] Means differ significantly between values in rows not sharing a common superscript (by one-way ANOVA and Duncan's multiple range test).
[g] Percentages differ significantly among groups (chi-square).

Table 12. Weight fluctuation and dieting history of women with low, medium, and high scores for dietary restraint

	Low restraint[a] (n = 189)	Medium restraint[b] (n = 262)	High restraint[c] (n = 145)	P value
Presently trying to lose weight	15.3%	45.0%	80.3%[d]	0.000
Ever tried to lose weight	49.7%	80.3%	96.5%[d]	0.000
History of eating disorders	1.2%	1.4%	13.7%[d]	0.000
Weight fluctuation[e,f]	1.1 ± 1.4[g]	1.5 ± 1.5 [g]	2.1 ± 3.0[h]	0.000

[a] Score 0-5 on the Three-Factor Eating Questionnaire (TFEQ) restraint scale (Stunkard AJ & Messick S, 1985).
[b] Score 6-12 on TFEQ restraint scale.
[c] Score 13-21 on TFEQ restraint scale.
[d] Percentages differ significantly among groups (chi-square).
[e] Number of times > 5 lbs lost during the past two years.
[f] Mean ± SD.
[g, h] Means differ significantly between values in rows not sharing a common superscript (by one-way ANOVA and Duncan's multiple range test).

women with high scores for restraint responding "yes". A difference was also found in response to the question, "Have you ever tried to lose weight?". Over 90% of women in the high restraint group reported having tried to lose weight.

A total of 516 women completed the restraint scale and responded to the question, "Have you ever been diagnosed with or treated for an eating disorder?". Twenty-four women responded "yes" with the highest proportion (n = 17) having high scores for restraint.

Weight fluctuation (number of times > 5 lbs was lost) was higher in the previous two years in women with high scores compared to those with low or medium scores for restraint.

4.4.2.4 Menstrual cycle characteristics

Table 13 reports the menstrual cycle characteristics, according to restraint group, of women who reported having menstrual cycles and were not using oral contraceptives (n = 424). A significant difference was found in self-reported menstrual cycle regularity among restraint groups with more than a third of women with high restraint scores reporting irregular cycles, compared to about 17% of women with low or medium restraint scores.

Table 13. Menstrual cycle characteristics of women with low, medium, and high scores for dietary restraint[a]

	Low restraint[b] (n = 131)	Medium restraint[c] (n = 187)	High restraint[d] (n = 106)	P value
Cycling irregularly	17.6%	16.6%	34.0%[e]	0.005
Cycle length (d)[f]	28.9 ± 4.1	29.4 ± 4.0	29.4 ± 4.1	0.360

[a] Participants not using oral contraceptives and having menstrual cycles.
[b] Score 0-5 on the Three-Factor Eating Questionnaire (TFEQ) restraint scale (Stunkard AJ & Messick S, 1985).
[c] Score 6-12 on TFEQ restraint scale.
[d] Score 13-21 on TFEQ restraint scale.
[e] Percentages differ significantly among groups (chi-square).
[f] Mean ± SD.

Three hundred and seventy-nine women who completed the restraint scale reported their average menstrual cycle length. No difference was found among restraint groups in self-reported menstrual cycle length. Of women who reported their cycle length there was a significant difference (P = 0.005) among restraint groups in terms of menstrual cycle regularity with 27.5% of women with high restraint scores reporting irregular cycles compared with 14.8% of women with low restraint scores.

4.4.2.5 Eating behaviour, eating attitudes and psychometric subscales

Participants' scores on the Three-Factor Eating Questionnaire (TFEQ) subscales, the Perceived Stress Scale, Rosenberg's Self-esteem Scale and the eight Eating Disorders Inventory (EDI) subscales are presented in Table 14 (grouped by restraint scale scores). There were no group differences on the TFEQ hunger scale or the EDI maturity fears scale. All other scales differed among groups.

4.4.3 Participants Grouped According to Menstrual Cycle Regularity

A comparison of the characteristics of women grouped according to self-reported menstrual cycle regularity was undertaken due to the significantly higher prevalence of menstrual cycle irregularity reported among women with high scores for restraint. Accordingly, women who were not using oral contraceptives and reported having menstrual cycles were grouped based on whether they reported their menstrual cycles to be regular, or irregular. Of the 474 women in this group, just over 20% (n = 97) reported their cycles to be irregular.

4.4.3.1 Physical characteristics

Physical characteristics of women reporting regular and irregular cycles are presented in Table 15 (see p. 69). No differences were found between groups.

Table 14. TFEQ[a] subscale, Perceived Stress Scale[b], Rosenberg's Self-esteem Scale[c] and EDI[d] subscale scores (mean ± SD) for women with low, medium and high scores for dietary restraint

	n	Low restraint[e]	n	Medium restraint[f]	n	High restraint[g]	P value
TFEQ restraint	189	2.7 ± 1.6[h]	262	8.8 ± 2.0[i]	145	16.1 ± 2.3[j]	0.000
TFEQ disinhibition	182	4.8 ± 3.3[h]	246	6.3 ± 3.5[i]	141	8.1 ± 3.8[j]	0.000
TFEQ hunger	182	6.1 ± 3.0	246	6.3 ± 3.6	140	6.8 ± 3.4	0.124
Perceived stress	187	25.0 ± 7.2[h]	261	25.5 ± 7.4[h]	144	28.9 ± 7.9[i]	0.000
Self-esteem	183	1.1 ± 1.5[h]	259	1.4 ± 1.5[i]	142	2.2 ± 1.8[j]	0.000
EDI drive for thinness	95	1.1 ± 2.5[h]	104	4.2 ± 4.5[i]	66	10.0 ± 5.9[j]	0.000
EDI bulimia	94	0.7 ± 1.5[h]	105	1.1 ± 1.8[h]	62	2.4 ± 3.3[i]	0.000
EDI body dissatisfaction	96	5. 4 ± 6.3[h]	103	9.8 ± 7.7[i]	66	13.9 ± 7.8[j]	0.000
EDI ineffectiveness	95	2.2 ± 4.4[h]	103	2.6 ± 3.7[h]	65	4.6 ± 5.3[i]	0.002
EDI perfectionism	94	5.2 ± 4.2 [h]	105	5.7 ± 3.7[h,i]	65	6.9 ± 4.8[i]	0.037
EDI interpersonal distrust	96	1.7 ± 2.7[h]	105	2.1 ± 2.5[h,i]	65	2.9 ± 3.1[i]	0.029
EDI interoceptive awareness	91	1.4 ± 2.1[h]	99	2.2 ± 3.4[h]	65	4.3 ± 4.9[i]	0.000
EDI maturity fears	95	3.3 ± 4.2	104	3.6 ± 4.4	65	4.4 ± 4.2	0.273

[a] TFEQ = Three-Factor Eating Questionnaire (Stunkard AJ & Messick S, 1985).
[b] Perceived Stress Scale (Cohen S et al, 1983).
[c] Rosenberg's Self-esteem Scale (Rosenberg M, 1965). Lower scores reflect higher self-esteem.
[d] EDI = Eating Disorder Inventory (Garner DM & Olmstead MP, 1984).
[e] Score 0-5 on TFEQ restraint scale.
[f] Score 6-12 on TFEQ restraint scale.
[g] score 13-21 on TFEQ restraint scale.
[h, i, j] Means differ significantly between values in rows not sharing a common superscript (by one-way ANOVA and Duncan's multiple range test).

4.4.3.2 Lifestyle characteristics

Lifestyle characteristics of women grouped according to whether their menstrual cycles were regular or irregular are presented in Table 16. Hours of weekly exercise and alcohol use were similar between groups, but a higher percentage of women who reported irregular menstrual cycles reported being current smokers. Although there were tendencies for differences in other variables, none was significant.

Table 15. Physical characteristics (mean ± SD) of women reporting regular and irregular menstrual cycles[a]

	Regular menstrual cycles (n = 377)	Irregular menstrual cycles (n = 97)	P value
Age (y)	21.4 ± 3.5	21.0 ± 2.7	0.326
Height (cm)	164.2 ± 7.0	163.5 ± 7.7	0.402
Weight (kg)	56.7 ± 10.1	56.0 ± 9.5	0.531
BMI (kg/m^2)	21.0 ± 3.1	20.8 ± 3.0	0.592
Highest BMI (kg/m^2)[b]	22.4 ± 3.9	22.6 ± 4.2	0.747
Lowest BMI (kg/m^2)[c]	19.6 ± 2.5	19.7 ± 2.8	0.944
Best BMI (kg/m^2)[d]	20.0 ± 2.0	19.6 ± 1.8	0.070

[a] Participants not using oral contraceptives and having menstrual cycles.
[b] Calculated from weight given as 'highest adult weight'.
[c] Calculated from weight given as 'lowest adult weight'.
[d] Calculated from weight given as 'best adult weight'.

Table 16. Lifestyle characteristics of women reporting regular and irregular menstrual cycles[a]

Characteristic	Regular menstrual cycles (n = 377)	Irregular menstrual cycles (n = 97)	P value
Coffee or tea (cups/d)[b]	1.0 ± 1.1	1.2 ± 1.1	0.061
Alcohol (drinks/wk)[b]	0.9 ± 2.0	1.0 ± 1.8	0.719
Exercise (hr/wk)[b]	3.3 ± 3.6	3.3 ± 3.0	0.989
Cigarette smokers	4.0%	9.3%	0.035[c]
Vegetarian	7.2%	12.4%	0.096
Using vitamin/mineral supplements	35.4%	26.0%	0.084

[a] Participants not using oral contraceptives and having menstrual cycles.
[b] Mean ± SD.
[c] Percentages differ significantly between groups (chi-square).

4.4.3.3 Weight fluctuation and dieting history

Weight fluctuation and dieting history of women reporting regular vs. irregular menstrual cycles are reported in Table 17. More women reporting irregular menstrual cycles had tried to lose weight, and there were tendencies for more of these women to be trying to

Table 17. Weight fluctuation and dieting history of women reporting regular and irregular menstrual cycles[a]

Characteristic	Regular menstrual cycles (n = 377)	Irregular menstrual cycles (n = 97)	P
Presently trying to lose weight	39.9%	50.5%	0.059
Ever tried to lose weight	70.4%	80.4%	0.049[b]
History of eating disorders	2.4%	6.3%	0.076
Weight fluctuation[c,d]	1.3 ± 1.5	1.7 ± 3.3	0.181

[a] Participants not using oral contraceptives and having menstrual cycles.
[b] Percentages differ significantly between groups (chi-square).
[c] Mean ± SD.
[d] Number of times > 5 lbs lost during the past two years.

lose weight at the time of the survey or to have reported being diagnosed with or treated for an eating disorder. Weight fluctuation was similar between the two groups.

4.4.3.4 Eating behaviour, eating attitudes and psychometric subscales

Scores on the Three-Factor Eating Questionnaire (TFEQ) subscales, the Perceived Stress Scale, Rosenberg's Self-esteem Scale and the eight Eating Disorder Inventory (EDI) subscales for women reporting regular and irregular menstrual cycles are presented in Table 18. Mean values for TFEQ restraint scale and Rosenberg's Self-esteem Scale scores were significantly higher for women reporting irregular menstrual cycles compared with those of women reporting regular menstrual cycles. All other scores were similar between the two groups.

4.4.4 Vegetarian and Nonvegetarian Participants

A comparison of the characteristics of women grouped according to whether they were following a vegetarian or nonvegetarian diet was conducted due to the difference in vegetarianism observed among restraint groups. A higher percentage of women with high scores for restraint reported following vegetarian diets and there are potential implications for menstrual function and bone health. Accordingly, further investigations were carried out

with women who reported currently following either a lacto-ovo vegetarian or vegan diet categorized as 'vegetarians' (n = 52) and all other participants grouped as 'nonvegetarians' (n = 614).

Table 18. TFEQ[a] subscale, Perceived Stress Scale[b], Rosenberg's Self-esteem Scale[c] and EDI[d] subscale scores of women (mean ± SD) reporting regular and irregular menstrual cycles[e]

Characteristic	n	Regular menstrual cycles	n	Irregular menstrual cycles	P value
TFEQ restraint	334	8.2 ± 5.1	90	10.3 ± 6.0	0.001[f]
TFEQ disinhibition	338	6.1 ± 3.7	93	6.7 ± 3.7	0.137
TFEQ hunger	341	6.3 ± 3.0	88	7.0 ± 3.3	0.054
Perceived stress	374	26.2 ± 7.4	96	27.7 ± 7.9	0.076
Self-esteem	374	1.5 ± 1.5	93	1.9 ± 1.8	0.037[f]
EDI drive for thinness	175	4.1 ± 5.2	36	5.9 ± 6.4	0.083
EDI bulimia	173	1.2 ± 2.3	33	1.4 ± 2.5	0.775
EDI body dissatisfaction	173	9.2 ± 7.9	37	10.4 ± 8.6	0.382
EDI ineffectiveness	171	2.8 ± 4.3	37	4.2 ± 5.0	0.074
EDI perfectionism	174	6.0 ± 4.4	37	6.4 ± 4.4	0.619
EDI interpersonal distrust	174	2.3 ± 2.8	37	2.7 ± 2.4	0.419
EDI interoceptive awareness	168	2.4 ± 3.7	35	3.1 ± 3.4	0.274
EDI maturity fears	175	3.7 ± 4.3	37	3.9 ± 4.5	0.822

[a] TFEQ = Three-Factor Eating Questionnaire (Stunkard AJ & Messick S, 1985).
[b] Perceived Stress Scale (Cohen S et al, 1983).
[c] Rosenberg's Self-esteem Scale (Rosenberg M, 1965). Lower scores reflect higher self-esteem.
[d] EDI = Eating Disorder Inventory (Garner DM & Olmstead MP, 1984).
[e] Participants not using oral contraceptives and having menstrual cycles.
[f] Mean values differ significantly between groups (t-test).

4.4.4.1 Physical characteristics

Physical characteristics of vegetarian and nonvegetarian women are presented in Table 19. Vegetarian women reported higher current body weights and the group difference in current BMI approached significance. Highest BMI, calculated from self-reported 'best weight', was also higher in the vegetarian group compared to the nonvegetarian group.

Table 19. Physical characteristics (mean ± SD) of vegetarian and nonvegetarian women

Characteristic	Nonvegetarian (n = 614)	Vegetarian (n = 52)	P-value
Age (y)	21.5 ± 4.3	22.2 ± 3.6	0.271
Height (cm)	164.4 ± 7.1	165.8 ± 8.0	0.159
Weight (kg)	56.9 ± 9.3	60.0 ± 12.0	0.029[a]
BMI (kg/m^2)	21.0 ± 2.9	21.8 ± 3.8	0.078
Highest BMI (kg/m^2)[b]	22.4 ± 3.5	24.3 ± 5.4	0.015[a]
Lowest BMI (kg/m^2)[c]	19.7 ± 2.5	19.6 ± 2.5	0.732
Best BMI (kg/m^2) [d]	20.1 ± 2.1	20.3 ± 2.0	0.507

[a] Mean values differ significantly between groups (t-test).
[b] Calculated from weight given as 'highest adult weight'.
[c] Calculated from weight given as 'lowest adult weight'.
[d] Calculated from weight given as 'best adult weight'.

4.4.4.2 Lifestyle characteristics

Lifestyle characteristics of participants currently following nonvegetarian or vegetarian diets are presented in Table 20. Vegetarians exercised more hours per week and a significantly higher percentage reported smoking cigarettes and using vitamin or mineral supplements when compared to nonvegetarians. Coffee or tea intakes and alcohol intake were similar between groups.

Table 20. Lifestyle characteristics of vegetarian and nonvegetarian women

Characteristic	Nonvegetarian (n = 614)	Vegetarian (n = 52)	P
Caffeine (cups/d)[a]	1.1 ± 1.1	1.3 ± 1.2	0.156
Alcohol (drinks/wk)[a]	1.1 ± 2.1	1.7 + 2.3	0.120
Exercise (hr/wk)[a]	3.6 ± 3.8	5.5 ± 6.1	0.029[b]
Cigarette smokers	5.3%	19.2%	0.000[c]
Using vitamin/mineral supplements	34.3%	57.7%	0.001[c]

[a] Mean ± SD.
[b] Mean values differ significantly between groups (t-test).
[c] Percentages differ significantly between groups (chi-square).

4.4.4.3 Weight fluctuation and dieting history

Weight fluctuation and dieting history of vegetarian and nonvegetarian women are presented in Table 21. A greater percentage of vegetarian women reported ever having tried to lose weight compared to nonvegetarian women, although the percentage who reported presently trying to lose weight was similar. Weight fluctuation did differ between groups with vegetarians reporting a weight loss of > 5 lb significantly more times in the past two years when compared to nonvegetarians. Finally, the percentage of women who reported having been diagnosed with or treated for an eating disorder was almost six times greater among vegetarians.

Table 21. Weight fluctuation and dieting history of vegetarian and nonvegetarian women

Characteristic	Nonvegetarian (n = 614)	Vegetarian (n = 52)	P
Presently trying to lose weight	41.7%	53.8%	0.089
Ever tried to lose weight	72.1%	90.4%	0.004[a]
History of eating disorders	3.0%	17.8%	0.000[a]
Weight fluctuation[b,c]	1.4 ± 1.6	2.4 ± 4.3	0.001[d]

[a] Percentages differ significantly between groups (chi-square).
[b] Mean ± SD.
[c] Number of times > 5 lbs was lost during the past two years.
[d] Mean values differ significantly between groups (t-test).

4.4.4.4 Menstrual cycle characteristics

Menstrual cycle characteristics for vegetarian and nonvegetarian women who reported having menstrual cycles and were not using oral contraceptives are presented in Table 22. A greater percentage of vegetarians reported having irregular menstrual cycles although the difference was not significant (P = 0.096).

Table 22. Menstrual cycle characteristics of vegetarian and nonvegetarian women

	Nonvegetarian (n = 435)	Vegetarian (n = 39)
Cycling irregularly	19.5%	30.8%
Cycle length (d)[b]	29.3 ± 4.0	29.3 ± 3.0

[a] Participants not using oral contraceptives and having menstrual cycles.
[b] Mean ± SD.

4.4.4.5 Eating behaviour, eating attitudes and psychometric subscales

Scores on the Three-Factor Eating Questionnaire (TFEQ) subscales, the Perceived Stress Scale, Rosenberg's Self-esteem Scale and the eight Eating Disorder Inventory (EDI) subscales for vegetarian and nonvegetarian women are presented in Table 23. Vegetarian

Table 23. TFEQ[a] subscale, Perceived Stress Scale[b], Rosenberg's Self-esteem Scale[c] and EDI[d] subscale scores (mean ± SD) for vegetarian and nonvegetarian women

	n	Nonvegetarian	n	Vegetarian	P value
TFEQ restraint	549	8.4 ± 5.2	47	11.4 ± 5.6	0.000[e]
TFEQ disinhibition	557	6.1 ± 3.7	47	7.2 ± 4.1	0.042[e]
TFEQ hunger	557	6.4 ± 3.0	48	7.1 ± 3.8	0.131
Perceived stress	609	25.8 ± 7.5	52	29.0 ± 7.7	0.004[e]
Self-esteem	602	1.4 ± 1.5	52	2.0 ± 1.8	0.035[e]
EDI drive for thinness	268	4.2 ± 5.3	21	6.2 ± 6.6	0.108
EDI bulimia	266	1.2 ± 2.1	19	1.5 ± 2.5	0.528
EDI body dissatisfaction	269	9.3 ± 7.9	21	8.9 ± 7.7	0.822
EDI ineffectiveness	267	2.6 ± 4.1	20	4.9 ± 6.7	0.027[e]
EDI perfectionism	268	5.9 ± 4.2	21	6.6 ± 3.6	0.468
EDI interpersonal distrust	271	2.0 ± 2.6	20	3.2 ± 3.6	0.049[e]
EDI interoceptive awareness	259	2.2 ± 3.5	19	3.6 ± 4.7	0.091
EDI maturity fears	269	3.6 ± 4.2	20	3.4 ± 4.4	0.833

[a] TFEQ = Three-Factor Eating Questionnaire (Stunkard AJ & Messick S, 1985).
[b] Perceived Stress Scale (Cohen S et al, 1983).
[c] Rosenberg's Self-esteem Scale (Rosenberg M, 1965). High scores reflect lower self-esteem.
[d] EDI = Eating Disorder Inventory (Garner DM & Olmstead MP, 1984).
[e] Mean values differ significantly between groups (t-test).

women had higher scores on the TFEQ restraint scale, TFEQ disinhibition scale, Perceived Stress Scale, Rosenberg's Self-esteem Scale, EDI ineffectiveness and interpersonal distrust scales.

4.4.5 Results Summary

4.4.5.1 Participants grouped according to TFEQ restraint scores – Summary of results with regard to hypotheses.

Hypothesis 1: *The age, physical and lifestyle characteristics will not differ among women with low, medium and high scores for dietary restraint.*

The null hypothesis was rejected as there were significant group differences in mean values for several physical and lifestyle characteristics. Highest BMI (kg/m^2), calculated from self-reported highest body weight, was higher in women grouped as having high or medium scores for restraint compared to those grouped as having low restraint scores ($P = 0.002$). Lowest BMI, calculated from lowest body weight, differed only between the low restraint group and the medium restraint group ($P = 0.023$). However, age, height, weight, BMI and best BMI were all similar among groups.

Self-reported weekly hours of exercise were significantly higher in the high restraint group compared to the low or medium restraint groups ($P = 0.027$). Women with high restraint scores were also more likely to report following a lacto-ovo vegetarian or vegan diet ($P = 0.001$). Finally, no significant group differences were detected in use of caffeinated or alcoholic beverages, cigarettes, oral contraceptive usage or vitamin/mineral supplements.

Hypothesis 2: *Weight fluctuation and dieting history will not differ among women with low, medium and high scores for dietary restraint.*

The null hypothesis was rejected as all variables differed among groups. Higher percentages of women in the high restraint group were presently trying to lose weight and reported ever trying to lose weight ($P < 0.001$). Weight fluctuation (number of times > 5 lbs was lost in the past two years) was also significantly higher ($P < 0.001$) in the high restraint group and more women in this group reported having been diagnosed with or treated for an eating disorder ($P < 0.001$).

Hypothesis 3: *Self-reported menstrual cycle characteristics will not differ among women with low, medium and high scores for dietary restraint.*

The null hypothesis was rejected as menstrual cycle regularity differed among restraint groups with a greater percentage of women with high scores for restraint reporting cycle irregularity than women with low or medium scores for restraint ($P < 0.01$). Menstrual cycle length, however, did not differ among groups.

Hypothesis 4: *Scores on the Three-Factor Eating Questionnaire subscales, the Perceived Stress Scale, Rosenberg's Self-esteem Scale and the Eating Disorder Inventory subscales will not differ among women with low, medium and high scores for dietary restraint.*

Scores on the TFEQ hunger scale and the EDI maturity fears scale did not differ and the null hypothesis was, therefore, not rejected in relation to these variables. All other scales and subscales did differ among groups, with women in the high restraint group consistently having higher scores than those in the low restraint group.

4.4.5.2 Participants grouped according to menstrual cycle regularity – Summary of results

Women grouped according to whether they reported their menstrual cycles to be regular or irregular did not differ in age or physical characteristics. A significantly greater

percentage of women reporting irregular cycles were current cigarette smokers. Coffee or tea intakes were nonsignificantly higher in women reporting irregular cycles as was the percentage of women currently following a lacto-ovo or vegan diet. However, hours of weekly exercise and alcohol intake did not differ between groups.

More women reporting irregular cycles were presently dieting and reported having ever dieted although only the latter was significant. The difference between women with regular and irregular cycles reporting a history of being diagnosed with or treated for an eating disorder approached significance.

On the various eating behaviour, eating attitudes and psychometric scales, only scores on the TFEQ restraint scale and Rosenberg's Self-esteem Scale differed between women reporting regular and irregular menstrual cycles.

4.4.5.3 Vegetarian and nonvegetarian participants – Summary of results

Vegetarian women reported significantly higher values for current body weight and for highest BMI, calculated from highest adult body weight. Vegetarian women reported exercising significantly more hours per week than nonvegetarian women. They also were more likely to be cigarette smokers and to use vitamin or mineral supplements than nonvegetarian women.

Over 90% of vegetarian women reported having tried to lose weight compared to less than 75% of nonvegetarian women. Reported weight fluctuation was also higher in vegetarian women as was the history of being diagnosed with or treated for an eating disorder. Vegetarian women had significantly higher scores on the TFEQ restraint scale compared to nonvegetarian women. They also had higher scores on the TFEQ disinhibition scale, Perceived Stress Scale, Rosenberg's Self-esteem Scale and the EDI ineffectiveness and interoceptive awareness scales.

4.5 Discussion

4.5.1 Introduction

The original purpose of Part One of this study was to characterize a large cross-section of young women in relation to their scores on the TFEQ restraint scale and to recruit participants for a more in-depth study (Part Two). During the analysis of the results of Part One certain factors arose which led to further divisions and characterizations of the study population. Specifically, the finding that more women with high restraint scores reported their menstrual cycles to be irregular when compared with women with low restraint scores led to a division of the population according to whether they reported regular or irregular menstrual cycles. This permitted an investigation into whether the two groups differed in general characteristics and particularly characteristics which have previously been associated with menstrual cycle irregularity.

Additionally, women with higher restraint scores were more likely to report following vegetarian diets which led to an analysis of women grouped according to whether or not they were currently following a vegetarian diet. This allowed for a comparison with other studies of vegetarian women and the identification of characteristics which differed between vegetarian and nonvegetarian groups in the present study. Of particular interest were variables which may impact on menstrual cycle function and bone health.

The discussion of the results of Part One has been divided into four sections in accordance with the presentation of results. The first section (4.5.2) centres on the characteristics of all participants who completed the survey and compares these results to the findings of others. The second section (4.5.3) examines the characteristics of participants grouped according to their scores on the TFEQ restraint scale and discusses these findings in relation to the current body of literature. The third section (4.5.4) reviews the characteristics

of participants grouped according to whether they reported having regular or irregular menstrual cycles and how comparable these are to the findings of others. In the fourth section (4.5.5), participants grouped according to whether they are currently following vegetarian or nonvegetarian diets are compared and these findings related to the present body of knowledge. Study limitations, and directions for further research are discussed. Finally, the conclusions of Part One are presented.

4.5.2 All Participants

Before findings of the present study can be compared to those of others, it is important to consider whether the subjects were representative of the population from which the sample was obtained. In this study the 'population' was female students at U.B.C., who at the time of the study (1998) comprised 45% of the student body of 33,474 students (www.ubc.ca). The sample of 666 women reflected a 56% response rate to the questionnaire. It should be noted that questionnaires were distributed to all female students in classes and not just to those who indicated potential interest. Furthermore, classes offered by a variety of departments (biochemistry, nutrition, psychology, nursing, family science and human kinetics) were used, suggesting that the initial study frame was likely relatively representative of the student body.

The present study's response rate was comparable to the 55% response rate reported by Raciti and Norcross (Raciti MC & Norcross JC, 1987) in response to a questionnaire packet distributed to 436 incoming female freshman and sophomores. It was lower than recently reported by Heatherton et al (Heatherton TF et al, 1995) who had a 71% response rate from 800 female college students surveyed. Our lower response rate was most likely due to the length of the present questionnaire, different methods of distribution, and incentives used. Heatherton used an abbreviated form (26 items) of Garner's Eating Disorder Inventory

(EDI) in addition to questions regarding demographic characteristics and dieting behaviours while the present study used the full EDI (64 items) and TFEQ (51 items). Our study also listed recruitment criteria for Part Two which may have dissuaded ineligible women from proceeding with the survey. Lastly, U.B.C. students are frequently given course credit for completing surveys, particularly in the department of Psychology, which was not the case in this study.

It is possible that women who completed the survey differed from those who did not as it was made clear at the time of distribution that volunteers for Part Two of the study would have the opportunity to have their body composition assessed by DEXA. Women who were particularly concerned about their percentage body fat or bone mineral density may have been more likely to respond to the survey and complete the recruitment form. Women who were unconcerned about their body composition may not have had any interest or incentive to complete the survey. Greater concerns about body composition may be associated with disordered eating patterns. For these reasons the sample may have been biased towards women with more concerns about their eating behaviour, body shape and the consequences of disordered eating although scores on various scales were similar to those of students at other universities.

4.5.2.1 Physical characteristics

The mean BMI (21.1 ± 3.0 kg/m^2) of all participants fell within the so-called 'normal' range (18-25 kg/m^2) for adult men and women although the range of 15.3 to 45.7 kg/m^2 was quite broad due to the large sample size. A comparable sample of female students surveyed in 1992 at Dartmouth College (n = 564) had a mean BMI of 21.9 (Heatherton TF et al, 1995).

The mean 'best' BMI, calculated from weight given as 'best' weight, was significantly lower than the mean current BMI, suggesting that desired body weight is lower

than present body weight even in normal weight women. Although expressed in various ways, this finding is similar to that of other authors (Heatherton TF et al, 1995; Health and Welfare Canada, 1993; Hetherington MM & Burnett L, 1994). Health and Welfare Canada reported that 37% of women with acceptable body weights were trying to lose weight and 8% of those who were underweight were trying to lose weight. In the study by Heatherton et al almost 72% of college women (19.9 ± 1.8 y) surveyed wanted to lose weight although the mean BMI of this group was 21.9 kg/m^2. In Hetherington and Burnett's study of young women from the Dundee University community the difference between weight given as present weight and 'ideal' weight was 11.3 ± 1.2 lbs in a group with a mean BMI of 22.1 ± 0.3 kg/m^2. Comparable results were reported from a survey of 716 U.C.L.A. female students (Kurtzman FD et al, 1989) who reported desired weight to be an average of 9.1 lbs less than present weight (117.5 lbs vs. 126.6 lbs). In comparison, while desired weight was not requested in our study, 'best' weight was an average of 6.0 (3.7 kg) lbs less than current reported weight.

4.5.2.2 Lifestyle characteristics

Participants reported exercising more hours per week than is average for females in this age group in British Columbia (Health and Welfare Canada, 1993), although university students frequently report being more active than their nonuniversity peers. The relatively higher activity level of the current sample may be due in part to the fact that questionnaires were distributed to several classes related to fitness such as Human Kinetics. A number of students played on varsity teams and trained over 15 hr/wk which may have skewed the results. Of interest is that one student reported exercising 42 hr/wk and also identified herself as amenorrheic. Statistics Canada reported 18.4% of women aged 20-24 years old in British Columbia do not exercise at all, while in this study only 10% reported 0 hours of weekly

exercise. A study investigating physical activity trends among 26 U.S. states (Caspersen CJ & Merritt RK, 1995) reported 25.8% of all women 18-29 years of age were physically inactive although the percentage of inactive female college graduates was lower at 17.9%.

Cigarette smoking by women living in British Columbia is reported to be 23.8% (Health and Welfare Canada, 1993) compared with 6.3% in the present study. Further qualifying the statistics from Health and Welfare Canada, fewer women (16%) with a university education smoke compared with their nonuniversity educated peers. Recent data from a representative sample (n = 25,627 students) of 140 American colleges reported 22.3% of students had smoked during the previous 30 days (Emmons KM et al, 1998) while a survey of 300,000 freshman (Sax LJ, 1997) reporting the incidence of smoking among female students to be 15.3%. The ethnicity of the population may have been a factor in our study although this information was not requested in Part One. U.B.C. has a large population of Asian students (percentages unavailable) and Asian women comprised over 50% of participants in Part Two. Ethnic data regarding cigarette smoking were not available for Canada but the U.S. Surgeon General reports the current rate of smoking among Asian Americans to be considerably lower than for white Americans (15.3 vs. 25.9%). Finally, several of the classes in which questionnaires were distributed were related to fitness and nutrition and fewer students in these disciplines may be smokers.

Reports of the percentage of young women who are currently following vegetarian diets are variable. Our finding that 7.8% of the study population were vegetarian is similar to the recent report that 9.5% of women in British Columbia describe themselves as vegetarian (National Institute of Nutrition, 1997). In a recent survey of 52 high schools in South Australia 8-37% of women described themselves as vegetarian (Worsley A & Skrzypiec G, 1998). In the CARDIA study (Slattery ML et al, 1991) the actual rate of 18-30 year old

women who described themselves as being lacto-ovo-vegetarian was only 0.8%, although the percentage of white women with very low meat consumption (< 1.0 times/wk) was 3.8%. Slattery also reported that individuals who were older, white, and female with more than high school education were more likely to be vegetarian (up to 7.3%).

Alcohol and coffee or tea intakes were relatively low in this population. Health and Welfare Canada reported that 15% of women age 20 to 24 do not consume alcohol compared with 54% in the present study. Again, ethnicity and level of education may be factors in the higher than normal percentage of nondrinkers in our study although comparative data were not available for female Asian university students in Canada. Vitamin and mineral supplement use was reported to be 47% among 692 pharmacy students (Ranelli PL et al, 1993) compared with 35.7% in our study although a higher rate might be expected in the former due to the nature of their field of study. In general, fewer adolescents (20-25%) report consuming vitamin and mineral supplements (Sobal J & Muncie HL, 1988) compared with adults (45% of women). Due to the mean age of participants in our study it is predictable that the percentage reporting supplement usage would fall between the younger and older cohorts. In conclusion, these results suggest that this sample, similar to other studies of young university women, may practice more health related behaviours such as exercising more, smoking less and drinking less alcohol than other women of similar age and background.

4.5.2.3 Weight fluctuation and dieting history

The percentage of women (73%) in the present study who reported having ever tried to lose weight is comparable to the findings of others (Heatherton TF et al, 1995; Hetherington MM & Burnett L, 1994) in spite of the fact that few women in this study would have been classified as overweight. Using weights given as highest adult body weight, 10%

of women had a previous BMI between 25 and 27 kg/m^2 and < 8% over 27 kg/m^2. Therefore, the majority (82%) of women who had tried to lose weight had a BMI < 25 kg/m^2. In a recent study Heatherton et al surveyed almost 600 college women and 72.3% reported having dieted at some point in time, although only 5.1% were categorized as overweight or obese.

Discrepancies in criteria make it difficult to compare the data reported in the present study with estimates of the presence or history of eating disorders in college females reported in other studies. In a study by Streiger-Moore et al (Striegel-Moore RH et al, 1989) 3.8% of a large sample of freshman women (n = 450) were identified as meeting the DSM-111-R criteria for bulimia nervosa (American Psychiatric Association, 1987). This is similar to the percentage of women in this study who reported having ever been diagnosed with or treated for an eating disorder (4.2%). As bulimia nervosa is the most prevalent eating disorder in college women it is probable that the majority of women with an eating disorder in our study had been diagnosed with or treated for bulimia. Heatherton et al estimated the prevalence of bulimia nervosa to be 5.1% for college women surveyed in 1992 using the DSM-111-R criteria. The percentage of young women with anorexia nervosa is usually reported to be < 1%. Our results appear to be in line with the reports of others although criteria differed among studies.

Western standards of beauty currently emphasize a lean, fit, body shape and dieting is a method used by a large percentage of women in an attempt to attain this culturally endorsed image. In many cases, cognition and biology are at odds as the body is not that malleable. The unrealistic pursuit of a model-like shape has many women living with constant body dissatisfaction and pursuing various behaviours in order to lose body weight or fat.

4.5.2.4 Menstrual cycle characteristics

The results of studies reporting menstrual cycle regularity are quite variable as the menstrual cycle is affected by multiple factors. A higher percentage (79.5%) of women in this study reported their menstrual cycles to be regular compared with a large study of college women conducted by Carlberg et al (Carlberg KA et al, 1983). In the latter study, questionnaires were completed by female athletes (n = 140) and nonathlete controls (n = 426) and interviews conducted with 95 athletes. The authors defined irregular menstruation as cycles > 35 days or < 23 days at least once during the previous year. Based on these criteria, irregular menstruation was reported by 45.0% of the athletes and 33.1% of the controls. In both the athletes and controls the mean age was significantly lower in women reporting irregular cycles compared to those reporting regular cycles. Our study group would be more comparable to the control group in Carlberg's study, although slightly older (21.6 ± 4.2 y vs. 20.6 ± 4.0 y), which may account for the lower percentage of self-reported menstrual cycle irregularity.

In contrast to other studies related to menstrual cycle regularity, women in this study were younger and only 6.5% had ever been pregnant, both factors which affect cycle regularity. Over 20% (n = 143) of women who completed the survey were under 20 years of age and menstrual cycle irregularity is common in this age group (Vollman RF, 1977). Unstable menstruation is most common in younger women, lowest for ages 35-39 and increases towards menopause. In addition, we did not provide participants with a definition for 'irregular' and, therefore, cannot compare our results with others who did.

4.5.2.5 Eating behaviour, eating attitudes and psychometric subscales

Mean scores on the TFEQ restraint scale were very similar to those recently reported for 50 young women from the Dundee University community (UK) (Hetherington MM &

Burnett L, 1994) and 139 middle aged normal weight Swedish women (Lindroos AK et al, 1997). In Hetherington and Burnett's study, TFEQ scores for 50 young university women were, restraint 8.3 ± 0.8, disinhibition 8.5 ± 0.5, and hunger 6.4 ± 0.4 (mean ± SEM). Mean TFEQ scores (± SD) for the scales in the present study were 8.6 ± 5.3, 6.2 ± 3.7 and 6.4 ± 3.1. Participants in the study conducted by Lindroos et al (Lindroos AK et al, 1997) had a mean (± SD) restraint scale score of 9.1 ± 2.8.

Scores on the scales comprising the Eating Disorder Inventory (EDI) were similar to those reported by others (Garner DM & Olmstead MP, 1984; Raciti MC & Norcross JC, 1987; Kurtzman FD et al, 1989; Klemchuk HP et al, 1990). Mean EDI scores (Garner DM & Olmstead MP, 1991) from a sample (n = 205) of college women are listed in Appendix 9. Based on the comparability of scores on the various eating attitudes and behaviour scales it appears that women in the present study were similar to those in other studies with regard to their concerns about body shape. Scores on the EDI drive for thinness, bulimia and body dissatisfaction scales were somewhat lower in the present study than published scores from a large sample (n = 627) of sorority women assessing their body size perceptions and weight related attitudes and behaviours (Schulken ED et al, 1997). The response rate to the survey conducted by Schulken et al was 98% and although sorority women may be more concerned about body image than other young women, their scores did not differ greatly from a larger college sample (n = 1,506) studied by Klemchuk et al (Klemchuk HP et al, 1990). Accordingly, based on the comparable eating behaviour scores of young women in the present study compared with those in other studies with high response rates, it is unlikely that our sample was biased towards women with greater concerns about food intake and body image.

Perceived Stress Scale (PSS) scores were similar to those published in a prospective study of disordered eating among college students (Striegel-Moore RH et al, 1989). The mean PSS score for the total group (n = 178) was not given in the latter study as subjects were divided into three groups according to symptoms of disordered eating. Women were grouped according to whether they were 1) free of disordered eating symptoms, 2) symptoms had worsened or 3) symptoms had remained the same over a one year period. Disordered eating was assessed by a questionnaire which included several items from the EDI (Garner DM & Olmstead MP, 1984). The mean PSS score for participants who had not experienced a change in disordered eating behaviour (n = 78) over a one year period was 26.55 ± 7.18 which was almost identical to our findings (26.1 ± 7.6).

Mean scores on Rosenberg's Self-esteem Scale (1.4 ± 1.6) were comparable, although slightly lower than those reported in Wylie (Wylie RC, 1989) based on 1,583 high school students (1.9 ± 1.4). Lower scores indicate higher self-esteem and the lower scores in the present study may be partially explained by the higher mean age of the participants. Button (Button EJ, 1996) reported higher scores in girls (2.4 ± 1.8) 15-16 years of age. Women in our study were all university students and more educated women may also have higher self-esteem.

The restraint scale of the TFEQ was positively correlated with highest BMI, weight fluctuation and exercise although highest BMI and weight fluctuation were more strongly correlated with the TFEQ disinhibition scale. This corresponds to the finding of Carmody et al (Carmody TP et al, 1995) who reported women with a history of weight cycling had significantly higher disinhibition scores than those with no history. In contrast, he did not find an association between weight cycling and restraint scores.

With regard to correlations between the TFEQ and EDI scales, Williamson et al (Williamson DA et al, 1995) found the TFEQ restraint scale to be most strongly correlated with the drive for thinness scale of the EDI as was found in this study. Scores on the TFEQ disinhibition scale correlated most strongly with the EDI bulimia scale which appears to match Laessle's finding that women diagnosed with bulimia nervosa scored significantly higher on the disinhibition scale than others (Laessle RG et al, 1989c).

A unique finding was the relationship between the TFEQ restraint scale and Cohen's Perceived Stress Scale (Cohen S et al, 1983). The positive correlation suggests that women with high scores on the restraint scale may appraise events in their lives as more stressful than those with low scores. How this relationship is mediated requires further investigation. This study also found a positive relationship between scores on Rosenberg's Self-esteem Scale and the scales of the TFEQ. This indicates that women with higher restraint, disinhibition and hunger scores may have lower self-esteem than those with lower scores. Only one study could be found which reported correlation coefficients between TFEQ restraint scale and Rosenberg's Self-esteem Scale scores and the relationship was not significant (Ricciardelli LA & Williams RJ, 1997). It should be noted that several studies reported using Rosenberg's Self-esteem Scale and cited Rosenberg (1965) or Rosenberg (1979) but did not correctly score the scale. In the study by Ricciardelli & Williams means were not given nor was the scoring sysem explained. Also, the authors commented in the methods section that "higher scores indicated higher self-esteem" which is contrary to Rosenberg's description. Therefore, it is difficult to compare these findings.

4.5.3 Participants Grouped According to TFEQ Restraint Scores

4.5.3.1 Physical characteristics

While age, height, weight and BMI were similar among the three levels of dietary restraint, highest adult BMI was significantly higher in the medium and high restraint groups compared with the low restraint group. This finding is comparable to that of other authors (Tuschl RJ et al, 1990a; Lowe MR, 1984) who also reported that women with high restraint scores had higher maximal adult BMIs than women with low restraint scores. Others reported a trend towards higher values for former BMIs in women with high restraint scores compared to those with low restraint scores (Laessle RG et al, 1989b; Schweiger U et al, 1992; Lautenbacher S et al, 1992). The sample sizes in the latter studies were much smaller than in the present study which may explain why the differences found in self-reported highest BMI were not significant. Some studies (Tuschl RJ et al, 1990a; Tuschl RJ et al, 1990b) have noted differences in current BMIs with women with high restraint scores having higher values than those with low restraint scores. Other studies have not found significant differences in current BMI values but have still noted an elevation in group means for women with high restraint scores. Based on these prior findings it has been postulated that although the current BMI of women with high restraint scores is frequently elevated in relation to women with low restraint scores, it is still lower than if dietary restraint was not imposed. Women who are naturally larger may feel greater social pressure to monitor their food intake as they perceive themselves as less attractive in today's world of ultrathin models and actors.

4.5.3.2 Lifestyle characteristics

Several lifestyle characteristics of women with high restraint scores differed from those of women with low restraint scores, suggesting that other behaviours are being used to regulate body weight and achieve the well-toned, fit look that is currently fashionable. Women with high restraint scores reported exercising more hours per week and were more likely to identify themselves as vegetarian than those with lower scores. Unfortunately these data cannot be compared with the findings of others as daily exercise has not generally been reported in studies comparing women with varying levels of restraint, or higher exercise was part of the exclusion criteria. Barr did report that women with high scores for restraint appeared to exercise more than those with low scores although the difference was not significant (Barr SI et al, 1994a). Laessle et al (Laessle RG et al, 1989b) commented in the discussion of a paper comparing eating behaviour of restrained and unrestrained eaters that physical activity levels were similar between groups. This information was obtained through interview data and appeared to be quite general ('about 3-7 hr/wk').

Whether women with different restraint scale scores are following vegetarian or nonvegetarian diets also does not appear to have been documented in other studies. In contrast to the dearth of studies relating vegetarianism and restraint, there is considerable literature regarding vegetarianism and clinical eating disorders such as anorexia nervosa. Kadambari et al (Kadambari R et al, 1986) reported the prevalence of vegetarianism to be 45% among 180 women with anorexia nervosa. A higher percentage (54.3%) of women reported following a vegetarian diet in a retrospective study of 116 women with anorexia nervosa (O'Connor MA et al, 1987) although vegetarianism was defined as "avoiding red meat". As vegetarian diets may be lower in total energy and fat, women with greater weight concerns may adopt such practices as a means of controlling weight (Dwyer JT, 1988). In

addition, vegetarian women are reported to be leaner than nonvegetarian women (Dwyer JT, 1988) which would give women with weight concerns more motivation to avoid consuming meat and other animal products.

A greater percentage of women in the high restraint group reportedly smoked cigarettes, although this difference was not significant. It is difficult to compare these results with the findings of others as most studies using the restraint scale of the TFEQ have excluded smokers (Schweiger U et al, 1992; Barr SI et al, 1994a; Tuschl RJ et al, 1990a).

In summary, the findings on lifestyle practices suggest that women with high scores for restraint may practice several different behaviours (such as exercising, adopting a vegetarian diet, and smoking) in addition to monitoring their food intake in order to regulate body weight.

4.5.3.3 Weight fluctuation and dieting history

All characteristics assessed in relation to weight fluctuation and dieting history for women with low, medium and high scores for restraint differed among groups. As dietary restraint is defined as the cognitive attempt to control or limit food intake, the relationship between restraint group and dieting is not surprising. Others (Tuschl RJ et al, 1990a; Laessle RG et al, 1989b) have reported a significant difference in the number of previous dieting periods reported by women with high and low restraint scores.

The difference in past history of eating disorders between women with high scores and those with medium or low scores for restraint is also not unexpected as there were no exclusion criteria for participation in the survey. Women with eating disorders would most likely score high on any instrument assessing restrictive attitudes towards food intake. Laessle et al (Laessle RG et al, 1989c) found women with

bulimia nervosa had significantly higher restraint scale scores compared to women classified as restrained or unrestrained eaters in a study comparing the psychopathology of the three groups.

4.5.3.4 Menstrual cycle characteristics

The results of this study concur with the findings of several studies of women with high and low scores for restraint with regards to menstrual cycle characteristics (Schweiger U et al, 1992; Barr SI et al, 1994a; Barr SI et al, 1994b). In the present study a higher percentage of women with high restraint scores reported irregular menstrual cycles compared to those with lower scores. In previous studies an association has been found between restrained eating and subclinical ovulatory disturbances. In the study by Schweiger et al (Schweiger U et al, 1992) women were excluded if their menstrual cycles length was outside the range of 22 to 37 days with variability more than six days. Participants were grouped as restrained (TFEQ scores above the 75^{th} percentile for a reference population) or unrestrained (scores below the 50^{th} percentile). Eleven of the 13 women with low restraint scores had menstrual cycles that fulfilled the standard criteria for serum estradiol, peak progesterone and luteal phase length. Only 2 of 9 women with high restraint scores met the criteria. Schweiger et al reported that women with high restraint scores had shorter mean cycle lengths, lower progesterone and short luteal phase cycles. He concluded that high cognitive restraint may be a risk factor for the development of menstrual disturbances in young women. In the study by Barr et al (Barr SI et al, 1994a) the criteria for enrollment included normal menstrual cycle length (21-36 d) and normal luteal phase length (10-16 d) in two consecutive menstrual cycles prior to the beginning of the study. Women in the upper and lower tertiles for TFEQ restraint scores recorded basal temperature and exercise for at least three menstrual cycles. Luteal phase length was significantly shorter for women in the upper

tertile compared with the lower tertile. Menstrual cycle length did not differ between the two restraint groups in Barr's study in agreement with our findings from self-reported data. While cycle regularity was not defined in the survey instrument used in the present study, almost twice as many women in the high restraint group *believed* their cycles were irregular compared with women in the low restraint group. Barr also studied ovulatory function in vegetarian and nonvegetarian women with clinically normal menstrual cycles (Barr SI et al, 1994b). Participants were grouped according to restraint scale scores and highly restrained women had fewer ovulatory cycles and shorter mean luteal phase lengths compared to those with restraint scores below the median.

Different hypotheses arose from these studies which may relate to our findings. In Schweiger's study energy and macronutrient intakes were assessed from food diaries and although participants were similar in age, weight and activity, women in the high restraint group consumed 23% less energy than those in the low restraint group. The luteal phase of the menstrual cycle is associated with higher energy expenditure and the authors suggested that decreased ovarian function, leading to a decrease in progesterone secretion, may be part of the body's adaptation to decreased energy intake. Barr proposed that the stress of restrained eating (physiological, psychological, and nutritional) may lead to the release of corticotropin releasing hormone (CRH) which can interfere with LH pulsatility and, therefore, lead to menstrual cycle disturbances. The idea that stress related hormones, known to impact on menstrual cycle function, may be higher in women with high restraint scores than in those with low scores has been investigated in Part Two of this study.

4.5.3.5 Eating behaviour, eating attitudes and psychometric subscales

The results of this study agree with those of Laessle et al (Laessle RG et al, 1989b) and Rossiter et al (Rossiter EM et al, 1989) in finding that women with high scores on the

restraint scale of the TFEQ also had higher scores on the TFEQ disinhibition scale. Laessle identified restrained eaters as women with restraint scores in the upper third for the sample and unrestrained eaters as women with scores in the lower third. Comparisons were done between these two groups and also with bulimia nervosa patients. Scores on all EDI scales were higher for women grouped as bulimic compared with both the restrained and unrestrained groups although values were expressed differently (as percentages of maximum values) than in the present study. Between restrained and unrestrained eaters only scores on the drive for thinness and body dissatisfaction scales differed with higher scores reported for the restrained group. Another study published the same year (Rossiter EM et al, 1989) also compared patients with bulimia and nonbulimic restrained and unrestrained eaters on several questionnaires including the EDI. Women in the upper quartile for TFEQ restraint scores again had significantly higher scores on the EDI drive for thinness and body dissatisfaction scales compared with women in the lower quartile and these scores were comparable to those of women in our high restraint group. Both the latter two studies had considerably fewer participants which may account for the lack of significant findings in relation to the other scales of the EDI although the direction of scores was similar to ours.

Women with high restraint scores also scored higher on the Perceived Stress Scale (PSS). In a prospective study of disordered eating, Striegel-Moore et al (Striegel-Moore RH et al, 1989) found that young female students with increasing symptoms of disordered eating across a scholastic year also had higher scores on the PSS compared to those who were categorized as symptom-free (27.30 ± 8.75 vs. 22.39 ± 6.59). It may be hypothesized that individuals who perceive events in their lives as more stressful may experience more negative feelings with regard to their weight and attempt to restrain food intake in order to reduce their sense of dissatisfaction. Alternatively, higher levels of dietary restraint may lead

to a general feeling of stress, which is subsequently extrapolated into other situations. Obviously cause and effect cannot be determined from this type of analysis but provide a basis for further investigation. A predisposition to restrained eating may exist in individuals who have a greater response to stressful situations. The relationship between perceived stress and restrained eating has not been examined and merits further attention as stress may play a role in menstrual cycle disturbances which have been observed in other studies (Schweiger U et al, 1992; Barr SI et al, 1994a; Barr SI et al, 1994b). Van Eck (van Eck MM & Nicolson NA, 1994) noted a difference in salivary cortisol in men with high scores on the PSS compared with men with low PSS scores although this difference was only present on workdays. If salivary cortisol differs between individuals with different PSS scores it may also differ in those with different restraint scores as PSS scores and restraint scores were significantly correlated ($r = 0.34$, $P < 0.001$) in our study.

Another finding unique to this study was that women with high restraint scores had scores on Rosenberg's Self-esteem Scale reflective of lower self-esteem. Self-esteem scores increased with the level of dietary restraint indicating a decrease in self-esteem. While our data are cross-sectional it has previously been hypothesized that low self-esteem predates the onset of an eating disorder and is in fact a necessary prerequisite for the development of eating disorders (Silverstone PH, 1992). In accordance with this theory, low self-esteem may be an aspect of personality which increases women's sensitivity to current cultural pressures to be thin and, therefore, susceptibility to dietary restraint. Women with low self-esteem may believe that losing weight will improve their feelings of self-worth and increase their social acceptability even if they are not overweight. In our study, self-esteem scores were not related to either weight or BMI. Button (Button EJ, 1996) recently reported findings from a prospective study of self-esteem and eating problems in adolescent girls. Rosenberg's Self-

esteem Scale was completed by 400 girls at age 11-12 and later at age 15-16. At the older age eating problems were also assessed. Results showed that girls with low self-esteem at age 11-12 were at significantly greater risk of developing signs of eating problems by age 15-16. While further research is needed in this area before cause and effect can be determined, our results do suggest that low self-esteem may be a common feature of women with high dietary restraint.

4.5.4 Participants Grouped According to Menstrual Cycle Regularity

4.5.4.1 Physical and lifestyle characteristics

All variables related to physical and lifestyle characteristics of women grouped according to menstrual cycle regularity were similar except cigarette smoking which was more common in women reporting irregular cycles. Epidemiological evidence has suggested that cigarette smoking has an anti-estrogenic effect in women but the physiological significance has not been firmly established (Key TJ et al, 1991). Variables such as age, weight, BMI and exercise which have been hypothesized to affect the menstrual cycle in other studies (Carlberg KA et al, 1983) did not differ between women grouped according to menstrual cycle regularity. The only lifestyle variables which approached significance were the percentages of women following vegetarian diets ($P = 0.096$) and those reporting current use of vitamin/mineral supplements ($P = 0.084$). Vegetarianism has been proposed as a negative influence on menstrual cycle function potentially due to the association with lower body weight (Dwyer JT, 1988), dietary components such as lower fat or higher fibre (Rose DP et al, 1991; Rose DP et al, 1987), and/or stress related factors (Schweiger U et al, 1988). Pederson et al (Pedersen AB et al, 1991) reported normally active, vegetarian women were more likely to have irregular menstrual cycles and suggested that the results were consistent with the idea that premenopausal vegetarian women have decreased levels of estrogen. More

recently, Barr et al (Barr SI et al, 1994b) prospectively assessed ovulatory function in vegetarian and nonvegetarian women with clinically normal menstrual cycles, and found fewer cycle disturbances in the vegetarian group. Possible reasons for these discrepancies will be discussed further in section 4.5.5.

4.5.4.2 Weight fluctuation and dieting history

A higher percentage of women reporting irregular menstrual cycles had previously tried to lose weight and they were more likely to be trying to lose weight at present (P = 0.059). These findings are in agreement with studies evaluating the impact of dieting on the menstrual cycle (Pirke KM et al, 1989; Fichter MM & Pirke KM, 1984; Schweiger U et al, 1987; Schweiger U et al, 1989). Fichter et al (Fichter MM & Pirke KM, 1984) studied the effects of total energy deprivation in 5 young women over a three week period. Three of the 5 experienced serious regression of LH secretion and none of the women menstruated during the three week study period, or during a six week follow up. Schweiger et al (Schweiger U et al, 1987) conducted a study of 22 healthy, normal weight women for a control menstrual cycle and a diet menstrual cycle. Differences were found between the control period and diet period in the percentage of women who met the normal criteria for luteal phase length and progesterone maximum. The impact of dieting was greater on the menstrual cycles of younger women (19-24 y vs. 25-30 y). The authors hypothesized that younger women are more vulnerable to diet-induced cycle disturbances for several years after the normal adult hypothalamic-pituitary axis is established. Pirke et al (Pirke KM et al, 1989) studied 13 healthy, normal weight young women through a control and diet cycle and also found reduced progesterone secretion and impaired LH secretion during the diet cycle.

The history of eating disorders tended to be higher (P = 0.076) in women reporting irregular cycles compared to those with regular cycles. It should be noted that women who

were not having menstrual cycles (amenorrheic) were excluded from this analysis. Anorexia nervosa is characterized by amenorrhea (American Psychiatric Association, 1987) and a high percentage of women with bulimia nervosa suffer from menstrual irregularities (Pirke KM et al, 1987).

The finding that restricting food intake, voluntarily or otherwise, consistently impacts on menstrual cycle function has long been known. Reproductive function may be adjusted according to the supply of energy and specific nutrients, or altered due to the impact of dieting stress on hypothalamic regulatory mechanisms.

4.5.4.3 Eating behaviour, eating attitudes and psychometric subscales

A significant finding in this study was that women reporting irregular menstrual cycles had higher restraint scores than women reporting regular cycles. Scores on all other scales related to eating attitudes and behaviour were similar. This ties in with the finding that a higher percentage of women reporting irregular cycles also reported having tried to lose weight and were more likely to be trying to lose weight at present. In this sample of women, irregular menstrual cycles appear to be related to cognitive attempts at weight control. The stress of trying to lose weight or monitor food intake may lead to alterations in hypothalamic hormones which could impact on menstrual function. As weight, BMI, highest BMI and lowest BMI did not differ between regularly and irregularly cycling women it appears that weight loss attempts have not been successful which may cause greater stress. It should be noted that although women with irregular menstrual cycles had higher restraint scores, and a higher percentage reported trying to lose weight, less than 8% had a BMI over 25 kg/m^2. In fact, 13% of women with irregular cycles had a BMI < 18 which was almost the same percentage as in the group reporting regular cycles (~10%). Women of low body weight may

have a more difficult time trying to lose weight as they already have low energy reserves in terms of body fat and the body is resistant to such changes.

Women with irregular menstrual cycles also had higher scores on Rosenberg's Self-esteem Scale indicating lower self-esteem. As stated earlier it is not known whether low self-esteem predates or predisposes women to dietary restraint but repeated unsuccesful attempts at weight loss may reinforce feelings of low self-esteem.

While low body weight may affect menstrual cycle regularity in some women, the percentages of low weight women did not differ between menstrual cycle groups in this study. As physical characteristics were similar between regularly cycling and irregularly cycling women it may be postulated that other characteristics such as psychosocial or cognitive factors were having an impact on menstrual function. As cognitive dietary restraint has recently been associated with menstrual cycle ovulatory abnormalities (Barr SI et al, 1994a; Barr SI et al, 1994b), and was strongly correlated with cycle irregularity in this study, it is hypothesized that restraint may be having an effect on cycle regularity. Women reporting irregular cycles tended to have higher scores on the Perceived Stress Scale. As reported earlier, higher PSS scores were also observed in women with higher scores for restraint. In summary, these findings suggest a relationship among dietary restraint, stress and menstrual cycle function.

4.5.5 Vegetarian and Nonvegetarian Participants

As stated earlier, 7.8% of women in the total study population reported currently following a vegetarian (lacto-ovo or vegan) diet. Due to differences reported in other studies comparing vegetarians and nonvegetarians with relation to physical, lifestyle (Dwyer JT, 1988; Appleby PN et al, 1998; Hunt IF, 1994; Key TJ et al, 1996) and menstrual cycle characteristics (Pedersen AB et al, 1991) it was considered appropriate to investigate whether

such differences were present in our study. This study did not intentionally recruit or select for vegetarian women which may mean vegetarians in our study are more representative of young, vegetarian women than study volunteers described in other studies.

4.5.5.1 Physical characteristics

This study differed from others (Slattery ML et al, 1991; Appleby PN et al, 1998; Janelle KC & Barr SI, 1995) in that vegetarian women reported current body weights that were significantly higher than nonvegetarian women. They also reported higher maximum BMIs and current BMIs although the latter was not significant (P = 0.078). In contrast, Janelle reported healthy vegetarian women to have significantly lower BMIs compared with nonvegetarian women. In the large CARDIA study, Slattery (Slattery ML et al, 1991) found that nonmeat eaters had significantly lower BMIs than meat eaters as was also found by Appleby et al (Appleby PN et al, 1998) in the Oxford Vegetarian Study. The finding in our study that vegetarians weighed more than nonvegetarians is thus quite unique among studies of Western vegetarians. Women in Janelle's study were from the same geographic area as women in the present study and possible reasons for the differences between her study and ours are that she excluded women who exercised > 7 hr/wk, had a BMI > 25, smoked cigarettes, were irregularly menstruating or were not weight stable. Based on these criteria, only 11 of the 52 vegetarian women in this study would have been potential candidates for Janelle's study. Participants in the latter study also had to have followed their respective diets for 2 years. The profile of the vegetarian is commonly believed to fit many of the study criteria for Janelle's study but that does not appear to be the case in the present study as only 21% fit these criteria. Six vegetarian women in the present study had a BMI > 25 and this combined with the finding of a higher maximum adult BMI among vegetarians suggests that vegetarianism may have been adopted in order to lose or maintain a lower body weight.

Dwyer (Dwyer JT, 1988) reviewed many larger studies comparing vegetarians and nonvegetarians and reported that vegetarians were leaner than nonvegetarians although it is likely the subjects studied had followed their current diet for longer periods of time and possibly for quite different reasons than women in the present study.

4.6.5.2 Lifestyle characteristics

Vegetarian women typically report being more physically active than nonvegetarian women in accordance with what is presumed to be a healthier lifestyle (Slattery ML et al, 1991) although this is not always the case (Pedersen AB et al, 1991; Appleby PN et al, 1998). Janelle reported similar values (3.1 ± 1.8 vs. 4.0 ± 2.3 hr/wk) to our study (3.6 ± 3.8 vs. 5.5 ± 6.1 hr/wk) for exercise in nonvegetarian and vegetarian women although the group difference was not significant in her study. Janelle's study is worth noting because participant inclusion criteria was restricted to subjects who exercised ≤ 7 hr/wk which accounts for the lower standard deviation. She also had a much smaller sample size (n = 45). While exercise is generally assumed to be associated with a healthy lifestyle it is not always the case. In the present study some vegetarian women may have been using exercise in a compulsive or 'bulimic' manner as 13% of vegetarian women reported exercising ≥ 14 hr/wk, compared to less than 5% of nonvegetarian women. In conclusion, some research has shown that classic bulimic behaviours are not increasing (Striegel-Moore RH et al, 1989) but the results of this study suggest that normal weight women with potential eating disorders may simply be switching to other methods which are perceived as 'healthy'.

Caffeinated beverage and alcohol intakes were similar between groups which differs from Pederson's findings that nonvegetarian women consumed significantly more alcohol and caffeine (Pedersen AB et al, 1991). Vegetarian participants in the present study did report using vitamin and/or mineral supplements more than their nonvegetarian peers. This

is a comparable finding to other studies as Freeland et al (Freeland-Graves JH et al, 1986) reported vegetarians and nonvegetarians differed significantly in the percentages reporting current supplement use. Vitamin C was the most popular individual nutrient consumed in Freeland's study, which was also reported by Janelle who found vegetarian women consumed more Vitamin C but not other supplements (Janell KC & Barr SI, 1995).

Contrary to the premise that vegetarianism is part of a cluster of healthy behaviours, more vegetarian women in this study reported smoking cigarettes compared with nonvegetarian women (17% vs. 5.3%, $P < 0.000$). This finding contradicts that of others (Dwyer JT, 1988; Freeland-Graves JH et al, 1986) where vegetarians were more likely to be nonsmokers (Slattery ML et al, 1991). It may be that vegetarian women in this study were using cigarette smoking as another means of weight control as increased cigarette smoking has been cited as a weight loss tool in 16-18 year old teenage girls (French SA et al, 1995). Many other studies of vegetarian women differ from the present as others have frequently studied Seventh-day Adventists or other vegetarian groups which may differ from omnivores in lifestyle characteristics (Dwyer JT, 1988).

4.5.5.3 Weight fluctuation and dieting history

In accordance with the previously stated findings that vegetarians had higher present body weights and previous maximum adult BMIs, they also reported having ever tried to lose weight more often than nonvegetarians (90.4% vs. 41.7%, $P = 0.004$). Furthermore, a significantly higher percentage of vegetarians reported a history of eating disorders (17.8% vs. 3.0%, $P < 0.000$) and weight fluctuation (the number of times > 5 lbs was lost in the past two years). Previous studies have found a relationship between eating disorders and vegetarianism. In a retrospective study of 116 patients with anorexia nervosa 54.3% were found to be avoiding red meat (O'Connor MA et al, 1987). Other studies have reported the

range of prevalence of vegetarianism among women with anorexia nervosa to be between 2.5% and 45% (Kadambari R et al, 1986). While the motives behind choosing a vegetarian diet range from religious to economical, humanitarian and health, the motivation in patients with eating disorders appears to revolve more around reducing energy and fat intake, as well as psychosocial characteristics such as self-denial and control.

In a recently published study comparing a large group of adolescent vegetarian (n = 107) and nonvegetarian (n = 214) women (12-20 y), the vegetarians were almost twice as likely to report frequent dieting ($P < 0.001$), four times as likely to report intentional vomiting ($P < 0.001$) and eight times as likely to report laxative use ($P < 0.001$) (Neumark-Sztainer D et al, 1997). Overall associations with other health promoting and health compromising behaviours were not evident in the latter study. Another recent study of young (mean age = 16 y) vegetarians (Worsley A & Skrzypiec G, 1998) reported vegetarians had more concerns about being slim, tended to restrict their energy intake more, and had a different view of food in general compared with nonvegetarians. The vegetarians in the current study appear to be more comparable to the younger vegetarians discussed in the studies by Neumark-Sztainer et al and Worsley and Skrzypiec than to the frequently used Seventh-day Adventist cohort.

4.5.5.4 Menstrual cycle characteristics

Vegetarian women were more likely to report irregular menstrual cycles than nonvegetarian women although the difference was not significant ($P = 0.096$). Pedersen et al (Pedersen AB et al, 1991) previously reported the incidence of menstrual cycle irregularity to be significantly higher among vegetarians (26.5%) compared with nonvegetarians (4.9%) according to responses to a mailed questionnaire. These authors defined regular menstrual cycles as 11-13 menses/y and irregular menstrual cycles as 3-10 menses/y, whereas, the

present study did not offer a definition for cycle regularity. Pederson's two groups differed in many characteristics known to affect menstrual cycle characteristics. In particular, nonvegetarian women reported longer use of oral contraceptives and how long (or whether) individuals had been off 'the pill' was not stated. Lloyd et al (Lloyd T et al, 1991) also found a higher frequency of menstrual irregularity in premenopausal vegetarian women compared with nonvegetarian women. He classified cycle regularity in the same manner as Pederson, although in this study oral contraceptive users were excluded.

Barr's findings differed from other authors in that subtle disturbances of the menstrual cycle including anovulation and shorter luteal phase lengths were less common in vegetarians compared with nonvegetarians (Barr SI et al, 1994b). Again, the inclusion criteria used by Barr et al would have excluded the majority of vegetarians in the present study and comparison between groups is, therefore, difficult. Self-reported menstrual cycle length was similar between groups in the present study which is in agreement with others (Barr SI et al, 1994a; Lloyd T et al, 1991). It should be noted that the reliability of self-reported cycle length may be questionable as women appear to report the expected norm. In this study almost 50% of women reported cycle lengths of either 28 or 30 days while just over 5% reported 29 day cycles.

4.5.5.5 Eating behaviour, eating attitudes and psychometric subscales

Vegetarian women had higher scores on several scales related to eating attitudes and behaviour which differed from the findings of Barr et al (Barr SI et al, 1994b). The most significant difference between the present study and the latter was in TFEQ restraint scale scores. The mean restraint score for vegetarians in the present study was 11.4 ± 5.6 compared with 6.4 ± 4.4 in Barr's study. In the current group nonvegetarians had a mean restraint score of 8.4 ± 5.2 vs. 9.5 ± 3.7 in the latter. In both studies the group differences

were significant although in the reverse direction. Disinhibition scores differed significantly in this study but not in Barr's, while hunger scores did not differ between groups in either study.

Again, the difference in restraint scores is not surprising as the present study did not have exclusion criteria. Barr excluded women who exercised > 7 hr/wk, smoked, were not weight stable, or had a BMI outside the range of 18 to 25 kg/m^2. In addition, only women reporting a menstrual cycle length between 21 and 35 days were invited to participate in her study. It is apparent that many of the vegetarians from this study would not have been eligible for Barr's study and, therefore, the results cannot really be compared.

It is notable in the present study that vegetarians' scores on the Perceived Stress Scale (PSS) were significantly higher than those of nonvegetarians. Individuals who are trying to follow a vegetarian diet may experience more stress with regard to food related decisions and attribute this stress to other events in their lives. Conversely, feeling higher stress in relation to outside events may lead to attempts to exert control over areas believed to be controllable, such as food intake. Earlier it was found that PSS scores correlated with TFEQ restraint scale scores and, therefore, higher PSS scores may reflect vegetarians' higher restraint scores.

Vegetarian women scored higher on Rosenberg's Self-esteem Scale indicating lower self-esteem. Low self-esteem may exist prior to the adoption of a vegetarian diet and women may be using vegetarian diets as a means of losing weight and, therefore, improving self-image.

Significant differences were not found in scores on most scales of the EDI between vegetarian and nonvegetarian women, contrary to what may have been anticipated. Possibly vegetarian women do not score higher on scales such as the EDI bulimia or drive for thinness

scales as they are using their present diet and exercise for weight control in place of other behaviours. Although vegetarian women in the present study appear to have more weight concerns, they may differ from nonvegetarian women in ways that decrease their vulnerability to the more stigmatized symptomology of bulimia nervosa.

Because vegetarianism is not a concrete construct and lifestyle variables differ considerably among vegetarian women it is impossible to extrapolate the current findings to the general population of young vegetarian women. However, it does appear from the present study that in many cases vegetarianism is associated with *less* healthy lifestyle characteristics and should not be automatically regarded as *more* healthy.

4.6 Study Limitations

The questionnaire had several limitations, some of which are typical of all self-report instruments and others which are specific to this questionnaire. As with other studies, the generalizability of results is limited to the subjects in the sample as they were not randomly selected from the target population. The response rate of 56% may not be adequate to ensure that participants were comparable to nonparticipants with regard to certain characteristics although comparisons with other studies did not detect any obvious differences. Participants may have been influenced by the general research area which was described verbally and in the written introduction to the questionnaire. Women with concerns about food and weight related issues may have been more inclined to participate than those with little concern. Several standardized instruments were used in the questionnaire and the response rate to several items was lower than others due to wording which some participants felt was dated or made implications that were not applicable (such as the presumption in the TFEQ of previous dieting).

Self-reported physical characteristics may not be accurate as research has shown that women tend to report lower body weights and greater heights than measured values although self-reported values are generally correlated with actual measurements (Ziebland S et al, 1996). Other questions involved recall or retrospective data which may not be reliable although these results are still useful for group comparisons. Generalizability of the results of several questions is limited due to the operational definitions used. In retrospect, we realize that a revision of several questions could provide more useful data in future research. For example, a more precise definition of menstrual cycle regularity would be helpful in clarifying the types of disturbances that are present. What may be regular to one woman may be considered irregular to another. Where participants reported having tried to lose weight a checklist of weight loss methods would provide valuable information. Participants were asked at what weight they felt best. Alternatively, "What is your desired weight?" would be more comparable to other questionnaires. This study did not qualify the type of physical activity women participated in, therefore, it did not allow for differentiation between weight bearing and nonweight bearing activities. While much of this information would have been interesting and informative, it is recognized that additional questions would increase the length of the questionnaire and, therefore, decrease the response rate. At the time the questionnaire was created a large response rate was considered more valuable than additional information.

4.7 Future Research

The current study has raised several issues which require further investigation. Of particular interest are the following:

1) An examination of the items in the TFEQ is needed as some may no longer be appropriate due to dated terminology or assumptions which are not applicable.

2) Further research is needed in clarifying weight control behaviours used by women with high scores for restraint as several of these methods have implications for long term health.
3) Research is needed into how various behaviours related to weight control, (including dietary restraint, exercise and vegetarian diets) may interact to disturb menstrual cycle regularity.
4) Prospective studies are needed to determine whether personality traits such as low self-esteem predispose women to dietary restraint.
5) Longitudinal research is needed into whether weight control behaviours change over time.
6) Further research is needed into why young women are choosing vegetarian diets.
7) Further research is needed into the relationship between vegetarianism and other weight control measures in women without clinical eating disorders.
8) Clarification is needed as to whether the vegetarian women in this study are more typical of young vegetarian women today as our results differ from those of others who recruited vegetarians volunteers or used members of select religious groups.

4.8 Conclusions

This study initially set out to characterize a group of female university students in relation to different levels of dietary restraint and to screen for eligible participants for a more in-depth study of eating behaviour, food intake, stress related hormones and variables related to bone health. During this process, several relationships were observed which merit addressing.

Women with high scores for dietary restraint may also use other behavioural strategies for weight control including exercise and following vegetarian diets. Increasing

level of dietary restraint was also associated with higher weight fluctuation and a history of eating disorders. Due to the focus of the media and health departments on unhealthy behaviours related to clinical eating disorders, it is postulated that some women may be using exercise and vegetarianism in place of the more stigmatized symptoms of eating disorders. As women with high scores for restraint were significantly more likely to report irregular menstrual cycles it may be that some of these behaviours act synergistically or additively in affecting menstrual cycle function. The exact relationship among these characteristics remains to be determined.

Women grouped according to low, medium or high dietary restraint differed in several personality traits including self-esteem and perceived stress as well as several measures used on the EDI. Whether characteristics such as low self-esteem or high perceived stress predispose women to dietary restraint remains to be clarified. From these cross-sectional data it appears that there are significant differences in personality characteristics of women with high or low dietary restraint.

In examining the differences between women reporting regular and irregular menstrual cycles it was notable that groups were similar in body weight, BMI, exercise level and weight fluctuation, although women reporting irregular cycles were more likely to have tried to lose weight and be current smokers. Women reporting irregular cycles had higher scores on the TFEQ restraint scale. This was statistically the strongest difference between participants grouped according to menstrual cycle regularity suggesting that cognitive factors potentially play a role in the etiology of menstrual cycle dysfunction.

When vegetarian women were compared with nonvegetarian women several differences were found which are contrary to much of the current literature, and to common beliefs. In particular, vegetarian women in this study were heavier, more likely to smoke,

and had a greater history of eating disorders and weight fluctuation. A greater percentage of vegetarians reported having tried to lose weight and vegetarians were currently exercising more than nonvegetarians. In relation to eating behaviour scales, the most significant difference was in restraint scale scores with vegetarians scoring higher than nonvegetarians. Vegetarian women had self-esteem scores reflective of lower self-esteem.

Vegetarian diets may provide certain health benefits but may also be used by women with greater concerns about body size and shape as part of a group of behaviours to regulate weight. This is of particular concern for women who are already within or below a healthy weight range. The implication of these findings are that health care providers should be aware that women who identify themselves as being vegetarian may not be pursuing a healthy lifestyle, and vegetarianism may be a marker for behaviours associated with health risks. Clarifying questions should be asked in order to determine if nutritional counselling is warranted when young women identify themselves as vegetarian.

Current unrealistic cultural ideals for the female body have led many women to experience discontent with their body weight and shape. Distorted perceptions of body size may lead to a series of behaviours which are likely to fail, thus increasing frustration and potentially precipitating more risky behaviours. The long term consequences of clusters of behaviours related to weight control have not been delineated and require further investigation.

CHAPTER 5:

PART TWO

5.1 Rationale

Part Two of this study was designed primarily to determine whether the 24-hour urinary excretion of cortisol would differ between women with high and low scores for dietary restraint. The rationale for the present study was described earlier and a schematic summary of the background to the current investigation is provided in Figure 2. The solid lines represent relationships which have been observed in other studies, while the dotted lines represent proposed relationships.

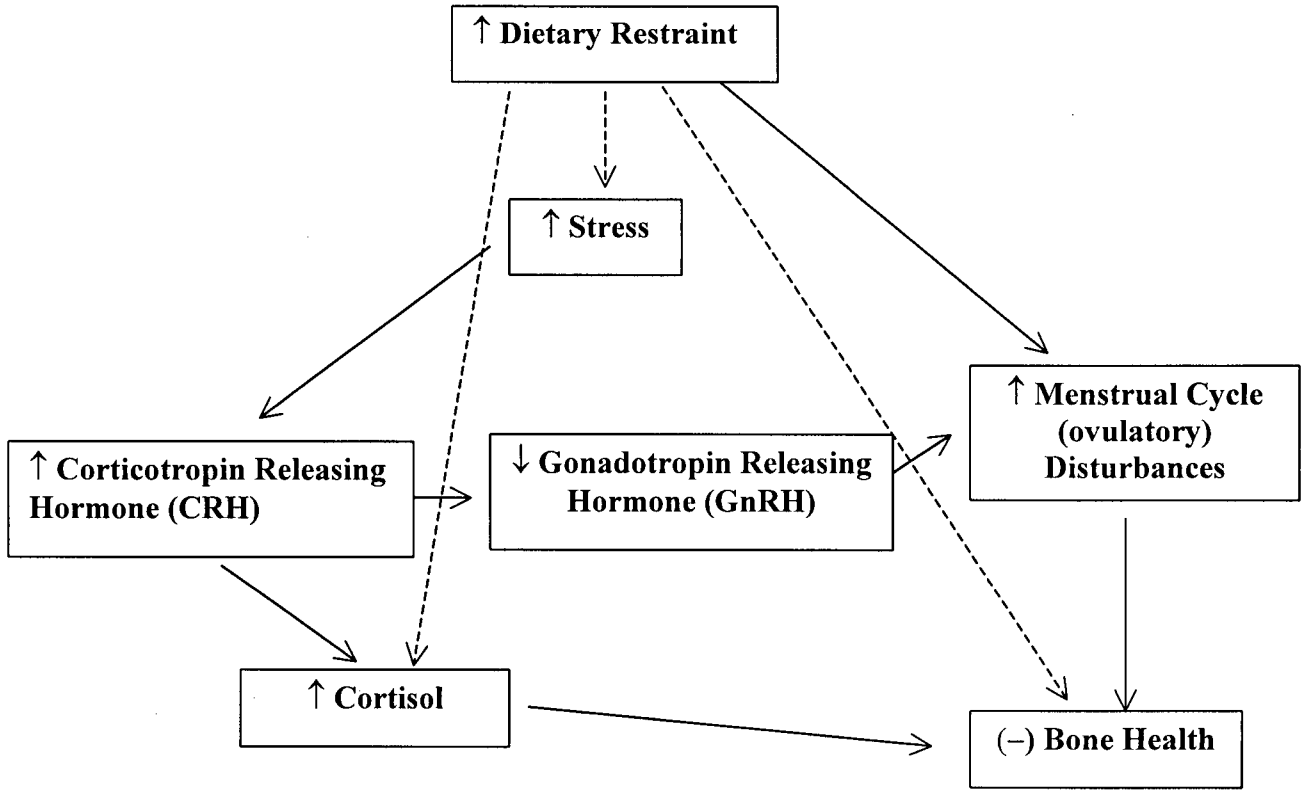

Figure 2. The observed (—) and proposed (----) relationships among dietary restraint, stress, hormones, menstrual cycle disturbances and bone health. Note that proposed mechanisms between dietary restraint and each of cortisol and bone health are not direct, but mediated through observed relationships.

As shown in Figure 2, stress is known to activate the hypothalamic-pituitary-adrenal axis leading to an increase in circulating levels of cortisol. Corticotropin releasing hormone (CRH), an intermediate in the stress activated pathway, inhibits the release of gonadotropin releasing hormone (GnRH) which is essential for normal menstrual cycle function. Menstrual cycle disturbances ranging from short luteal phase or cycle length, anovulation to to amenorrhea may negatively affect bone health. Cortisol also has a negative impact on bone health through both direct and indirect mechanisms. Therefore, if dietary restraint does activate a physiological stress response there may be long term implications for bone. Cortisol does serve as a marker for increased stress and if cortisol excretion is found to be higher in women with high restraint scores it would suggest that this group is experiencing more stress. This study attempts to control for other variables which are known to activate the hypothalamic-pituitary-adrenal-axis.

In addition to the primary purpose of assessing the relationship between dietary restraint and cortisol, the current study assesses the relationship between dietary restraint and bone health. A difference in cortisol excretion between women with high and low scores for dietary restraint would suggest that the pathways shown in Figure 2 have been activated. Women with overt menstrual cycle irregularities were excluded from Part Two and a detectable difference in bone values between women with high and low restraint scores would indicate the possibility of a mechanism, other than clinical alterations in reproductive hormones, was having an impact. Cortisol would be a likely intermediate. This study was not designed to rule out subclinical ovulatory disturbances which could also affect measures of bone health.

5.2 Objectives and Hypotheses

5.2.1 Objectives

1. To compare the 24-hour urinary excretion of cortisol between women with low scores for dietary restraint and women with high scores for dietary restraint.
2. To compare energy and nutrient intakes from 3-day food records and a 24-hour documented intake period of women with low and high scores for dietary restraint.
3. To compare bone mineral density (BMD), bone mineral content (BMC) and body composition of women with low and high scores for dietary restraint.
4. To compare scores on selected scales measuring eating attitudes and personality characteristics of women with low and high scores for dietary restraint.
5. To compare exercise level and lifestyle variables of women with low and high scores for dietary restraint.

5.2.2 Hypotheses

1. Neither the 24-hour urinary excretion of cortisol nor the urinary cortisol/creatinine ratio will differ between women with low scores for dietary restraint and women with high scores for dietary restraint.
2. Neither the 24-hour urinary excretion of calcium nor the calcium/creatinine ratio will differ between women with low and high scores for dietary restraint.
3. There will be no differences in the energy, macronutrient, calcium or fibre intakes of women with low and high scores for dietary restraint when assessed by 3-day dietary intake records or during a 24-hour documented intake period.

4. There will be no differences in the total body or spinal bone mineral density (BMD), bone mineral content (BMC) or body composition of women with low or high scores for dietary restraint when assessed by dual energy x-ray absorptiometry (DEXA).
5. Bone characteristics will not differ according to exercise level or other lifestyle variables.
6. The demographic characteristics of women with low and high scores for dietary restraint will not differ.

5.3 Methods

5.3.1 Subject Recruitment

Women who completed the 'Interested in More' section of the questionnaire used in Part One, and fit the inclusion criteria for Part Two of the study were contacted and invited to participate further (Appendix 10). Eligible participants were 20 to 35 years of age, nulliparous, experiencing menstrual cycles of normal length (21-35 d), and exercising ≤ 7 hr/wk. They had a Body Mass Index (BMI) between 18 and 25 kg/m^2, were weight stable (defined as not having lost > 5 lbs more than twice in the past two years), and not presently dieting. Exclusion criteria included cigarette smoking, oral contraceptive or bone active medication use, alcoholic beverage consumption > 2 drinks/d, physically obvious clinical hirsutism (excess facial hair), and a history of having been diagnosed with or treated for an eating disorder. From telephone conversations it was determined that none of the interested participants worked night shifts or had other unusual sleep patterns which may have affected stress related hormones. Lastly, women were excluded who had TFEQ restraint scale scores between 6 and 12 (i.e. who were not classified as having low or high scores for restraint). Further explanation of the study protocol was done over the phone and appointments were

made with all interested women who still fit the study criteria after clarification. Interviews with prospective subjects were scheduled for a minimum of one hour. At this time the study protocol was thoroughly explained.

Women who expressed interest but did not meet the study criteria were contacted in writing. They were provided with a general explanation as to why they were ineligible for the study and thanked for their interest (Appendix 11). In some cases women met the inclusion criteria but had not responded to all the items on the questionnaire and were sent a letter requesting additional information (Appendix 12). The study protocol was approved by the University's Clinical Screening Committee for Research and Other Studies Involving Human Subjects (Appendix 4).

5.3.2 Study Design - Overview

Subjects were grouped according to their scores on the restraint scale of the TFEQ as described in Part One. Participants with restraint scores between 0 and 5 were categorized as 'women with low restraint scores' and those with restraint scores between 13 and 21 as 'women with high restraint scores'. During the initial interview (Appendix 13), participants were given an additional copy of the questionnaire to complete in order to establish the reliability of earlier results. Women who agreed to participate in Part Two of the study signed consent forms at this time (Appendix 14). During the meeting, waist, hip, height and weight measurements were taken and recorded on a data collection sheet (Appendix 15). Participants received a complete instruction package with a covering letter (Appendix 16) describing the key requirements of the study.

The study design was cross-sectional with participants required to complete the following:

1) A 3-day food record kept during the first eight days of their next menstrual cycle.

2) A 24-hour urine collection in the first eight days of the following menstrual cycle.

3) Consume only food and beverages supplied by the investigator during the 24-hour urine collection period.

4) An abbreviated version of the daily Menstrual Cycle Diary© for the duration of participation in the study (optional).

5) Body composition, bone mineral density and bone mass assessment by DEXA.

The 24-hour period during which all urine was collected and food supplied was referred to as the participant's 'study day'.

5.3.3 Anthropometry

Measurements took place during the subject interview session in the Family and Nutritional Sciences Building after consent forms had been signed. The meeting was scheduled during the mid-follicular phase to reduce the possibility of pre-menstrual fluid retention. All measurements were recorded on a data collection sheet (Appendix 15). The rationale for the anthropometric methods is described in Appendix 17.

5.3.3.1 Weight

A medical balance scale accurate to the nearest 0.1 kg was used for the measurement of weight. Scales were checked for zero-balance prior to each measurement. Participants were weighed wearing only underclothing and a paper examination gown. The time at which the measurements were made was noted and weight was recorded to the nearest 0.1 kg (Gibson RS, 1990). Each participant was weighed in duplicate and the two weights averaged. If there was a major difference between the two weights a third weight measurement was taken to verify which of the two was more accurate.

5.3.3.2 Height

A stadiometer was used to measure height. Participants continued to wear minimal clothing without shoes or socks. They were instructed to stand straight with feet together, knees straight, and heels, buttocks, and shoulder blades in contact with the vertical surface of the stadiometer. Participants were asked to take a deep breath and stand tall to aid the straightening of the spine. Shoulders were relaxed. The moving headboard was then gently lowered until it just touched the crown of the head. The height measurement was taken at maximum inspiration, with the examiner's eyes level with the headboard. Height was measured twice and the average of the two readings recorded to the nearest millimetre (Gibson RS, 1990). If there was a major difference between the two measurements, a third was taken for verification.

5.3.3.3 Waist and hip measurements

Again, these measurements were taken in duplicate with participants wearing minimal clothing, standing erect with abdomen relaxed, arms at the sides, feet together and weight equally balanced on both legs. An elastic tape was first tied horizontally midway between the lowest rib margin and the iliac crest. This defined the level of the waist circumference, which can then be measured by positioning a fibreglass tape measure over the elastic tape. The reading was taken to the nearest millimetre. The hip circumference measurement were taken at the point yielding the maximum circumference over the buttocks, with the tape held in a horizontal plane, touching the skin but not indenting the soft tissue (Gibson RS, 1990).

5.3.3.4 Calculations from anthropometry

a.) Body Mass Index – (BMI) was calculated from the weight and height measurements according to the following formula: $BMI = (wt\ \{kg\})/(ht\ \{m\})^2$

b.) Waist/hip ratio – calculated as waist measurement divided by hip measurement:

Waist/hip ratio = (waist {cm})/(hip {cm})

5.3.4 Assessment of Dietary Intake

5.3.4.1 Dietary intake from 3-day food records

For group comparisons of self-reported food intake women were asked to record all food and beverage intake for 3 consecutive days. The rationale for the use of 3-day food records is provided in Appendix 18. Because food intake studies have shown that women consume significantly more energy during the luteal phase compared to the follicular phase of ovulatory menstrual cycles (Barr SI et al, 1995), completion of dietary intake records was scheduled during the mid-follicular phase (days 5-8). Participants identified the approximate time period when this would be most convenient for them and were instructed to phone the principal investigator on the first day of their menstrual cycle in this period. A 3-day early-mid-follicular cycle time was then agreed upon which included 2 consecutive and one weekend day to account for the normal variability that occurs during these days. Participants were encouraged to maintain normal eating patterns during this time and the importance of doing this was emphasized. Dietary intake instruction sheets and record forms were provided (Appendix 19 and Appendix 20).

For the 3-day period, participants recorded all food and beverage intakes at the time of consumption. Thorough descriptions of foods and beverages including brand names were recorded on the intake forms. Participants were provided with measuring cups and spoons to aid in quantifying amounts whenever possible. Counts were used for foods such as eggs and bread and rulers for items such as meat and cake (Gibson RS, 1990). Food intake records were analysed using the computer program Food Processor II (Version 7.0, 1997, ESHA Research, Salem OR).

5.3.4.2 Dietary intake from 24-hour food records

Participants were provided with all food and beverages for the 24-hour period encompassing their 'study day'. A general description of the meal plan is provided in Appendix 21. The study day was scheduled during the early follicular phase of the participant's menstrual cycle in the month after the 3-day food record was kept. Again, by establishing the early follicular phase of the menstrual cycle for the study day any potential confounding of energy or macronutrient intake by menstrual cycle phase could be eliminated.

Participants met the investigator at a prearranged time on the morning of their study day in the feeding lab of the Family and Nutritional Sciences Building. At this time they were provided with breakfast choices and a menu with a variety of selections for lunch, dinner and snacks (Appendix 22). Selections for later meals were prepared and ready for participants at scheduled meal times. Between meal snacks were taken from the study centre and quantities were not limited. Any uneaten portions were returned and quantities subtracted from the amount recorded.

During the day, all portions of food and beverages consumed by participants were weighed or measured and recorded by the investigator (Appendix 23). Breakfast, lunch and dinner were consumed at the study centre if at all possible. If not possible, participants took out their meals in containers and returned any uneaten portions.

5.3.5 Urine Collection and Analysis

Participants collected all urine for the 24-hour period designated as their 'study day'. They were provided with large collection bottles, wide-mouth spouted cups, and funnels to facilitate gathering samples. All women were given verbal and written instructions regarding the urine collection (Appendix 24). Rationale for the 24-hour urine collection is presented in Appendix 25. Urine collection was scheduled to begin upon arising and after the first

bladder emptying on the morning of the study day. All urine was then collected for the following 24 hours and complete samples were dropped off at the study centre in the Family and Nutritional Sciences building at U.B.C. Specimens were delivered to the laboratory at Vancouver Hospital for analysis of cortisol, creatinine, and calcium. An aliquot was removed and stored for possible future analysis of catecholamines.

Twenty-four hour urinary cortisol was quantitatively determined using the Chiron Diagnostics ACS:180® Automated Chemiluminescence Systems (Synchron Clinical Systems, 1996). The Chiron diagnostics ACS:180 cortisol assay is a competitive immunoassay using direct luminescent technology. The cortisol in the sample competes with acridinium ester-labelled cortisol for binding to polyclonal rabbit anti-cortisol antibody. An inverse relationship exists between the amount of cortisol present in the patient sample and the amount of relative light units detected by the system. The reference interval (80.0-600.0 nmol/d) for this method is higher than that used by other methods and for comparison purposes adjustments may need to be made. For relating the results from 216 urine samples using the ACS:180 method and an alternate fluorescent polarization immunoassay method the following equation was used:

ACS180 Cortisol = 1.03 (alternate method) + 18.82 μg/24 hours

Twenty-four hour urinary creatinine was measured using the Synchron CX3 module which measures the change in absorbance of an alkaline picrate solution at 41°C following sample addition (Synchron Clinical Systems, 1996). Creatinine combines with the alkaline-picrate to form a coloured complex. The rate of coloured creatinine-alkaline picrate formation has been shown to be a direct measure of the concentration of the creatinine in the sample.

Twenty-four hour urinary calcium concentration was determined by atomic absorption spectrophotometry in an air acetylene flame using the calcium spectral line of 422.7 nm. In atomic absorption spectophotometry the element (e.g. Ca) is not appreciably excited in the flame, but is merely disassociated from its chemical bonds and placed in an unexcited or ground state (Burtis CA & Ashwood ER, 1999). The atom is at a low energy level and can absorb radiation at a very narrow bandwidth corresponding to its own line spectrum (422.7 nm). The amount of radiation absorbed reflects the amount of calcium in the sample. The instrument used in this analysis was the Perkin Elmer Atomic Absorption Spectrophotometer AA 3300.

5.3.6 Dual Energy X-Ray Absorptiometry (DEXA)

Women had their bone mineral density (BMD), bone mineral content (BMC) and body composition measured using dual energy x-ray absorptiometry (DEXA). Rationale is provided in Appendix 26. Both total body BMD and spinal BMD (L1-L4) were assessed. Appointments for analysis were made during the follicular phase of the menstrual cycle following the completion of the 24-hour study day to assure compliance with the study protocol. Assessment by DEXA (Lunar DPX, software version 4.6B) took place at the Department of Nuclear Medicine at Vancouver Hospital where the densitometer was calibrated according to the manufacturer's recommendations and quality control procedures.

5.3.7 Menstrual Cycle Characteristics

Participants were asked to keep an abbreviated version of a the Daily Menstrual Cycle Diary© (Prior JC, 1996) for the period of time in which they participated in the study (Appendix 27). They were to begin entries into the diary on the first day of their menstrual

period in the cycle in which they were scheduled to keep a 3-day food record. Completion of the diaries was voluntary.

5.3.8 Statistical Analysis

Sample size for the study was calculated in the following way (Brown, 1970):

$$\text{Sample size (n)} = 2 \left(\frac{(\alpha \text{ error} \pm \beta \text{ error}) \times SD}{\text{Difference}} \right)^2$$

where n is the population size per group, α error = 1.96 so that all tests were done at a significance level of $P < 0.05$, and β error = 0.84 (power of 0.80). The difference term is that which is deemed to be biologically meaningful and desirable to detect, in this case 7 ug (19.3 nmol/d) /24-hours, based on a study by Yehuda et al (Yehuda R et al, 1993) in which the mean cortisol excretion was 63.25 ± 10 μg/day.

$$\text{Sample size (n)} = 2 \left(\frac{(1.96 \pm 0.84) \times 10}{7} \right)^2$$

Therefore, a sample size of 32 subjects per group would permit the detection of a difference ($P < 0.05$) in 24-hour cortisol excretion of 7 μg (19.3 nmol). The primary independent variable in Part Two of this study was the level of dietary restraint as assessed by the restraint scale of the TFEQ. Participants were divided into groups based on their restraint scale scores, as previously described, and selection was limited to women with low or high scores.

Group comparisons for all variables were made between women with low scores for restraint and those with high scores for restraint. Mean characteristics of the two groups were made using unpaired t tests. The following variables were of primary interest:

1. The 24-hour urinary excretion of cortisol and the cortisol/creatinine ratio.

2. The 24-hour urinary excretion of calcium and the calcium/creatinine ratio.
3. Whole body bone mineral density (BMD), bone mineral content (BMC) and body composition by DEXA.
4. Energy, macronutrient and fibre intakes as assessed by 3-day dietary intake records.
5. Energy, macronutrient and fibre intakes during the 24-hour study day.
6. Personality characteristics including self-esteem, perceived stress, and perfectionism.
7. Descriptive characteristics including exercise level and menstrual cycle length.

Participants were also grouped into three levels based on their reported hours of weekly exercise. Women who exercised < 2 hr/wk were grouped in the lower level, 2-< 3.5 hr/wk, the middle level and 3.5-7 hr/wk the upper level. Analysis of group differences for all characteristics was made using ANOVA and Duncan's multiple range test when applicable.

Associations between continuous variables were evaluated using Pearson correlation analysis. Multiple comparisons were made increasing the possibility of Type I errors and associations were, therefore, interpreted conservatively using a level of significance of $P < 0.01$. Comparisons involving group proportions were made using chi-square.

The statistical analysis was achieved through computer programs available in the Statistical Package for the Social Sciences, Personal Computer version 7.5 (SPSS Inc., 1996, Chicago). The level of significance was set at $P < 0.05$ for most analyses and all comparisons were two-tailed.

5.4 Results

5.4.1 Introduction

Of the 666 women who completed the screening questionnaire, 281 (42%) expressed an interest in participating in Part Two of the study. An overview of the recruitment process

is presented in Figure 3. Study criteria led to the exclusion of 198 women with the primary reason (n = 122) being scores on the TFEQ restraint scale in the mid range (6-12). Of the interested women, 83 met the inclusion criteria and 74 were available and subsequently interviewed. Seven women were determined to be ineligible during the interview or did not agree to participate further. Sixty-seven women interviewed were invited to participate in Part Two and signed consent forms. Sixty-two women continued to meet the inclusion criteria throughout the study period. Five women were excluded subsequent to study enrollment. Detailed reasons for exclusion are presented in Appendix 28.

5.4.2 Participants Grouped According to Restraint Group

Of the 62 women who completed the study, 29 were grouped as 'low restraint' and 33 as 'high restraint' according to their scores on the TFEQ restraint scale.

5.4.2.1 Demographic characteristics

Participants were grouped according to ethnicity and whether nutrition was their major field of study or not. These data are presented in Tables 24 and 25. Ethnicity had been recorded on forms used at the Department of Nuclear Medicine at Vancouver Hospital prior to DEXA analysis. The ethnicity of participants was similar in the two groups of women. The majority of participants were nonwhite (67.8%).

A total of 10 students identified themselves as majoring in either nutrition or dietetics. Eighty percent of nutrition students had high scores for restraint compared with just under 50% of nonnutrition students but group percentages did not differ significantly by field of study (P = 0.064).

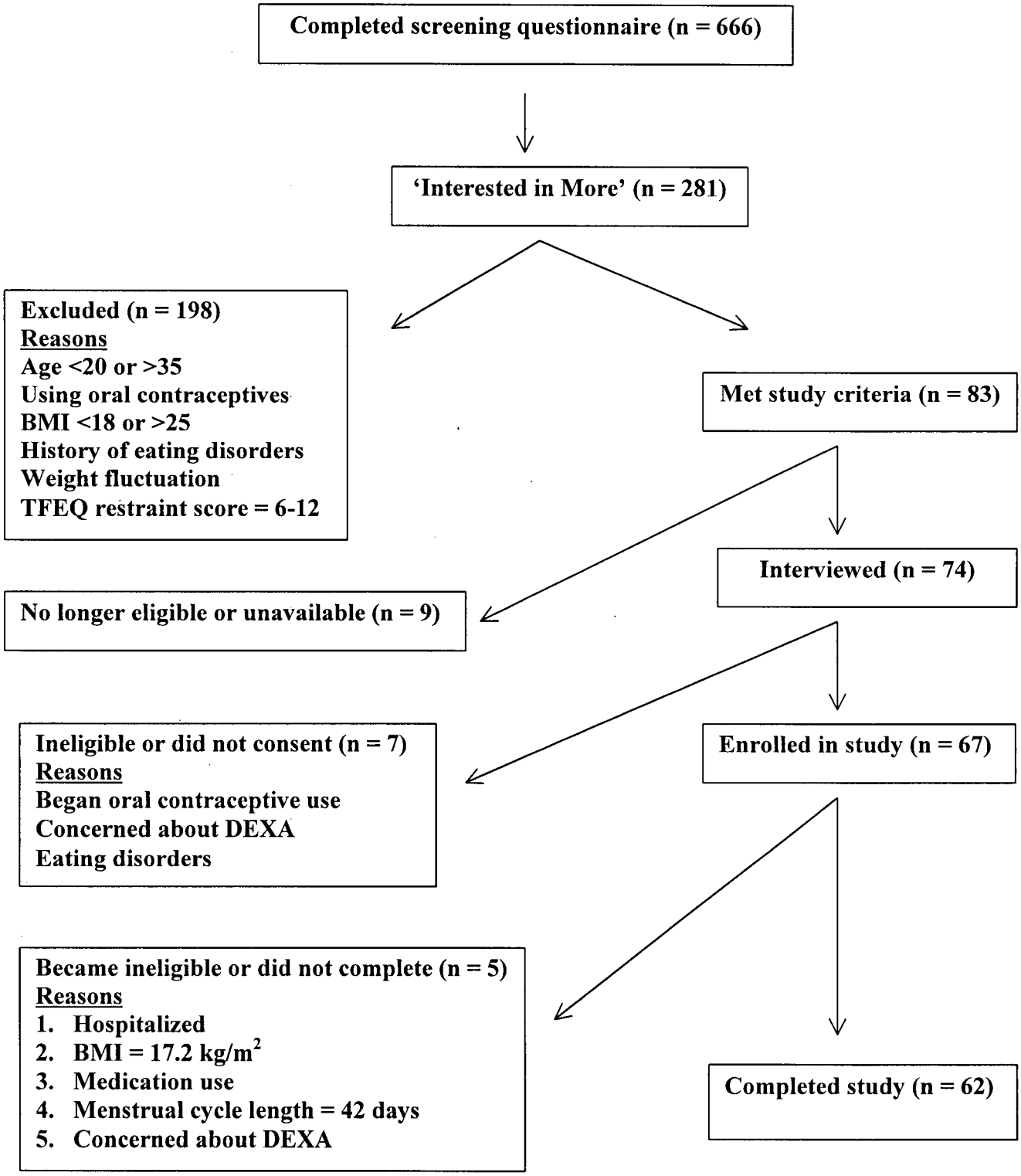

Figure 3. Overview of study recruitment.

Table 24. Ethnicity of participants grouped according to restraint scores

Ethnicity	n	Low restraint[a] (n = 29)	n	High restraint[b] (n = 33)
White	11	37.9%	9	27.3%
Chinese	12	41.4%	16	48.5%
South Asian	4	13.8%	6	18.2%
Hispanic	2	6.9%	2	6.1%

[a] Score 0-5 on the Three-Factor Eating Questionnaire (TFEQ) restraint scale (Stunkard AJ & Messick S, 1985).
[b] Score 13-21 on TFEQ restraint scale.
There were no significant differences (chi-square).

Table 25. Field of study of participants grouped according to restraint scores

Study area	n	Low restraint[a] (n = 29)	n	High restraint[b] (n = 33)
Nutrition or dietetics	2	6.9%	8	24.2%
Nonnutrition	27	93.1%	25	75.8%

[a] Score 0-5 on the Three-Factor Eating Questionnaire (TFEQ) restraint scale (Stunkard AJ & Messick S, 1985).
[b] Score 13-21 on TFEQ restraint scale.
There were no significant differences (chi-square).

5.4.2.2 Physical characteristics

Physical characteristics of women with low scores for dietary restraint are compared to those of women with high scores for restraint in Table 26. All participants were physically similar although BMI (kg/m^2), highest BMI and lowest BMI tended to be higher in the high restraint group. Menstrual cycle length did not differ between groups from self-report data or daily Menstrual Cycle Diary© data. The correlation coefficient between self-reported cycle length and actual cycle length was 0.293 (P = 0.021).

5.4.2.3 Lifestyle characteristics

Lifestyle characteristics of women with low scores for dietary restraint are compared to those of women with high scores for restraint in Table 27. Only exercise level differed

Table 26. Physical characteristics (mean ± SD) of participants grouped according to restraint scores

Characteristic	Low restraint[a] (n = 29)	High restraint[b] (n = 33)	P value
Age (y)	22.2 ± 3.1	21.2 ± 1.7	0.104
Height (cm)	163.7 ± 8.1	162.7 ± 6.9	0.573
Weight (kg)	55.3 ± 8.3	56.4 ± 5.8	0.548
BMI (kg/m^2)	20.5 ± 2.0	21.3 ± 1.6	0.095
Highest BMI (kg/m^2)[c]	21.9 ± 2.2	22.7 ± 1.8	0.096
Lowest BMI (kg/m^2)[d]	19.3 ± 1.7	20.1 ± 1.6	0.052
Best BMI (kg/m^2)[e]	20.1 ± 1.4	20.0 ± 1.1	0.712
Waist (cm)	66.1 ± 4.7	67.1 ± 4.0	0.355
Hip (cm)	89.2 ± 6.3	89.4 ± 5.5	0.888
Waist/hip (cm/cm)	0.74 ± 0.03	0.75 ± 0.05	0.336
Menstrual cycle length (d)[f]	28.3 ± 3.4	28.8 ± 3.0	0.560
Menstrual cycle length (d)[g]	29.7 ± 4.0	29.2 ± 2.8	0.546

[a] Score 0-5 on the Three-Factor Eating Questionnaire (TFEQ) restraint scale (Stunkard AJ & Messick S, 1985).
[b] Score 13-21 on TFEQ restraint scale.
[c] Calculated from weight given as 'highest adult weight'.
[d] Calculated from weight given as 'lowest adult weight'.
[e] Calculated from weight given as 'best adult weight'.
[f] Self-reported menstrual cycle length.
[g] Documented menstrual cycle length.

Table 27. Lifestyle characteristics of participants grouped according to restraint scores

Characteristic	Low restraint[a] (n = 29)	High restraint[b] (n = 33)	P value
Coffee or tea (cups/d)[c]	1.0 ± 1.0	1.1 ± 1.0	0.719
Alcohol (drinks/wk)[c]	1.2 ± 1.6	0.8 ± 1.4	0.354
Exercise (hr/wk)[c]	2.2 ± 1.8	3.4 ± 1.7	0.010[d]
Vegetarian	10.3%	12.1%	0.825
Using vitamin/mineral supplements	48.3%	36.4%	0.343

[a] Score 0-5 on the Three-Factor Eating Questionnaire (TFEQ) restraint scale (Stunkard AJ & Messick S, 1985).
[b] Score 13-21 on TFEQ restraint scale.
[c] Mean ± SD.
[d] Mean values differ significantly between groups (t-test).

significantly between the two groups as women with high scores for restraint reported exercising more hours per week than women with low scores for restraint.

5.4.2.4 Weight fluctuation and dieting history

Table 28 presents the weight fluctuation and dieting history of women with high restraint scores and women with low restraint scores. All women with high restraint scores responded "yes" to whether they had ever tried to lose weight, while < 50% of women with low restraint scores responded similarly. Over 80% of women with high restraint scores were presently trying to lose weight, compared to only 1 women with a low restraint score.

Although exclusion criteria eliminated women who reported losing > 5 lbs more than twice in the past two years, women with high scores for restraint still reported a weight loss of > 5 lbs more times. Five women (15%) with high restraint scores reported no weight fluctuation during the past two years while 12 (41.4%) women with low scores reported no weight change.

Table 28. Weight fluctuation and dieting history of participants grouped according to restraint scores

Characteristic	Low restraint[a] (n = 29)	High restraint[b] (n = 33)	P value
Presently trying to lose weight	3.4%	81.8%	0.000[c]
Ever tried to lose weight	44.8%	100%	0.000[c]
Weight fluctuation[d,e]	0.9 ± 0.9	1.4 ± 0.8	0.011[f]

[a] Score 0-5 on the Three-Factor Eating Questionnaire (TFEQ) restraint scale (Stunkard AJ & Messick S, 1985).
[b] Score 13-21 on TFEQ restraint scale.
[c] Percentages differ significantly between groups (chi-square).
[d] Mean ± SD.
[e] Number of times > 5 lbs lost during the past two years.
[f] Mean values differ significantly between groups (t-test).

5.4.2.5 Eating behaviour, eating attitudes and psychometric subscales

Scores on the Three-Factor Eating Questionnaire (TFEQ) subscales, the Perceived Stress Scale, Rosenberg's Self-esteem Scale and the eight Eating Disorder Inventory (EDI) subscales for women with low and high scores for restraint are presented in Table 29. Women with high scores for restraint had significantly higher scores on all scales except the TFEQ hunger scale and the EDI perfectionism scale. Women were also grouped according

Table 29. TFEQ[a] subscale, Perceived Stress Scale[b], Rosenberg's Self-esteem Scale[c] and EDI[d] subscale scores (mean ± SD) of participants grouped according to restraint scores

Characteristic	Low restraint[e] (n = 29)	High restraint[f] (n = 33)	P value
TFEQ restraint	2.7 ± 1.8	15.0 ± 2.2	0.000[g]
TFEQ disinhibition	3.5 ± 2.5	7.6 ± 4.1	0.000[g]
TFEQ hunger	5.2 ± 2.2	6.4 ± 3.7	0.117
Perceived stress	25.0 ± 6.5	28.6 ± 7.5	0.050[g]
Self-esteem	0.8 ± 1.9	1.9 ± 1.7	0.002[g]
EDI drive for thinness	0.4 ± 1.2	7.3 ± 6.0	0.000[g]
EDI bulimia	0.2 ± 0.6	1.3 ± 2.4	0.020[g]
EDI body dissatisfaction	2.9 ± 4.3	14.2 ± 8.4	0.000[g]
EDI ineffectiveness	0.6 ± 2.1	4.1 ± 5.0	0.001[g]
EDI perfectionism	5.8 ± 4.8	6.2 ± 5.4	0.764
EDI interpersonal distrust	0.7 ± 1.7	3.3 ± 3.2	0.000[g]
EDI interoceptive awareness	0.7 ± 1.4	3.1 ± 4.1	0.004[g]
EDI maturity fears	2.5 ± 2.5	4.5 ± 4.5	0.034[g]

[a] TFEQ = Three-Factor Eating Questionnaire (Stunkard AJ & Messick S, 1985).
[b] Perceived Stress Scale (Cohen S et al, 1983).
[c] Rosenberg's Self-esteem Scale (Rosenberg M, 1965). Lower scores reflect higher self-esteem.
[d] EDI = Eating Disorder Inventory (Garner DM & Olmstead MP, 1984).
[e] Score 0-5 on the Three-Factor Eating Questionnaire (TFEQ) restraint scale (Stunkard AJ & Messick S, 1985).
[f] Score 13-21 on TFEQ restraint scale.
[g] Mean values differ significantly between groups (t-test).

to whether they had low, medium or high self-esteem. The proportion of women with low, medium or high self-esteem differed according to restraint group. Just over 30% of women in the high restraint group were grouped as having low self-esteem while under 10% of women in the low restraint group were grouped as having low self-esteem ($P < 0.05$).

Test-retest reliability of the TFEQ was assessed using the two copies of the questionnaire completed by participants. The coefficients for the restraint scale, disinhibition scale and hunger scale were 0.94, 0.84 and 0.71 respectively, all of which were significant. The time interval between completion of the two copies of the questionnaire was highly variable between individuals, and ranged from two weeks to six months.

5.4.2.6 Energy and nutrient intakes from 3-day food records

The mean energy and selected nutrient intakes from 3-day food records for women with low and high scores for restraint are presented in Table 30. Energy intake expressed in absolute terms or in relation to body weight was lower in women with high restraint scores compared to women with low restraint scores. Carbohydrate and protein intakes were similar between groups both in absolute terms and as a percentage of energy. Fat intake was lower in absolute terms but not as a percentage of energy for women with high scores compared to women with low scores for restraint, although the latter approached significance. Fibre, calcium and sodium intakes were similar between the two groups as was the calcium/protein ratio.

5.4.2.7 Energy and nutrient intakes from 24-hour food records

The energy and selected nutrient intakes of women with low and high scores for restraint from documented 24-hour study day records are shown in Table 31. Both energy intake in absolute terms and in relation to body weight were lower for women with high

Table 30. Daily energy and nutrient intakes (mean ± SD) from 3-day food records of participants grouped according to restraint scores

Characteristic	Low restraint[a] (n = 29)	High restraint[b] (n = 33)	P value
Energy (kcal)	2235 ± 546	1919 ± 355	0.011[c]
Energy (kcal/kg body wt)	40.8 ± 9.5	34.4 ± 7.3	0.005[c]
Carbohydrate (g)	312.1 ± 91.5	281.1 ± 71.4	0.147
Carbohydrate (%)	55.5 ± 5.8	57.8 ± 11.4	0.336
Protein (g)	92.3 ± 59.7	80.8 ± 31.2	0.337
Protein (%)	15.0 ± 3.4	16.3 ± 4.5	0.207
Fat (g)	74.4 ± 22.6	56.3 ± 23.1	0.003[c]
Fat (%)	29.2 ± 4.3	25.9 ± 8.7	0.064
Cholesterol (mg)	221.6 ± 111.0	194.1 ± 114.2	0.342
Fibre (g)	19.6 ± 7.8	19.1 ± 8.3	0.838
Calcium (mg)	840.3 ± 440.7	780.1 ± 293.2	0.536
Calcium/protein (mg/g)	10.2 ± 5.2	10.6 ± 4.2	0.751
Sodium (mg)	3136.2 ± 1247.2	2827.4 ± 1016.2	0.287

[a] Score 0-5 on the Three-Factor Eating Questionnaire (TFEQ) restraint scale (Stunkard AJ & Messick S, 1985).
[b] Score 13-21 on TFEQ restraint scale.
[c] Mean values differ significantly between groups (t-test).

restraint scores compared to women with low restraint scores. Carbohydrate intake was similar between groups. Women with high restraint scores had higher intakes of protein as a percentage of energy but not in absolute terms when compared with women with low restraint scores. Fat intake was lower in absolute terms and as a percentage of energy in the high restraint group. Women in the high restraint group also had lower mean cholesterol intakes. Fibre, calcium, and sodium intakes were similar between groups as was the calcium/protein ratio.

Table 31. Energy and nutrient intakes from 24-hour food records (mean ± SD) of participants grouped according to restraint scores

Characteristic	Low restraint[a] (n = 29)	High restraint[b] (n = 33)	P value
Energy (kcal)	2423 ± 475	2095 ± 569	0.018[c]
Energy (kcal/kg body wt)	44.1 ± 8.1	37.6 ± 11.2	0.012[c]
Carbohydrate (g)	393.9 ± 92.1	351.0 ± 98.2	0.082
Carbohydrate (%)	62.5 ± 5.0	64.9 ± 6.8	0.119
Protein (g)	74.6 ± 16.9	74.0 ± 18.9	0.885
Protein (%)	11.9 ± 1.9	13.9 ± 1.8	0.000[c]
Fat (g)	71.7 ± 17.8	50.5 ± 22.2	0.000[c]
Fat (%)	25.5 ± 4.0	21.2 ± 6.4	0.003[c]
Cholesterol (mg)	76.2 ± 39.9	46.2 ± 31.8	0.002[c]
Fibre (g)	26.1 ± 7.6	26.7 ± 9.4	0.783
Calcium (mg)	637.8 ± 328.4	578.3 ± 323.0	0.475
Calcium/protein (mg/g)	8.3 ± 3.1	7.8 ± 4.6	0.646
Sodium (mg)	2358.2 ± 574.8	2190.2 ± 640.1	0.284

[a] Score 0-5 on the Three-Factor Eating Questionnaire (TFEQ) restraint scale (Stunkard AJ & Messick S, 1985).
[b] Score 13-21 on TFEQ restraint scale.
[c] Mean values differ significantly between groups (t-test).

5.4.2.8 Correlation analysis of energy and nutrient intakes

Correlation coefficients between absolute energy and nutrient intakes from 24-hour study day documented intake records and 3-day food records are presented in Table 32. Energy, carbohydrate and fibre intakes were significantly correlated between the two records but protein, fat, cholesterol and calcium intakes were not. Calcium intake from 3-day food records was correlated with carbohydrate and fibre intake from 24-hour study day records.

Table 32. Correlation coefficients[a] between energy and nutrient intakes from 24-hour documented intake records and 3-day food records

	3-day energy (kcal)	3-day protein (g)	3-day carbohydrate (g)	3-day fat (g)	3-day cholesterol (mg)	3-day fibre (g)	3-day calcium (mg)
24-hour energy (kcal)	0.351[b]	0.094	0.312	0.197	0.029	0.120	0.312
24-hour protein (g)	0.122	0.070	0.048	0.048	0.074	-0.024	0.146
24-hour carbohydrate (g)	0.396[b]	0.089	0.447[b]	0.156	-0.050	0.306	0.408[b]
24-hour fat (g)	0.212	0.160	0.015	0.272	0.192	-0.204	0.075
24-hour cholesterol (mg)	0.216	0.039	0.074	0.258	0.115	-0.168	-0.020
24-hour fibre (g)	0.224	-0.008	0.292	0.029	-0.093	0.381[b]	0.426[b]
24-hour calcium (mg)	0.142	0.040	0.244	-0.026	-0.068	0.290	0.290

[a] Pearson correlation coefficients are shown; all significance levels were 2-tailed.
[b] $P < 0.01$.

5.4.2.9 Food choices

Food choices of selected items chosen by women with low or high scores for restraint during the 24-hour study day are presented in Table 33. Women with high restraint scores chose 'lite', lower fat, or lower energy food items more often than women with low restraint scores. Significant group differences were found in selections of milk, cream cheese, mayonnaise and pop. Group differences were also found in selections of red (ham or beef) or white (turkey) sandwich meat. Finally, no differences were found in selections of cereal or bread.

5.4.2.10 Urine analysis from 24-hour samples

Results from the analysis of 24-hour urine samples are presented in Table 34. Cortisol levels and cortisol/creatinine ratios were significantly higher for women with high scores for restraint compared to those with low scores for restraint while calcium levels and

calcium/creatinine ratios were significantly lower. Twenty-four hour calcium excretion was correlated with 24-hour calcium intake in the total group ($r = 0.459$, $P < 0.000$) and in women with low scores for restraint ($r = 0.677$, $P < 0.000$) but not in women with high scores for restraint ($r = 0.068$, $P = 0.727$). Calcium/creatinine was also correlated with calcium intake on the study day in the total group ($r = 0.449$, $P < 0.000$) and in the low restraint group ($r = 0.650$, $P < 0.000$) but not in the high restraint group ($r = 0.128$, $P = 0.507$).

Table 33. Selected food choices of participants grouped according to restraint scores (from 24-hour intake records)

Food choice	n[a]	Low restraint[b] (%)	n[a]	High restraint[c] (%)	P
Cream cheese					
regular	9	64.3	2	15.4	
lite	5	35.7	11	84.6	0.010[d]
Milk					
2 %	9	64.3	2	16.7	
skim	5	35.7	10	83.3	0.014[d]
Pop					
regular	13	86.7	3	20.0	
diet	2	13.3	12	80.0	0.000[d]
Salad dressing					
regular	12	75.0	3	16.7	
lite	4	25.0	15	83.3	0.001[d]
Mayonnaise					
regular	19	76.0	4	21.1	
lite	6	24.0	15	78.9	0.000[d]
Bread					
white	28	56.0	40	71.4	
whole grain	22	44.0	16	28.6	0.098
Meat[e]					
red meat	7	33.3	2	8.3	
white meat	14	66.7	22	91.7	0.036[d]
Cereal					
Raisin Bran	4	40.0	5	55.6	
Frosted Flakes	3	30.0	3	33.3	
Cheerios	3	30.0	1	11.1	0.588

[a] n's represent the number of women who selected the particular food item.
[b] Score 0-5 on the Three-Factor Eating Questionnaire (TFEQ) restraint scale (Stunkard AJ & Messick S, 1985).
[c] Score 13-21 on TFEQ restraint scale.
[d] Percentages differ significantly between groups (chi-square).
[e] Red meat = ham or beef; white meat = turkey.

Table 34. Analysis (mean ± SD) of 24-hour urine samples of participants grouped according to restraint scores

Characteristic	Low restraint[a] (n = 28)	High restraint[b] (n = 30)	P value
Urine volume (ml)	1391 ± 665	1370 ± 418	0.883
Creatinine (mmol)[c]	10.0 ± 1.9	9.8 ± 1.7	0.731
Cortisol (nmol)[d]	354.7 ± 83.7	418.8 ± 134.6	0.041[f]
Cortisol/creatinine (nmol/mmol)	36.3 ± 8.9	42.9 ± 12.9	0.034[f]
Calcium (mmol)[e]	3.8 ± 2.1	2.7 ± 1.3	0.017[f]
Calcium/creatinine (mmol/mmol)	0.4 ± 0.2	0.3 ± 0.1	0.023[f]

[a] Score 0-5 on the Three-Factor Eating Questionnaire (TFEQ) restraint scale (Stunkard AJ & Messick S, 1985).
[b] Score 13-21 on TFEQ restraint scale.
[c] Reference interval: 7.0-16.0 mmol/24 hr.
[d] Reference interval: 80.0-600.0 nmol/24 hr.
[e] Reference interval: 2.5-7.5 mmol/24 hr.
[f] Mean values differ significantly between groups (t-test).

The number of samples analyzed differs from the number of participants as there were two laboratory errors and one incomplete collection. Additionally, one woman was excluded from the analysis as she had both a very high urine output (3700 ml) and cortisol excretion. High urine volume has recently been associated with an increase in urinary cortisol excretion (Mericq MV & Cutler GB, Jr., 1998) and was, therefore, a potential confounder.

5.4.2.11 Body composition

Table 35 presents the body composition, measured from dual energy x-ray absorptiometry (DEXA), of women with low scores for restraint and women with high scores for restraint. Mean values did not differ between the two groups on any of the measured variables.

Table 35. Body composition[a] of participants (mean ± SD) grouped according to restraint scores

Characteristic	Low restraint[b] (n = 28)	High restraint[c] (n = 33)	P value
Body mass (g)	55678 ± 8967	56107 ± 5884	0.830
Tissue mass (g)	53336 ± 8700	53805 ± 5736	0.809
Bone free lean tissue (g)	38400 ± 4911	38703 ± 4436	0.801
Bone free lean tissue (%)	69.6 ± 6.5	69.1 ± 5.2	0.738
Fat mass (g)	14937 ± 5631	15101 ± 3814	0.893
Body fat (%)	26.2 ± 6.8	26.8 ± 5.6	0.696
Fat free mass (g)	40741 ± 521	41006 ± 465	0.835

[a] Measured by dual energy x-ray absorptiometry.
[b] Score 0-5 on the Three-Factor Eating Questionnaire (TFEQ) restraint scale (Stunkard AJ & Messick S, 1985).
[c] Score 13-21 on TFEQ restraint scale.

5.4.2.12 Bone analysis

Bone analysis, measured using dual energy x-ray absorptiometry (DEXA), is presented in Table 36. Mean values for all bone characteristics were similar between groups.

Table 36. Bone analysis[a] (mean ± SD) results of participants according to restraint group

Characteristic	Low restraint[b] (n = 28)	High restraint[c] (n = 33)	P value
Total body			
BMD (g/cm^2)	1.126 ± 0.076	1.127 ± 0.054	0.928
Age matched (%)	103 ± 6.19	103 ± 5.14	0.854
BMC (g)	2341.25 ± 350.21	2301.33 ± 251.58	0.617
Bone calcium (g)	889.68 ± 133.10	874.45 ± 95.67	0.617
Lumbar 1-lumbar 4			
BMD (g/cm^2)	1.145 ± 0.147	1.135 ± 0.100	0.765
Age matched (%)	100 ± 12.06	99 ± 8.92	0.743
BMC (g)	58.72 ± 11.60	55.56 ± 13.01	0.342

[a] Measured by dual energy x-ray absorptiometry
[b] Score 0-5 on the Three-Factor Eating Questionnaire (TFEQ) restraint scale (Stunkard AJ & Messick S, 1985)
[c] Score 13-21 on TFEQ restraint scale

Correlation coefficients between bone analysis, age, anthropometric, lifestyle and menstrual cycle characteristics are presented in Table 37. Total bone mineral density (BMD) and waist circumference were significantly correlated. Bone mineral content (BMC) was significantly correlated with height, weight, BMI, waist and hip circumference as well as

Table 37. Correlation coefficients[a] between bone analysis, and age, anthropometric, lifestyle and menstrual cycle variables

	Total body BMD (g/cm^2)	Total body BMC (g)	Spinal BMD (g/cm^2) (L1-L4)[b]	Spinal BMC (g) (L1-L4)[b]
Age (y)	0.067	0.251	0.188	0.116
Height (cm)	0.106	0.626[c]	0.077	0.195
Weight (kg)	0.288	0.680[c]	0.201	0.187
BMI (kg/cm^2)	0.299	0.357[d]	0.197	0.066
Waist (cm)	0.328[d]	0.473[c]	0.185	0.207
Hip (cm)	0.311	0.566[c]	0.139	0.128
Waist/hip	0.020	-0.097	0.053	0.087
Body fat %	0.146	-0.092	-0.178	-0.161
Bone free lean tissue (%)	0.111	0.071	0.147	0.140
Exercise (hr/wk)	0.324	0.408[c]	0.342[d]	0.181
Coffee or tea (cups/d)	-0.029	0.067	-0.013	-0.074
Alcohol (drinks/wk)	-0.122	0.082	0.043	0.186
Menstrual cycle length (d)[e]	0.030	0.132	0.093	0.094
Menstrual cycle length (d)[f]	0.146	-0.071	0.045	-0.103

[a] Pearson correlation coefficients are shown; all significance levels were 2-tailed.
[b] L1-L4 = lumbar 1-lumbar 4.
[c] $P < 0.001$.
[d] $P < 0.01$.
[e] Self-reported menstrual cycle length.
[f] Documented menstrual cycle length.

with hours of weekly exercise. Spinal bone mineral density (BMD) was correlated only with exercise and there were no significant correlations with spinal bone mineral content (BMC).

Correlation coefficients between bone analysis and scores on the TFEQ disinhibition and hunger scales, Perceived Stress Scale, Rosenberg's Self-esteem Scale and EDI subscales are shown in Table 38. Restraint scores were not included as scores were not continuous. No associations were detected between bone values and scores on the various scales at the

Table 38. Correlation coefficients[a] between bone analyses and scores on the TFEQ[b] subscales, Perceived Stress Scale[c], Rosenberg's Self-esteem Scale[d] and EDI[e] subscales

	Total body BMD (g/cm^2)	Total body BMC (g)	Spinal BMD (g/cm^2) (L1-L4)[f]	Spinal BMC (g) (L1-L4)[f]
TFEQ disinhibition	0.008	-0.128	-0.187	-0.165
TFEQ hunger	-0.140	-0.295	-0.151	-0.092
Perceived stress	-0.185	-0.219	0.026	0.046
Self-esteem	-0.068	-0.215	0.036	-0.129
EDI drive for thinness	0.222	-0.122	0.086	-0.097
EDI bulimia	0.034	-0.057	0.056	-0.061
EDI body dissatisfaction	-0.106	-0.208	-0.031	-0.198
EDI ineffectiveness	0.034	-0.097	0.122	0.038
EDI perfectionism	0.174	0.003	0.114	-0.018
EDI interpersonal distrust	0.003	-0.082	0.106	0.096
EDI interoceptive awareness	-0.014	-0.071	0.108	0.073
EDI maturity fears	-0.006	-0.082	0.001	0.029

[a] Pearson correlation coefficients are shown; all significance levels were 2-tailed.
[b] TFEQ = Three-Factor Eating Questionnaire (Stunkard AJ & Messick S, 1985).
[c] Perceived Stress Scale (Cohen S et al, 1983).
[d] Rosenberg's Self-esteem Scale (Rosenberg M, 1965).
[e] EDI = Eating Disorder Inventory (Garner DM & Olmstead MP, 1984).
[f] L1-L4 = lumbar 1-lumbar 4.

$P < 0.01$ level. When correlation analysis was done separately according to restraint group an inverse relationship was observed between restraint score and total BMD in women with high ($r = -0.413$, $P = 0.019$) but not low restraint scores ($r = -0.015$, $P = 0.941$). In women grouped as having high restraint scores a negative correlation was also found between scores on the Perceived Stress Scale and total BMD ($r = -0.404$, $P = 0.022$). This relationship was not found in women grouped as having low restraint scores ($r = 0.001$, $P = 0.994$). Scores on the restraint scale and Perceived Stress Scale were positively correlated within the high but not the low restraint group.

The results of correlation analysis between bone values and 3-day food records are presented in Table 39. Total BMC was positively correlated with calcium intake ($P < 0.01$) and calcium/protein at the $P < 0.05$ level. Correlation analysis conducted separately on women grouped according to restraint score revealed a positive correlation between calcium

Table 39. Correlation coefficients[a] between bone analysis, and energy and nutrient intakes (from 3-day food records)

	Total body BMD (g/cm^2)	Total body BMC (g)	Spinal BMD (g/cm^2) (L1-L4)[b]	Spinal BMC (g) (L1-L4)[b]
Energy (kcal)	-0.038	0.122	-0.087	0.065
Protein (g)	-0.007	-0.031	-0.064	0.005
Carbohydrate (g)	-0.023	0.213	-0.092	0.032
Fat (g)	-0.056	0.029	-0.055	0.050
Fibre (g)	-0.020	0.169	0.022	-0.038
Cholesterol (mg)	0.065	-0.047	0.138	0.193
Calcium (mg)	0.134	0.354[c]	-0.035	0.093
Calcium/protein (mg/g)	0.078	0.310	-0.010	0.054
Sodium (mg)	-0.233	-0.133	-0.137	0.001

[a] Pearson correlation coefficients are shown; all significance levels were 2-tailed.
[b] L1-L4 = lumbar 1-lumbar 4.
[c] $P < 0.01$.

intake and total BMC (r = 0.388, P = 0.028) and calcium/protein and total BMC (r = 0.415, P = 0.018) in the high restraint group. These correlations were not observed in the low restraint group.

Correlation analysis between bone values and the results of 24-hour urine sample analysis is presented in Table 40. Although none of the observed associations were significant at $P < 0.01$, cortisol/creatinine was negatively correlated with total BMC (r = -0.299, P = 0.028). Urine volume was positively correlated with cortisol excretion (r = 0.305, $P < 0.05$) but not with cortisol/creatinine. Correlation analysis was also conducted separately within the two restraint groups. In the high restraint group cortisol/creatinine was negatively correlated with total BMD (r = -0.397, P = 0.033) and with total BMC (r = -0.414, P = 0.026). These relationships were not observed in the low restraint group.

Table 40. Correlation coefficients[a] between bone analysis and 24-hour urine sample analysis

	Total body BMD (g/cm^2)	Total body BMC (g)	Spinal BMD (g/cm^2) (L1-L4)[b]	Spinal BMC (g) (L1-L4)[b]
Urine volume (mL)	0.017	0.137	0.039	0.017
Cortisol (nmol)	0.042	0.077	-0.102	-0.056
Cortisol/creatinine (nmol/mmol)	-0.135	-0.299[c]	-0.155	-0.077
Calcium (mmol)	0.058	0.091	0.091	0.097
Calcium/creatinine (mmol/mmol)	-0.053	-0.121	0.015	0.007

[a] Pearson correlation coefficients are shown; all significance levels were 2-tailed.
[b] L1-L4 = lumbar 1-lumbar 4.
[c] $P < 0.05$.

At the $P < 0.01$ cortisol/creatinine was positively correlated with the EDI drive for thinness, and bulimia scales while at the $P < 0.05$ level it was also correlated with the TFEQ disinhibition scale, Rosenberg's Self-esteem scale, the Perceived Stress Scale and the EDI

interoceptive awareness scale. Again, the TFEQ restraint scale was not included in the correlation analysis as scores were not continuous.

5.4.3 Participants Grouped According to Exercise Level

Due to the significantly higher level of weekly exercise reported by women with high scores for restraint compared to those with low scores for restraint, and the positive relationship between exercise and bone health, it was considered appropriate to characterize the study population according to exercise level. Women reporting exercise of 0- < 2 hr/wk were included in the lower exercise group (n = 20), 2- < 3.5 hr/wk in the middle exercise group (n = 19), and 3.5-7 hr/wk in the upper exercise group (n = 23).

Table 41 presents the ethnic make-up of the three exercise groups. The ethnic composition of each exercise group tended to differ (P = 0.076) with white women participating in higher levels of activity than nonwhites. Participants were also grouped according to whether their major field of study was nutrition or otherwise. Major field of study was similar among exercise groups (Table 42). Nutrition students tended (P = 0.100) to participate in exercise more than nonnutrition students, as 90% stated they exercised 2-7 hr/wk while less than 65% of nonnutrition students reported similar levels of activity.

Table 41. Ethnicity of participants according to exercise group

Ethnicity	n	Exercise (0- < 2 hr/wk)	n	Exercise (2- < 3.5 hr/wk)	n	Exercise (3.5-7 hr/wk)
White	3	15.0%	6	31.6%	11	47.8%
Chinese	12	60.0%	11	57.9%	5	21.7%
South Asian	4	20.0%	2	10.5%	4	17.4%
Hispanic	1	5.0%	0	0.0%	3	13.0%

There were no significant differences (chi-square).

Table 42. Field of study of participants according to exercise group

	n	Exercise (0- < 2 hr/wk)	n	Exercise (2- < 3.5 hr/wk)	n	Exercise (3.5-7 hr/wk)
Nutrition	1	5.0%	5	26.3%	4	17.4%
Nonnutrition	19	95.0%	14	73.7%	19	82.6%

There were no significant differences (chi-square).

5.4.3.1 Physical characteristics

Table 43 presents the physical characteristics of women grouped according to reported hours of weekly exercise. Physical characteristics were similar among exercise groups except for documented menstrual cycle length, which was longer for women in the lower group compared to the upper group.

5.4.3.2 Lifestyle characteristics

Lifestyle characteristics of women grouped according to exercise level are shown in Table 44. Among the three exercise groups, participants did not differ in consumption of caffeinated (coffee or tea) or alcoholic beverages, the proportion who were vegetarian, or who reported using vitamin or mineral supplements.

5.4.3.3 Weight fluctuation and dieting history

Weight fluctuation and dieting history of women grouped according to exercise level are presented in Table 45. A significantly lower percentage of women in the lower group for the middle or upper groups. The percentage of women who reported they were presently trying to lose weight tended to differ among women grouped according to exercise level although this difference did not attain statistical significance (P = 0.054). Weight fluctuation was similar among groups.

Table 43. Physical characteristics (mean ± SD) of participants according to exercise group

Characteristic	Exercise (hr/wk) 0- < 2 (n = 20)	2- < 3.5 (n = 19)	3.5-7 (n = 23)	P value
Age (y)	21.2 ± 1.3	21.0 ± 1.9	22.6 ± 3.3	0.680
Height (cm)	161.1 ± 7.1	162.9 ± 7.4	165.2 ± 6.9	0.184
Weight (kg)	53.5 ± 7.2	57.0 ± 7.4	57.0 ± 6.3	0.185
BMI (kg/m^2)	20.5 ± 1.7	21.5 ± 1.9	20.9 ± 1.8	0.277
Highest BMI (kg/m^2)[a]	22.1 ± 2.6	22.5 ± 1.5	22.4 ± 2.0	0.823
Lowest BMI (kg/m^2)[b]	19.6 ± 1.7	20.3 ± 1.4	19.3 ± 1.8	0.174
Best BMI (kg/m^2)[c]	20.0 ± 1.3	20.1 ± 1.2	20.1 ± 1.3	0.964
Waist (cm)	65.4 ± 4.6	67.8 ± 4.2	66.7 ± 4.1	0.228
Hip (cm)	88.6 ± 6.0	90.2 ± 6.6	89.1 ± 5.2	0.685
Waist/hip ratio	0.74 ± 0.05	0.75 ± 0.03	0.75 ± 0.05	0.601
Menstrual cycle length (d)[d]	29.6 ± 3.3	28.6 ± 3.9	27.7 ± 2.0	0.156
Menstrual cycle length (d)[e]	31.1 ± 3.5[f]	29.1 ± 2.8[f,g]	28.3 ± 3.2[g]	0.021

[a] Calculated from weight given as 'highest adult weight'.
[b] Calculated from weight given as 'lowest adult weight'.
[c] Calculated from weight given as 'best adult weight'.
[d] Self-reported menstrual cycle length.
[e] Documented menstrual cycle length.
[f,g] Means differ significantly between values not sharing a common superscript (by one-way ANOVA and Duncan's multiple range test).

Table 44. Lifestyle characteristics of participants according to exercise group

Characteristic	Exercise (hr/wk) 0- < 2 (n = 20)	2- < 3.5 (n = 19)	3.5-7 (n = 23)	P value
Coffee or tea (cups/d)[a]	0.90 ± 0.85	1.00 ± 1.00	1.22 ± 1.09	0.561
Alcohol (drinks/wk)[a]	0.7 ± 1.4	0.8 ± 1.4	1.4 ± 1.6	0.237
Vegetarian	15.0%	10.5%	8.7%	0.802
Using vitamin/mineral supplements	40.0%	31.6%	52.2%	0.395

[a] Mean ± SD.

Table 45. Weight fluctuation and dieting history of participants according to exercise group

Characteristic	Exercise (hr/wk) 0- < 2 (n = 20)	2- < 3.5 (n = 19)	3.5-7 (n = 23)	P value
Ever tried to lose weight	45.0%	89.5%	87.0%[a]	0.001
Presently trying to lose weight	25.0%	63.2%	47.8%	0.054
Weight fluctuation[b,c]	1.1 ± 0.9	1.2 ± 0.8	1.3 ± 0.8	0.721

[a] Percentages differ significantly (chi-square).
[b] Mean ± SD.
[c] Number of times > 5 lbs lost during the past two years.
hours of weekly exercise reported having ever tried to lose weight compared with women in

5.4.3.4 Eating behaviour, eating attitudes and psychometric subscales

Scores on the Three-Factor Eating Questionnaire (TFEQ) subscales, the Perceived Stress Scale, Rosenberg's Self-esteem Scale and the eight Eating Disorder Inventory (EDI) subscales for women grouped according to exercise level are shown in Table 46. Women in the lower exercise group had lower restraint scale scores than women in both the middle and upper groups. Scores on all other scales were similar among groups.

5.4.3.5 Energy and nutrient intakes

The mean energy and nutrient intakes from analysis of 3-day food records are presented in Table 47. Energy intakes were similar among groups in absolute terms and in relation to body weight. Carbohydrate intakes in absolute terms and as a percentage of energy were highest, and fat as a percentage of energy intake lowest, in the upper exercise group. Fibre intake was also higher in the upper exercise group. Other values were similar among groups.

Table 46. TFEQ[a] subscale, Perceived Stress Scale[b], Rosenberg's Self-esteem Scale[c] and EDI[d] subscale scores (mean ± SD) of participants according to exercise group

	Exercise (hr/wk)			
Characteristic	**0- < 2 (n = 20)**	**2- < 3.5 (n = 19)**	**3.5-7 (n = 23)**	**P value**
TFEQ restraint	5.3 ± 5.9[e]	11.0 ± 6.7[f]	11.30 ± 5.3[f]	0.002
TFEQ disinhibition	5.1 ± 3.7	6.2 ± 4.0	5.7 ± 4.4	0.717
TFEQ hunger	6.4 ± 2.8	5.1 ± 3.0	6.0 ± 3.5	0.440
Perceived stress	26.7 ± 6.7	27.4 ± 5.8	26.7 ± 8.9	0.939
Self-esteem	1.2 ± 1.1	1.4 ± 1.2	1.6 ± 2.0	0.223
EDI drive for thinness	2.3 ± 4.9	4.4 ± 5.8	5.2 ± 6.0	0.223
EDI bulimia	0.8 ± 1.5	0.6 ± 1.1	1.9 ± 2.5	0.877
EDI body dissatisfaction	7.6 ± 8.6	9.9 ± 9.2	9.1 ± 8.9	0.720
EDI ineffectiveness	1.0 ± 2.4	2.3 ± 3.0	3.7 ± 5.8	0.115
EDI perfectionism	5.8 ± 5.4	6.1 ± 5.0	6.1 ± 5.1	0.965
EDI interpersonal distrust	1.2 ± 5.5	1.9 ± 2.7	3.0 ± 3.6	0.103
EDI interoceptive awareness	1.1 ± 1.9	2.3 ± 4.6	2.3 ± 3.0	0.401
EDI maturity fears	3.8 ± 4.5	3.3 ± 3.1	3.6 ± 3.6	0.945

[a] TFEQ = Three-Factor Eating Questionnaire (Stunkard AJ & Messick S, 1985).
[b] Perceived Stress Scale (Cohen S et al, 1983).
[c] Rosenberg's Self-esteem Scale (Rosenberg M, 1965). Lower scores reflect higher self-esteem.
[d] EDI = Eating Disorder Inventory (Garner DM & Olmstead MP, 1984).
[e,f] Means differ significantly between values in rows not sharing a common superscript (by one-way ANOVA and Duncan's multiple range test)

Table 47. Daily energy and nutrient intakes (mean ± SD) from 3-day food records of participants grouped according to exercise tertile

Characteristic	Exercise (hr/wk) 0- < 2 (n = 20)	2- < 3.5 (n = 19)	3.5-7 (n = 23)	P value
Energy (kcal)	2120.5 ± 495.9	1961.3 ± 452.0	2108.3 ± 488.4	0.516
Energy (kcal/kg body wt)	40.1 ± 9.8	34.8 ± 8.2	37.2 ± 8.3	0.177
Carbohydrate (g)	288.1 ± 88.5[a,b]	263.5 ± 65.4[a]	328.7 ± 80.0[b]	0.034
Carbohydrate (%)	53.6 ± 5.6[a]	54.2 ± 10.0[a]	61.4 ± 9.5[b]	0.006
Protein (g)	97.2 ± 69.7	80.0 ± 30.2	81.8 ± 30.7	0.445
Protein (%)	16.1 ± 4.1	15.9 ± 3.9	15.0 ± 4.3	0.651
Fat (g)	71.4 ± 20.2	67.5 ± 27.0	56.8 ± 24.4	0.123
Fat (%)	29.9 ± 3.8[a]	29.7 ± 8.6[a]	23.5 ± 6.4[b]	0.002
Cholesterol (mg)	204.0 ± 71.7	248.1 ± 136.6	175.5 ± 113.8	0.113
Fibre (g)	17.2 ± 6.3[a]	15.2 ± 5.8[a]	24.6 ± 8.3[b]	0.000
Calcium (mg)	783.0 ± 381.8	687.5 ± 297.9	930.0 ± 384.2	0.096
Calcium/protein (mg/g)	9.2 ± 4.6	9.5 ± 4.5	12.2 ± 4.6	0.073
Sodium (mg)	2937.3 ± 953.0	3087.6 ± 999.0	2906.3 ± 1389.6	0.867

[a,b] Means differ significantly between values in rows not sharing a common superscript (by one-way ANOVA and Duncan's multiple range test).

The mean energy and selected nutrient intakes from 24-hour study day records are shown in Table 48 for women grouped according to exercise level. Recorded intakes were similar among groups for all variables with the exception of fibre which was higher in the upper compared with the middle exercise group.

5.4.3.6 Urine analysis from 24-hour samples

Table 49 displays data from the analysis of 24-hour urine samples of women grouped according to exercise level. Women in the upper and middle exercise groups had higher values for creatinine excretion than women in the lower exercise group. All other values were similar among groups.

Table 48. Energy and nutrient intakes (mean ± SD) from 24-hour food records of participants grouped according to exercise tertile

Characteristic	Exercise (hr/wk) 0- < 2 (n = 20)	2- < 3.5 (n = 19)	3.5-7 (n = 23)	P value
Energy (kcal)	2305.1 ± 473.0	2079.3 ± 650.9	2339.5 ± 507.4	0.269
Energy (kcal/kg body wt)	43.4 ± 9.2	36.9 ± 11.9	41.3 ± 9.3	0.130
Carbohydrate (g)	373.6 ± 88.2	337.4 ± 113.1	396.7 ± 85.2	0.142
Carbohydrate (%)	62.4 ± 5.6	62.6 ± 6.9	66.0 ± 5.4	0.091
Protein (g)	75.5 ± 20.5	69.8 ± 18.4	76.9 ± 14.8	0.422
Protein (%)	12.5 ± 2.0	13.4 ± 2.2	13.0 ± 2.1	0.387
Fat (g)	65.6 ± 20.4	57.3 ± 23.8	58.9 ± 23.8	0.504
Fat (%)	25.0 ± 5.1	23.8 ± 5.9	21.2 ± 5.9	0.086
Cholesterol (mg)	74.3 ± 42.7	60.1 ± 42.6	48.1 ± 27.1	0.084
Fibre (g)	24.9 ± 7.9[a,b]	23.9 ± 8.3[a]	29.9 ± 8.4[b]	0.045
Calcium (mg)	597.7 ± 304.6	515.6 ± 352.1	688.2 ± 309.4	0.229
Calcium/protein (mg/g)	7.7 ± 2.8	7.0 ± 3.4	9.2 ± 5.0	0.202
Sodium (mg)	2190.5 ± 567.3	2176.6 ± 653.6	2413.0 ± 611.6	0.367

[a,b] Means differ significantly between values in rows not sharing a common superscript (by one-way ANOVA and Duncan's multiple range test).

Table 49. Urine sample analysis (mean ± SD) of participants according to exercise group

Characteristic	Exercise (hr/wk) 0- < 2 (n = 19)	2- < 3.5 (n = 19)	3.5-7 (n = 20)	P value
Urine volume (mL)	1265 ± 513	1385 ± 505	1486 ± 616	0.235
Creatinine (mmol)[a]	9.0 ± 1.8[d]	10.2 ± 1.6[e]	10.5 ± 1.7[e]	0.019
Cortisol (nmol)[b]	334.4 ± 74.2	420.8 ± 121.7	404.6 ± 131.1	0.080
Cortisol/creatinine (nmol/mmol)	38.4 ± 11.7	41.4 ± 10.5	39.5 ± 12.9	0.672
Calcium (mmol)[c]	2.9 ± 1.7	3.5 ± 2.1	3.2 ± 1.8	0.603
Calcium/creatinine (mmol/mmol)	0.3 ± 0.2	0.3 ± 0.2	0.3 ± 0.2	0.888

[a] Reference interval: 7.0-16.0 mmol/24 hr.
[b] Reference interval: 80.0-600.0 nmol/24 hr.
[c] Reference interval: 2.5-7.5 mmol/24 hr.
[d,e] Means differ significantly between values in rows not sharing a common superscript (by one-way ANOVA and Duncan's multiple range test).

5.4.3.7 Body composition

Body composition, measured using dual energy x-ray absorptiometry (DEXA), of participants grouped according to exercise level is presented in Table 50. Women in the upper exercise group had significantly greater values for bone free lean tissue mass and fat free mass compared to women in the lower but not middle group.

Table 50. Body composition[a] of participants (mean ± SD) according to exercise group

Characteristic	Exercise (hr/wk) 0- < 2 (n = 19)	2- < 3.5 (n = 19)	3.5-7 (n = 23)	P value
Tissue mass (g)	51609 ± 7587	54291 ± 7517	54648 ± 6524	0.352
Bone free lean tissue (g)	36442 ± 3716[b]	38277 ± 4375[b,c]	40554 ± 419[c]	0.013
Bone free lean tissue (%)	68.5 ± 6.9	67.9 ± 5.5	71.2 ± 4.7	0.143
Fat mass (g)	15167 ± 5640	16014 ± 4775	14092 ± 3692	0.420
Body fat (%)	27.5 ± 7.2	27.9 ± 5.8	24.5 ± 5.0	0.143
Fat free mass (g)	38597 ± 3924[b]	40622 ± 4565[b,c]	42991 ± 5096[c]	0.012

[a] Measured by dual energy x-ray absorptiometry.
[b,c] Means differ significantly between values in rows not sharing a common superscript (by one-way ANOVA and Duncan's multiple range test).

5.4.3.8 Bone analysis

Bone analysis, assessed by DEXA, is presented in Table 51. Women in the middle and upper exercise groups had significantly higher values for all total body bone values presented including BMD and BMC. Spinal (lumbar 1-lumbar 4) BMD was also higher in the middle and upper exercsie groups.

Table 51. Bone analysis[a] (mean ± SD) results of participants according to exercise group

	Exercise (hr/wk)			
Characteristic	**0- < 2**	**2- < 3.5**	**3.5-7**	**P value**
Total body	**(n = 19)**	**n = (19)**	**(n = 23)**	
BMD (g/cm^2)	1.095 ± 0.050[b]	1.135 ± 0.062[c]	1.146 ± 0.069 [c]	0.025
Age matched (%)	101 ± 4.58[b]	104 ± 5.90[c]	105 ± 5.77[c]	0.092
BMC (g)	2154.63 ± 245.44[b]	2344.79 ± 252.49[c]	2435.22 ± 322.81[c]	0.007
Bone calcium (g)	816.68 ± 93.22[b]	891.05 ± 96.04[c]	925.35 ± 122.71[c]	0.007
Lumbar 1-lumbar 4	**(n = 18)**	**(n = 18)**	**(n = 22)**	
BMD (g/cm^2)	1.071 ± 0.099[b]	1.149 ± 0.111[c]	1.187 + 0.124[c]	0.007
Age matched (%)	94 ± 8.26[b]	100 ± 10.8[c]	104 ± 9.78[c]	0.011
BMC (g)	53.04 ± 7.62	57.77 ± 9.46	59.39 ± 16.70	0.261

[a] Measured by dual energy x-ray absorptiometry.
[b,c] Means differ significantly between values in rows not sharing a common superscript (by one-way ANOVA and Duncan's multiple range test).

5.4.4 Dietary Restraint, Exercise and Bone Health

5.4.4.1 Minimal vs. moderate exercise groups

From the results of the bone analysis according to exercise level it was apparent that the difference in bone values was between women who reported exercising minimally (0- < 2 hr/wk) and those who reported exercising moderately (2-7 hr/wk). Therefore, the three groups were collapsed into two and all analysis reviewed. A summary of the characteristics from the DEXA analysis comparing women who exercise minimally or moderately is presented in Table 52. Fat free body mass was higher in women who reported exercising moderately but all other characteristics of body composition were similar between groups. Total BMD, BMC and spinal BMD were higher in the moderate exercise group. Correlations between hours of weekly exercise and bone characteristics within the minimal and moderate exercise groups were not significant.

Table 52. Body composition[a] and bone analysis (mean ± SD) of participants who reported exercising minimally and moderately

Characteristic	0- < 2 (hr/wk)	2–7 (hr/wk)	P value
Body composition	**(n = 19)**	**(n = 41)**	
Tissue mass (g)	51609 ± 7587	54487 ± 6905	0.149
Bone free lean tissue (g)	36442 ± 3716	39524 ± 4710	0.150
Bone free lean tissue (%)	68.5 ± 6.9	69.7 ± 5.3	0.440
Fat mass (g)	15167 ± 5640	14962 ± 4273	0.876
Body fat (%)	27.5 ± 7.2	26.1 ± 5.5	0.397
Fat free mass (g)	38597 ± 3924	41919 ± 4950	0.007[b]
Total body	**(n = 19)**	**(n = 41)**	
BMD (g/cm^2)	1.095 ± 0.050	1.141 ± 0.065	0.008[b]
BMC (g)	2154.63 ± 245.44	2394.31 ± 293.22	0.003[b]
Lumbar 1-lumbar 4	**(n = 18)**	**(n = 40)**	
BMD (g/cm^2)	1.071 ± 0.099	1.170 ± 0.118	0.003[b]
BMC (g)	53.04 ± 7.62	58.66 ± 13.78	0.111

[a] Measured by dual energy x-ray absorptiometry.
[b] Mean values differ significantly between groups (t-test).

Reviewing the analysis of all other characteristics (Appendixes 29-35) in relation to whether women reported exercising minimally or moderately, it was found that the women who exercised moderately had shorter menstrual cycles than those who exercised minimally (P = 0.008). The percentage of women presently trying to lose weight and those who had ever tried to lose weight was higher in the moderate exercise group. Restraint scores were also significantly higher (P = 0.001) in the moderate exercise group as were scores on the EDI ineffectiveness (P = 0.026) and interpersonal distrust (P = 0.030) scales. Energy intake was similar between groups on both the 24-hour study day and from 3-day food records although carbohydrate intake as a percentage of energy was higher and fat intake as a percentage of energy lower in moderate exercisers as documented in 3-day food records.

The results of the urine analysis were similar to those observed between women grouped according to the three different exercise levels in that creatinine was higher in women who exercised moderately and cortisol/creatinine, calcium and calcium/creatinine values were similar. Cortisol excretion was higher (412.7 ± 125.1 nmol vs. 334.4 ± 74.2 nmol, P = 0.020) in women who reported exercising moderately compared with those exercising minimally.

Earlier analysis without the inclusion of covariates had not uncovered any differences in bone characteristics between women with low or high scores for dietary restraint. Due to the difference in bone characteristics between women grouped according to exercise level and the observation that women who exercised ≥ 2 hr/wk had higher restraint scores (Table 46), the same analysis was redone using exercise group as a covariate. Indices of body size were also entered as covariates where correlations with bone characteristics had been significant. In these cases, the body size measurement most strongly correlated with the specific bone characteristic was used. These data are presented in Table 53. Total BMC

Table 53. Bone analysis[a] (mean ± SD) of participants according to restraint group with covariates[b]

Characteristic	Low restraint[c] (n = 28)	High restraint[d] (n = 33)	P value
Total body			
BMD (g/cm^2)[e]	1.126 ± 0.076	1.127 ± 0.054	0.251
BMC (g)[f]	2341.25 ± 350.21	2301.33 ± 251.58	0.018[g]
Lumbar 1-lumbar 4			
BMD (g/cm^2)	1.145 ± 0.147	1.135 ± 0.100	0.093
BMC (g)	58.72 ± 11.60	55.56 ± 13.01	0.086

[a] Measured by dual energy x-ray absorptiometry.
[b] Exercise group was used as a covariate for all comparisons.
[c] Score 0-5 on the Three-Factor Eating Questionnaire (TFEQ) restraint scale (Stunkard AJ & Messick S, 1985).
[d] Score 13-21 on TFEQ restraint scale.
[e] Waist (cm) was used as a covariate.
[f] Weight (kg) was used as a covariate.
[g] Means values differ significantly (ANOVA).

differed between groups with higher values observed in the low restraint group after controlling for correlated variables. The same trend was observed in spinal (L1-L4) BMD and BMC although the differences were not significant.

Factorial Analyses

The results of factorial analysis of two levels of exercise by two levels of dietary restraint (2 x 2 ANOVA) on bone characteristics are presented in Table 54. There was a significant main effect of exercise group on total body BMD, total body BMC, and spinal (L1-L4) BMD but not on spinal (L1-L4) BMC. The effect of dietary restraint group was not significant on bone characteristics although women in the high restraint group tended to have lower values than those with low restraint scores. There was an interaction effect of restraint group and exercise group on total body BMC, which indicated that the two variables were not independent. Within the moderately exercising group high restraint scores were associated with lower BMC.

Multiple Regression Analyses

The results of stepwise multiple regression analysis are presented in Tables 55 and 56. Characteristics which were significantly correlated with bone characteristics were entered into an equation to determine independent predictors of total body and spinal BMD and BMC. Restraint group was entered as opposed to restraint scores as scores were not continuous. Multiple regression analysis showed that only exercise group was significantly correlated with spinal BMD and there were no lifestyle or anthropometric characteristics correlated with spinal BMC, therefore, these data are not presented. Menstrual cycle length was not significant when entered into the equations.

Table 54. Restraint group, exercise group and bone characteristics (2 x 2 ANOVA)

	Exercise group				F ratio (P)		
	n	Minimal (0- < 2 hr/wk)	n	Moderate (2-7 hr/wk)	Restraint	Exercise	Interaction
Total body							
BMD (g/cm^2)[a]							
- low restraint[b]	14	1.092 ± 0.051	14	1.160 ± 0.082	0.228	6.547	1.011
- high restraint[c]	5	1.102 ± 0.050	27	1.132 ± 0.055	(0.635)	(0.013)[d]	(0.319)
BMC(g)[a]							
- low restraint[b]	14	2128.64 ± 257.64	14	2553.86 ± 301.64	0.713	9.610	4.153
- high restraint[c]	5	2227.40 ± 215.35	27	2315.30 ± 263.65	(0.402)	(0.003)[d]	(0.046)[d]
Lumbar 1-lumbar 4							
BMD (g/cm^2)[a]							
- low restraint[b]	13	1.072 + 0.102	12	1.224 ± 0.150	1.135	10.743	1.088
- high restraint[c]	5	1.068 ± 0.100	27	1.146 ± 0.097	(0.251)	(0.002)[d]	(0.302)
BMC (g)[a]							
- low restraint[b]	13	52.35 ± 7.90	12	65.61 ±11.21	0.967	3.545	2.700
- high restraint[c]	5	54.83 ± 7.36	27	55.73 ± 14.13	(0.330)	(0.065)	(0.106)

[a] Measured by dual energy x-ray absorptiometry.
[b] Score 0-5 on the Three-Factor Eating Questionnaire (TFEQ) restraint scale (Stunkard AJ & Messick S, 1985).
[c] Score 13-21 on TFEQ restraint scale.
[d] Means values differ significantly (ANOVA).

Table 55. Characteristics explaining variance in total BMD

Characteristic[a]	R Square	Significant F	B	Beta (β)	Significant T
Exercise group	0.113	0.009	0.039	0.280	0.026
Waist (cm)	0.182	0.003	0.040	0.269	0.032

[a] Characteristics in the stepwise multiple regression analysis equation

Table 56. Characteristics explaining variance in total BMC

Characteristic[a]	R Square	Significant F	B	Beta (β)	Significant T
Weight (kg)	0.462	0.000	26.377	0.623	0.000
Exercise group	0.508	0.000	198.202	0.333	0.003
Restraint group	0.555	0.000	-140.261	-0.234	0.018

[a] Characteristics in the stepwise multiple regression analysis equation

Total body BMD was significantly predicted by exercise group and waist circumference resulting in the following regression equation: total body BMD (g/cm^2) = 0.798 + 0.039 (exercise group) + 0.004 (waist {cm}). Weight, exercise group and restraint group were significant predictors of total body BMC resulting in the following multiple regression equation: total body BMC (g) = 727.9 + 26.4 (weight {kg}) + 198.2 (exercise group) – 140.3 (restraint group).

5.4.4.2 Women who exercise moderately

Lastly, we looked separately at women who reported exercising minimally (n = 19) or moderately (n = 41), and whether restraint level or other variables impacted on indices of bone within these two groups. Within the minimal exercise group there were too few women with high restraint scores (n = 5) to make valid comparisons between restraint groups and, therefore, only data from the moderate exercise group are presented.

When women in the moderate exercise group were grouped as high or low restraint, age and physical measurements were similar as was menstrual cycle length although the latter tended to be shorter in the low restraint group (Appendix 36). Lifestyle characteristics are reported in Appendix 37 and weight fluctuation and dieting history in Appendix 38. Values were similar. Differences in the various eating attitudes, eating behaviours and personality subscales were also similar to those reported earlier, although Perceived Stress Scale scores were not significantly different in this smaller group (Appendix 39). Analysis of 3-day food records showed women with low restraint scores had higher energy (2250.9 ± 624.0 kcal vs. 1937.3 ± 342.7 kcal, P = 0.041) and fat intakes (74.5 ± 25.6 g/d vs. 55.1 ± 23.8 g/d) compared to women with high restraint scores (Appendix 40). On the 24-hour study day absolute energy intake and energy in relation to body weight were higher in women with low restraint scores as were absolute intakes of carbohydrate and fat. Finally, protein as a percentage of energy was lower in the low restraint group. These data are presented in Appendix 41. There were no significant correlations between nutritional variables and indices of bone health within the moderate exercise group.

Women who reported moderate levels of exercise and had high restraint scores had cortisol/creatinine (Table 57) values which tended to be higher (P = 0.051) when compared to women with low restraint scores. Urinary cortisol/creatinine was negatively correlated with total BMC (r = -0.417, P = 0.009) and was also negatively related to spinal BMD (r = -0.339, P = 0.043). As observed earlier, women with high restraint scores again had lower values for 24-hour calcium excretion and calcium/creatinine tended to be higher (P = 0.051). Calcium intake from 3-day food records was positively correlated with total BMC (r = 0.422, P = 0.006 in women who exercise moderately).

Women who exercised moderately and had low restraint scores (n = 14) had higher values for total BMC and spinal BMC and tended to have higher values for spinal BMD when compared with women with high restraint scores (n = 27). These data are presented in Table 57. Values remained significant after controlling for body size (the most significantly correlated measure of body size was used as a covariate). Body composition did not differ between groups (e.g. weight, waist measurement, etc.).

Within this group of women, total BMD was positively related to menstrual cycle length as documented in menstrual cycle diaries, although this correlation was not significant ($r = 0.307$, $P = 0.051$). Women with low restraint scores tended to have shorter menstrual cycles than women with high restraint scores (27.4 ± 3.5 d vs. 29.3 ± 2.6 d, $P = 0.056$). Menstrual cycle length was correlated with BMI ($r = 0.391$, $P = 0.011$). Due to the relationship between menstrual cycle length and BMD found in this study and reported elsewhere, menstrual cycle length was used as a covariate in further analysis of bone characteristics and restraint group. The difference in total BMD was now significant ($P = 0.041$) as was the difference in spinal BMD ($P = 0.023$). The difference in total BMC ($P = 0.008$) and spinal BMC ($P = 0.049$) remained significant. The unadjusted data are presented in Table 57.

Stepwise multiple regression analysis of total body BMC resulted in weight (kg) being selected first, followed by restraint group and cortisol/creatinine. Calcium intake from 3-day food records was not a significant predictor of total BMC. The equation generated from this analysis was: total BMC (g) = 1705.5 + 21.7 (weight {kg}) – 166.5 (restraint group) – 6.5 (cortisol/creatinine). No other variables remained significant. None of the variables entered proved significant in predicting total BMD or spinal BMC and only cortisol/creatinine was predictive of spinal BMD. The following equation predicted spinal

BMD: spinal BMD (g/cm^2) = 1.307 – 0.003 (cortisol/creatinine). Multiple regression analyses are presented in Tables 58 and 59.

Table 57. Summary of urine analysis, bone analysis and body composition[a] (mean ± SD) of participants who exercise moderately according to restraint group

Characteristic	Low restraint[b] (n = 14)	High restraint[c] (n = 28)	P value
Urine Analysis	(n = 14)	(n = 27)	
Urine volume (mL)	1557 ± 755	1377 ± 437	0.436
Creatinine (mmol)[d]	11.5 ± 1.2	9.8 ± 1.6	0.002[g]
Cortisol (nmol)[e]	395.1 ± 85.5	420.9 ± 140.4	0.491
Cortisol/creatinine (nmol/mmol)	35.1 ± 7.5	43.0 ± 12.5	0.051
Calcium (mmol)[f]	4.6 ± 2.2	2.7 ± 1.4	0.003[g]
Calcium/creatinine (mmol/mmol)	0.4 ± 0.2	0.3 ± 0.1	0.051
Body Composition	(n = 14)	(n = 28)	
Tissue mass (g)	56403 ± 8720	53528 ± 5738	0.277
Bone free lean tissue (g)	41106 ± 4620	38733 ± 4632	0.125
Bone free lean tissue (%)	70.2 ± 4.8	69.5 ± 5.5	0.669
Fat mass (g)	15297 ± 5037	14794 ± 3928	0.724
Body fat (%)	25.4 ± 5.0	26.4 ± 5.8	0.602
Fat free mass (g)	43660 ± 4839	41049 ± 4856	0.108
Total body	(n = 14)	(n = 27)	
BMD (g/cm^2)	1.160 ± 0.082	1.132 ± 0.055	0.266
BMC (g)	2553.86 ± 301.64	2315.30 ± 263.65	0.013[g]
Lumbar 1-lumbar 4	(n = 12)	(n = 27)	
BMD (g/cm^2)	1.224 ± 0.150	1.146 ± 0.097	0.061
BMC (g)	65.61 ± 11.21	55.73 ± 14.13	0.039[g]

[a] Measured by dual energy x-ray absorptiometry.
[b] Score 0-5 on the Three-Factor Eating Questionnaire (TFEQ) restraint scale (Stunkard AJ & Messick S, 1985).
[c] Score 13-21 on TFEQ restraint scale.
[d] Reference interval: 7.0-16.0 mmol/24 hr.
[e] Reference interval: 80.0-600.0 nmol/24 hr.
[f] Reference interval: 2.5-7.5 mmol/24 hr.
[g] Mean values differ significantly between groups (t-test).

Table 58. Characteristics explaining variance in total BMC

Characteristic[a]	R Square	Significant F	B	Beta (β)	Significant T
Weight (kg)	0.331	0.000	21.694	0.500	0.000
Restraint group	0.452	0.000	-166.472	-0.272	0.040
Cortisol/creatinine	0.514	0.000	-6.519	-0.263	0.046

[a] Characteristics in the stepwise multiple regression analysis equation.

Table 59. Characteristics explaining variance in spinal BMD

Characteristic[a]	R Square	Significant F	B	Beta (β)	Significant T
Cortisol/creatinine	0.115	0.043	-0.003	-0.339	0.043

[a] Characteristics in the stepwise multiple regression analysis equation.

5.4.5 Results Summary

5.4.5.1 Participants grouped according to TFEQ restraint scores – Summary of results with regard to hypotheses

Hypothesis 1: *Neither the 24-hour urinary excretion of cortisol nor the urinary cortisol/creatinine ratio will differ between women with low scores for dietary restraint and women with high scores for dietary restraint.*

The null hypothesis was rejected as both the 24-hour urinary excretion of cortisol and cortisol/creatinine were significantly higher in women with high scores for restraint than in women with low scores for restraint.

Hypothesis 2: *Neither the 24-hour urinary excretion of calcium nor the calcium/creatinine ratio will differ between women with low and high scores for dietary restraint.*

The null hypothesis was rejected as both calcium excretion and calcium/creatinine were lower in women with high restraint scores compared to those with low restraint scores.

Hypothesis 3: *There will be no differences in the energy, macronutrient, calcium or fibre intakes of women with low and high scores for dietary restraint when assessed by 3-day dietary intake records or during a 24-hour documented intake period.*

Differences were found in some but not all intake values from dietary food records. The following summarizes the findings:

a) Energy and nutrient intakes from 3-day food records

The two groups were similar in absolute intakes of carbohydrate, protein, cholesterol, fibre, calcium and sodium intake, and in carbohydrate and protein intakes as a percentage of energy. The calcium/protein intake ratio was also similar. Both absolute energy and fat intakes and energy expressed in relation to body weight were lower in women with high restraint scores compared to those with low restraint scores.

b) Energy and nutrient intakes from 24-hour food records

Participants consumed similar amounts of carbohydrate, protein, fibre, calcium and sodium on the 24-hour study day. Carbohydrate intake as a percentage of energy intake did not differ between the two groups nor did the calcium/protein ratio. Energy intake, both in absolute terms and in relation to body weight, was higher in women with low restraint scores. Protein as a percentage of energy was higher, and absolute fat intake, fat intake as a percentage of energy and cholesterol intakes were lower in women with high restraint scores compared with women with low restraint scores.

In comparing nutrient intakes from the 3-day food records with intakes from the 24-hour study day records correlations were found between energy, carbohydrate, and fibre intakes ($P < 0.01$). Calcium intake from 3-day food records was correlated with 24-hour carbohydrate and fibre intake. Carbohydrate intake on the study day was correlated with

energy and calcium intake from 3-day food records. Finally, fibre intake on the study day was correlated with calcium intake from 3-day food records.

Hypothesis 4: *There will be no differences in the total body or spinal bone mineral density (BMD), bone mineral content (BMC) or body composition of women with low or high scores for dietary restraint when assessed by dual energy x-ray absorptiometry (DEXA).*

The null hypothesis was not rejected as bone values for women with high scores for restraint were similar to those with low scores for restraint. However, further analysis of group differences was conducted using exercise group as a covariate due to the significant relationship between exercise and restraint, and here total body BMC was significantly lower in the high restraint group ($P = 0.018$). Later analysis of women who reported moderate levels of exercise revealed significant differences in several characteristics of bone health between women with low and high restraint scores. Women with high restraint scores who reported moderate levels of exercise had lower values for bone compared to women with low restraint scores who exercised similarly. The significance of these findings was strengthened after adjusting for menstrual cycle length.

Hypothesis 5: *Bone characteristics will not differ according to exercise level or other lifestyle variables.*

The null hypothesis was rejected as several characteristics of bone health, including total BMD and total BMC, were higher in women who reported more hours of weekly exercise. Spinal BMD (L1-L4) also was significantly higher in women who reported 2-7 hours of weekly exercise compared to those who reported exercising less than 2 hr/wk.

Hypothesis 6: *The demographic characteristics of women with low and high scores for dietary restraint will not differ.*

The null hypothesis was not rejected as demographic variables including ethnicity and university major were similar between the two groups.

5.4.5.2 Participants grouped according to exercise level – Summary of results

Women grouped according to whether they reported exercising 0- < 2 hr/wk, 2- < 3.5 hr/wk or 3.5-7 hr/wk were similar in all physical characteristics except documented menstrual cycle length which was longer in women in the lower exercise group compared with the higher exercise group. Other lifestyle characteristics were similar among groups while the percentage of women reporting having tried to lose weight was lower in the lower exercise group.

Scores on the TFEQ restraint scale were significantly lower in the lower compared with the middle and upper exercise groups. All other scores on the various scales were similar among groups. Energy, protein and fat intakes were similar among exercise groups from analysis of 3-day intake records. Carbohydrate intake in absolute terms and as a percentage of energy were highest in the upper exercise group. Fat intake as a percentage of energy was lowest in the upper exercise group. Fibre intake was also higher in the upper exercise group. Fibre intake was the only variable that differed among groups on the 24-hour study day, with higher values observed in the upper exercise group.

Several indices of bone health differed between women grouped according to the three levels of exercise but the differences were primarily found between women in the lower exercise group and both the middle and higher exercise groups. Total BMC, BMD and spinal BMD were higher in the latter two groups compared with the lower exercise group. Further analysis comparing women in the lower (grouped as minimal exercisers) and the middle and

upper exercise (grouped as moderate exercisers) did not uncover other relevant findings. The two groups were similar in physical characteristics only differing in fat free body mass as assessed by DEXA.

5.4.5.3 Dietary restraint, exercise and bone health – Summary of results

When data from women grouped as exercising moderately were analyzed separately several important findings were uncovered. As noted earlier, women in the moderate (2-7 hr/wk) exercise group had higher values for total BMC, BMD and spinal BMD than women in the minimal (< 2 hr/wk) exercise group. When women reporting moderate exercise were divided into two groups according to whether they had high or low scores for restraint, total BMC and spinal BMC were found to be lower in the high restraint group compared with the low restraint group and the difference in spinal BMD approached significance (P = 0.061). Cortisol/creatinine excretion tended to be higher in the group of women with high restraint scores although the difference was not statistically significant (P = 0.051). Similarly, calcium/creatinine excretion tended to be lower in women who exercised moderately and had high restraint scores compared with those in the low restraint group (P = 0.051). A diagrammatic summary of the findings from the analysis of exercise, dietary restraint and bone indices is presented in Figure 4.

5.5 Discussion

5.5.1 Introduction

A total of 62 women participated in Part Two of the study, which was designed primarily to address whether the 24-hour urinary excretion of cortisol differed between women with high and low scores for dietary restraint. In Part One, several hypotheses were addressed which dealt with group differences among women with different levels of dietary

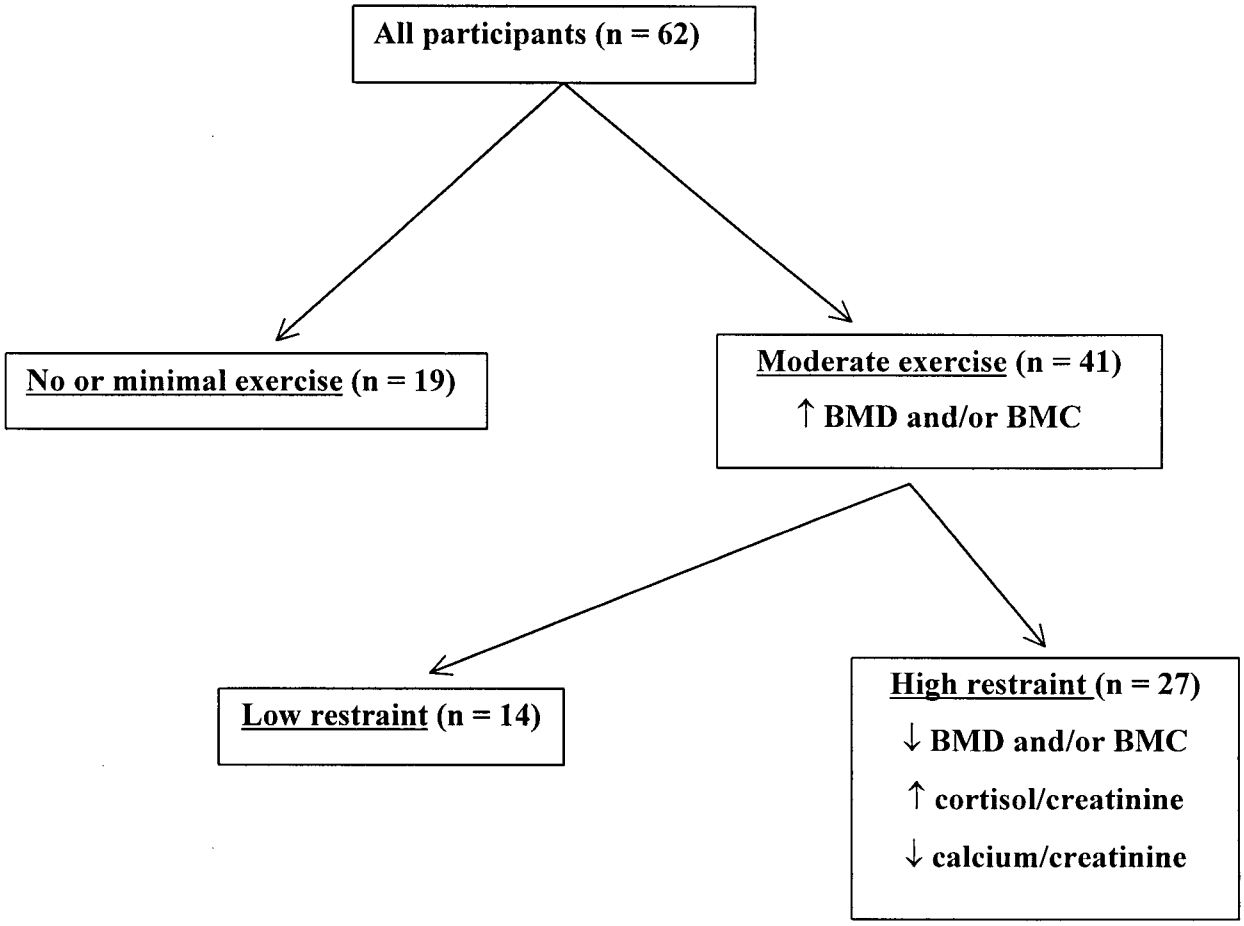

Figure 4. Overview of the relationships among exercise, dietary restraint and bone indices.

restraint in regard to physical, lifestyle and menstrual cycle characteristics as well as eating attitudes, eating behaviour and personality scale scores. In Part Two, only those characteristics which differed between groups and were not dealt with in Part One will be discussed. Accordingly, the focus of this discussion will be on the major findings of the study in relation to the study hypotheses and findings of others.

As pointed out in the results section, a significant group difference was observed in reported hours of weekly exercise between the high and low restraint groups. Therefore, the

discussion will also deal with our findings with respect to exercise level. Finally, our findings with relation to restraint group, exercise level and bone health will be addressed.

5.5.2 Dietary Restraint, Urine Analysis and Related Variables

The main finding of this study was that women with high scores for dietary restraint had higher urinary cortisol and cortisol/creatinine excretion over a 24-hour period compared to women with low scores for dietary restraint. Our central hypothesis was contingent on dietary restraint being an activator of the stress response. It was speculated that women with high scores for dietary restraint would experience more stress in relation to their daily experiences and decisions related to food intake. Stress is known to activate the hypothalamic-pituitary-adrenal (HPA) axis with the subsequent release of cortisol into the blood stream (Naylor AM et al, 1990). Higher cortisol in the blood is reflected in higher urinary excretion of cortisol after it is filtered through the kidneys. The outcome of this study supports our hypothesis and it is proposed that the observed higher levels of cortisol are a physiological reflection of a group difference in stress with regard to food-related attitudes and behaviours.

Our finding is unique among studies comparing characteristics of women with varying levels of dietary restraint as assessed by the TFEQ. The only other study which measured cortisol in women with high and low restraint scores assayed cortisol from blood samples measured at 30 minute intervals between 11:00 P.M. and 7:00 A.M. (Pirke KM et al, 1990). The present study assessed cortisol from a 24-hour urine sample in order to reflect the influence of various food related stresses throughout the day, and also to avoid the diurnal variability which is common to cortisol secretion (Miller RJ & Crapo L, 1994). Our study and that of Pirke et al differed considerably in that our central hypothesis revolved around

stress in relation to food intake. It is unlikely that food intake, or decisions related to food, would occur during the overnight hours.

This study was designed to limit or control for other variables which have previously been associated with hypercortisolism and could potentially have confounded our results. Characteristics known to be related to lower BMD were also used as exclusion criteria. Therefore, women who reported irregular menstrual cycles (Lloyd T et al, 1988) were excluded as were those who reported having been diagnosed with or treated for eating disorders (Licinio J et al, 1996). Various physiological stressors such as fasting, (Fichter MM & Pirke KM, 1984; Fichter MM et al, 1986; Fichter MM & Pirke KM, 1986) and exercise (Brenner I et al, 1998) are known to activate the HPA axis although exercise induced cortisol release appears to be dependent on the intensity and duration of the activity (Filaire E et al, 1996). In this study women with high restraint scores reported higher levels of exercise although the inclusion criterion was set at ≤ 7 hr/wk. In further analysis, hours of weekly exercise were not correlated with either cortisol or cortisol/creatinine excretion. Accordingly, it is unlikely that higher cortisol levels in women with high restraint scores were due to an increased frequency of exercise. Moreover, when the analysis was restricted to women who exercised moderately, cortisol/creatinine still tended to be higher in the high restraint group.

Food intake was carefully monitored on the day urine was collected to ensure that any difference in cortisol levels was not the result of very low energy intake or severely altered macronutrient intake. On the 24-hour study day women with high restraint scores did consume less energy and fat than those with low restraint scores although neither energy nor fat intakes correlated with cortisol or cortisol/creatinine. Women in both the high and low restraint groups consumed more energy on the study day compared with reported intake from

3-day food records. The increase in energy intake on the study day compared to that reported in food records was 8-9% in both groups, suggesting that women with high restraint scores responded similarly to the study conditions as did women with low restraint scores. The difference in energy intake may have been due to underreporting on the 3-day food records, higher consumption on the study day due to the unlimited food choices, or a combination of both factors. As observed by others (Laessle RG et al, 1989b; Tuschl RJ et al, 1990b; Alexander JM & Tepper BJ, 1995), women with high restraint scores selected lower fat foods more often than women with low restraint scores. These choices suggest that women with high restraint scores are more concerned about their fat intake and may be reducing fat as a primary means of controlling energy intake.

There was no evidence from either 3-day food records or 24-hour intake records to suggest women with high restraint scores had higher cortisol levels due to binge eating or fasting which could have activated the stress response (Cattanach L & Rodin J, 1988). This is also supported by the similarity between groups in body weight, BMI, and weight fluctuation (number of times > 5 lbs lost over the past two years).

Implicit in our hypothesis that women with high restraint scores would have higher cortisol excretion than women with low restraint scores is the supposition that cognitive dietary restraint is a stressor. In earlier research Selye (Selye H, 1956) argued that psychosocial stressors elicited the same physiological response as physical stressors, and this has been supported in the literature (Hofer MA et al, 1972). Others have suggested that it is the individual's response to the stressor as opposed to the stressor itself that determines the extent of the biological response (Lazarus RS & Folkman S, 1984). In the present study, Cohen's Perceived Stress Scale (PSS) (Cohen S et al, 1983) was used to assess whether women with high restraint scores would score higher on a measure of psychological stress

perception, which they did. Scores on the PSS were correlated with cortisol/ceatinine levels although the latter was also correlated with Rosenberg's Self-esteem scale and several subscales related to eating attitudes and behaviour. Both the difference in cortisol/creatinine excretion observed in women grouped according to restraint scores, and the correlations found among cortisol, PSS scores and Rosenberg's Self-esteem scores support the idea that higher cortisol/creatinine excretion was related to psychological as opposed to physiological variables. There were no relationships observed between cortisol excretion and physical characteristics or nutritional variables. While a difference in cortisol and cortisol/creatinine excretion was observed in women grouped according to whether they had high or low restraint scores, cortisol excretion was similar in women grouped according to either PSS or Self-esteem scores by median split. These data suggest that the difference in cortisol was not primarily due to a difference in either of these psychometric variables.

With cross-sectional data it is not possible to assess whether higher perceived stress was a predisposing factor, consequence or component of dietary restraint. Differences in personality characteristics, such as self-esteem, between women with high and low restraint scores may lead to differences in the perception of stress although this possibility would require further investigation. This study was not designed to investigate the relationship between perceived stress and cortisol excretion and presumably study criteria specifically related to this purpose would differ from those used in the present study. External stresses were assumed to be comparable between groups as all were university students, although it is possible that groups differed in this regard. While many factors differed on the study day compared to participants' normal daily experiences, and these factors may have been perceived differently by women with high restraint scores, group differences are still relevant in comparing women with high and low restraint scores.

In addition to cortisol, 24-hour urinary excretion of calcium was measured. Women with low restraint scores had higher values for calcium and calcium/creatinine excretion than women with high restraint scores although means were in the normal reference range. Calcium intake on the 24-hour study day was similar between groups suggesting that the drift in excretion was not related to a difference in intake. Calcium intake was also similar between groups according to 3-day food records although intake was about 200 mg lower on the study day. Although the observed difference in calcium excretion was not anticipated there are theoretical possibilities for the discrepancy in light of the differing levels of cortisol excretion. Several articles reviewing the research regarding cortisol and bone health have noted that an inverse relationship exists between circulating levels of cortisol and calcium absorption (Canalis E, 1996; Lukert BP & Raisz LG, 1990; Reid IR, 1997). Malabsorption of calcium is a consistent finding in patients treated with cortisol and may be observed within the first two weeks of treatment. A reduction in calcium absorption would likely lead to a reduction in excretory losses to protect the body's calcium balance (Heaney RP, 1991). Therefore, it is possible that lower excretion of calcium in women with high restraint scores reflects a cortisol-induced decrease in calcium absorption at the gut level. Interestingly, calcium intake on the study day was positively correlated with calcium excretion in the total study group and in the low restraint group, but not in the high restraint group. Women with high restraint scores may have retained more dietary calcium than women with low restraint scores, but there does not seem to be a physiological explanation for this possibility. It is more plausible that women with high restraint scores excreted less calcium due to lower absorption.

According to Reid's review article (Reid IR, 1997), cortisol is also known to increase calcium in the urine due to its impact on the kidney, although the balance between effects at

the intestinal level and the kidney are unclear. In the present study there does not appear to have been an effect of cortisol on the kidney. It is possible that higher levels of cortisol are needed before a negative effect on renal reabsorption occurs. While many of the mechanisms through which cortisol influences calcium balance are known, the relative importance of each is not fully understood. The finding that women with high restraint scores had both higher cortisol and lower calcium excretion may have implications for long term bone health. It has long been recognized that cortisol negatively affects bone through its influence on bone formation, bone resorption, calcium entry into the body in the gut, and calcium exit from the body in the renal tubule (Reid IR, 1997). Bone health is partially dependent on the maximization of peak bone mass during the first three decades of life (Lloyd T et al, 1987). Exposure to higher levels of cortisol during these years may decrease the potential for achieving maximum bone mass through the mechanisms previously mentioned. If low calcium excretion is reflective of lower absorption this could impact on long-term bone health as calcium is a major contributor to the attainment of higher bone mineral density during the developmental years (Heaney RP, 1991).

Cortisol is known to have direct negative effects on bone but it also impacts negatively on bone indirectly through effects on menstrual cycle function (Lukert BP & Raisz LG, 1990). More accurately, menstrual function is impaired by hormones which precede and stimulate the release of cortisol from the adrenal cortex (Rivier C et al, 1986; Barbarino A et al, 1989, Biller, 1990; Rivier C ,Vale W, 1984; Petraglia F et al, 1987). Cortisol is secreted in response to adrenocorticotropic hormone (ACTH) from the anterior pituitary. ACTH is itself secreted under control of the hypothalamic peptide, corticotropic-releasing hormone (CRH), which is increased during stress (Naylor AM et al, 1990). Cortisol-related menstrual dysfunction is actually the result of higher CRH in the

hypothalamus which interrupts the release of gonadotropin-releasing hormone (GnRH) resulting in decreased levels of circulating gonadotropins; luteinizing hormone (LH) and follicle stimulating hormone (FSH). Decreased levels of LH and FSH lead to a decrease in ovarian hormones with associated menstrual cycle and ovulatory irregularities (Prior JC et al, 1990; Prior JC, 1990; Patel S, 1996). Lower levels of reproductive hormones are generally associated with bone loss, regardless of the cause (Cann CE et al, 1984; Davies MC et al, 1990; Drinkwater BL et al, 1984). This study was set up to determine if a relationship exists between cognitive dietary restraint and cortisol excretion in regularly menstruating women. Women with irregular menstrual cycles were excluded from participation to prevent the confounding effect of reproductive hormonal differences on bone characteristics. Only women who reported regular menstrual cycles between 21 and 35 days in length were included in the present study. By excluding women from this study who reported irregular cycles we may have excluded those who had even higher levels of cortisol as they would have been more likely to experience menstrual disturbances.

Menstrual cycle length was similar between restraint groups and documented records confirmed cycles were of normal length. Although cycles were of normal length, this does not preclude the presence of subclinical or ovulatory menstrual disturbances (De Souza MJ et al, 1998) as the study was not designed to detect ovulatory disturbances. Previous studies have indicated an association between dietary restraint and minor ovulatory disturbances (Schweiger U et al, 1992; Barr SI et al, 1994a; Barr SI et al, 1994b). If, as was the case in the present study, dietary restraint was associated with higher cortisol, then the higher levels of cortisol may have contributed to the observed ovulatory disturbances in previous studies.

5.5.3 Dietary Restraint, Exercise and Bone Health

An important positive association was observed in Part One of this study between dietary restraint level and exercise. This relationship was confirmed in Part Two although the sample size was smaller and the inclusion criterion was set at $\leq$ 7 hr/wk of exercise. In most studies using the TFEQ restraint scale either exercise level has not been evaluated or exclusion criteria prevented any observable differences (Platte, 1996). A study by Kanarek et al (Kanarek RB et al, 1995) did report that dietary restraint and exercise were significantly correlated ($r = 0.549$, $P < 0.01$) although group means were not given. As commented on in Part One, exercise may be used by women with more concerns about weight and body image as a means of regulating weight.

The finding that exercise differed between restraint groups led to an examination of interrelationships among restraint, exercise and all other study variables. Women were initially grouped into three levels of exercise (0- < 2 hr/wk; 2- < 3.5 hr/wk; 3.5-7 hr/wk) based on self-reported activity sufficient to raise one's heart beat. Restraint scores were higher in the upper two exercise groups compared with the lower group again supporting the connection between exercise and dietary restraint.

Of primary interest to this study was the observation that several indices of bone health increased with increasing exercise level. The differences were primarily between the lowest exercise group and both the middle and upper groups. We, therefore, grouped the middle and upper exercise groups together as 'moderate exercise' and compared them with the lower or 'minimal exercise' group. Differences were found in bone characteristics and these remained significant after correcting for the effect of body size by using the most significantly correlated variable (weight or waist measurements). Bone and body size measures are normally correlated as weight and height include a bone component (Ilich JZ et

al, 1998) although there is also believed to be a positive effect of body size on bone, independent of the collinearity of these measures. Body weight is believed to affect BMD by increasing the mechanical stress placed on the skeleton and creating a stimulus for osteogenesis (Madsen KL et al, 1998). Similarly, exercise is hypothesized to increase the stress on bone increasing osteogenesis (Heaney RP, 1996). Our finding that women who reported exercising moderately had higher indices of bone health than those who reported exercising minimally concurs with recent reviews of other cross-sectional studies (Drinkwater BL, 1996; Rutherford OM, 1997). While it is true that cross-sectional studies indicate only an association between activity and bone measures, the literature is quite extensive and consistent in this area and provides strong support for a positive influence of moderate physical activity on bone mass. What is equivocal, and not documented in the present study, is the type and intensity of exercise that is most effective in maximizing and maintaining BMD. An earlier study by Nilsson and Westlin (Nilsson BE & Westlin NE, 1971) reported the highest BMD in male weight lifters followed by throwers, runners, soccer players, swimmers and controls with the latter two groups being comparable. In general, similar results have been reported in a review of female athletes with weight bearing exercise being more beneficial than nonweight bearing activities (Rutherford OM, 1997).

We did not anticipate associations between bone characteristics and dietary restraint as this study was not powered to detect such differences, although these data were collected. Initial analysis appeared to confirm our expectations as body composition and bone characteristics of women with high and low restraint scores were similar. Further investigation after controlling for exercise group and correcting for body size suggested at least a trend was present towards lower values for bone variables in women with high restraint scores. Here spinal BMD and BMC tended to be lower in the high restraint

compared to the low restraint group, and the difference in total BMC between groups was significant. In regression analysis, weight and exercise group were positive predictors of total BMC while restraint group entered the equation as a negative predictor. If an inverse relationship between dietary restraint and bone mass is confirmed, high levels of restraint may be a risk factor for bone loss over time. In reviewing the literature only one study (Barr SI et al, 1994a) was found which assessed BMD in women with high and low restraint scores and values in this study were similar between restraint groups. Barr et al did not anticipate finding a group difference in bone characteristics as there were only 9 women in each group and there is large individual variability in BMD. In the latter study exercise was not considered.

Over two-thirds of the participants (n = 41) reported exercising moderately and this group was separately assessed to evaluate whether different levels of restraint, or other variables, were related to the observed higher bone values. The same analysis was not feasible in the minimal exercise group as only 5 women in this group had high restraint scores making the detection of group differences unlikely. When women who reported moderate levels of exercise were grouped according to whether they had high or low restraint scores, some important relationships were detected. Notable was the finding that several characteristics of bone health differed between women with high and low restraint scores who reported a similar number of hours of weekly exercise. Women with high restraint scores had lower values for total body BMC, spinal BMC and the difference in spinal BMD approached significance. While these data must be interpreted cautiously, the findings suggest that dietary restraint, or factors associated with dietary restraint, may offset some of the positive benefits of moderate exercise on bone health. Body composition and body size

were similar between women with high and low restraint scores and the two groups did not differ in other lifestyle or physical characteristics which may have affected bone indices.

Investigating the possible factors mediating the relationship between dietary restraint and bone health led us back to cortisol. It was established that cortisol/creatinine excretion was still higher in the high restraint group compared with the low restraint group, although the difference did not attain significance with the smaller group size ($P = 0.051$). Correlation analysis revealed that the cortisol/creatinine ratio was negatively associated with total BMC and spinal BMD in women who exercise moderately and was the only significant predictor of spinal BMD in multiple regression analysis. Cortisol/creatinine was also a negative predictor of total BMC (after weight and restraint group) in moderate exercisers. These findings do not confirm that higher cortisol/creatinine mediates the relationship between dietary restraint and bone health, but are in accord with the known relationship between bone and cortisol as reported in the scientific literature (Canalis E, 1996; Hahn TJ, 1978; Baylink DJ, 1983). As an association has been found between dietary restraint and cortisol/creatinine, and cortisol has been inversely related to indices of bone health, it follows that women with high restraint scores may be inclined towards lower bone values compared with women with low restraint scores. Although mean cortisol values were within the normal range in both the high and low restraint groups, it is possible that long term exposure to even moderately higher circulating cortisol levels in the high restraint group may affect the attainment or maintenance of peak bone mass.

Another factor which may be a component of the observed association between dietary restraint and bone is calcium balance. As observed earlier in the total study group, calcium and calcium/creatinine excretion were lower in the high restraint group in spite of calcium intake being similar between groups, although again this was slightly above the

significance level (P = 0.051). Even in this smaller sample, a positive correlation was observed between calcium intake and calcium/creatinine excretion in the total group (n = 41) and in women with low restraint scores (n = 14) but not in women with high restraint scores (n = 27). The possibility that lower calcium excretion in women with high restraint scores may be related to greater retention was refuted by the finding that total BMC was actually lower in the high restraint group. This provides further support for the contention that lower calcium excretion may be due to lower absorption in women with high restraint scores. This could be confirmed by studies assessing calcium intake and intestinal absorption in women with high and low restraint scores. If lower renal calcium excretion is the result of the body's attempt to offset lower calcium absorption in women with high restraint, it may not be enough to offset the negative effect that lower absorption could have on bone (Heaney RP, 1991).

The last factor to be considered in the relationships among restraint, exercise and bone health is the menstrual cycle. In the present group of women who reported moderate levels of exercise, a positive relationship was observed between menstrual cycle length and total BMD, although this relationship was not significant (P = 0.051). When menstrual cycle length was controlled for, total BMD, total BMC, spinal BMD and spinal BMC were all significantly lower in women with high restraint scores compared to those with low restraint scores. A shorter menstrual cycle length may mean bone is exposed to osteogenic reproductive hormones for less time and this may be reflected in bone indices (Prior JC et al, 1990; De Souza MJ et al, 1997). In athletic women reduced BMD is more common in amenorrheic than eumenorrheic athletes (Cann CE et al, 1984; Drinkwater BL et al, 1984; Marcus R et al, 1985). While overt menstrual cycle irregularities appear to differentiate between athletic women with lower BMD and those without, the relationship between more

subtle irregularities (such as anovulation, short cycle or luteal phase lengths) and bone health is less clear (Prior JC, 1990; Waller K et al, 1996; De Souza MJ et al, 1997; Winters KM et al, 1996).

The findings of this study indicate that an inverse relationship may exist between dietary restraint and bone health and that this association may be mediated by several factors. The analysis of 24-hour urine samples demonstrated that women with high scores for restraint had higher cortisol and lower calcium excretion than women with low scores for restraint. Exercise was positively related to restraint and indices of bone health. In women who exercise moderately high levels of restraint were negatively associated with several measures of bone and this relationship was strengthened when menstrual cycle length was considered. These relationships require further investigation as there are potential consequences for long term bone health if they are confirmed in longitudinal studies.

5.6 Study Limitations

The results of this study revealed important relationships among dietary restraint, exercise and bone health but were limited in identifying the specific types of exercise practised by participants. This information would have contributed to the findings as different activities have different implications for bone health.

This study attempted to control for variables that could activate a physiological stress response but it was not possible to control for all external stressors. Life stress may have been greater in women with high restraint scores and could possibly be assessed with additional questions. We attempted to assess this through use of the Perceived Stress Scale (PSS) but it is limited in scope. Although this study found a relationship between scores on the PSS and the TFEQ restraint scale it was not designed to investigate this association.

Physical documentation of menstrual cycle, including ovulatory function would have provided useful information in evaluating the relationships among dietary restraint, cortisol and bone health. It is important to determine if and when ovulation occurs because anovulation, or alterations in cycle phase length, may negatively impact on bone health. Although participants were asked to keep menstrual cycle diaries from which an estimate could be made of when and whether ovulation had occurred, this was voluntary and compliance low.

5.7 Future Research

This cross-sectional study has found a difference in urinary cortisol/creatinine excretion between women with high and low scores for dietary restraint. As higher cortisol levels may predispose women with high restraint scores to increased bone loss and the risk of osteoporosis, longitudinal research is needed to determine if this was a transient finding or if it persists over time.

Self-reported exercise was higher in women with high scores for dietary restraint and further research is needed to understand the interrelationships among dietary restraint, exercise, and bone health. While moderate exercise may be positive for bone health, dietary restraint or associated factors may prevent the full benefits of exercise being achieved. Again, longitudinal research is needed to clarify our observations.

Both quantitative and qualitative research methods may be used to develop a better understanding of what the motivations are for participation in various forms of physical activity. As a strong relationship was observed in this study between dietary restraint and exercise it suggests that women with high restraint scores may be using exercise to control body weight. A scale could be developed which examines reasons for exercise and how

exercise level relates to food intake and body weight. Qualitative methods using interviews or focus groups could be used to help develop suitable items for such a scale.

This study found an interesting inverse association between dietary restraint and calcium excretion in women with similar calcium intakes. Further studies are needed to determine if and how dietary restraint affects calcium balance. Calcium balance studies measuring calcium intake and fecal excretion would clarify whether lower urinary calcium excretion is the result of a decrease in absorption at the intestinal level or other factors. In these studies, cortisol should also be measured due to the known relationship between higher cortisol and lower calcium absorption.

Prospective studies are needed in the area of dietary restraint, cortisol, menstrual cycle function and bone health, controlling for exercise level, as the long term implications of the present findings are not known. There appears to be interrelationships among these variables that need to be clarified. Relationships among dietary restraint, cortisol and menstrual cycle function could be assessed over several months providing the sample size was large enough. To detect associations between monitored variables and measurements of bone would require a follow-up period of several years.

5.8 Conclusions

Unique to this study is the finding that women with high scores for dietary restraint had higher urinary cortisol/creatinine excretion compared with women with low restraint scores. Cortisol/creatinine levels were not correlated with anthropometric measurements, lifestyle characteristics, nutritional intake or weight fluctuation. As this study controlled for factors known to initiate the stress response, the positive relationship between dietary restraint and cortisol/creatinine excretion supports our hypothesis that restraint is a psychological stressor with corresponding physiological responses from the neuroendocrine

system. Higher circulating cortisol has long term implications for bone health and the relationship observed in this study suggests a possible mechanism for an association between dietary restraint and bone loss.

In addition to cortisol, urinary calcium values differed between restraint groups with lower excretion in the high restraint group. This difference may be due to a cortisol-induced decrease in calcium absorption in the gut as intake was similar between groups. Higher calcium retention is also possible but unlikely in the high restraint group as this was not supported by the findings of DEXA analysis. Alterations in calcium balance may lead to a reduction in BMD or BMC with an increase in associated fracture risk.

This study concurs with the existing body of cross-sectional studies which have found differences in BMD and BMC between moderate and minimal exercisers. What it adds to the research is the finding that within groups of women who exercise moderately, high levels of dietary restraint may be a limiting factor in the maximization or maintenance of bone mass. While exercise level was assessed crudely, other variables such as bone characteristics, cortisol and calcium excretion, were assessed with more precision and the findings suggest that further investigation into the relationships among restraint, exercise, cortisol and bone health is merited.

Many women today are very aware of their food intake and are consciously monitoring the quantity and quality of their diet. These attempts at dietary restraint are generally believed to be innocuous. The results of this study provide evidence that this may not be the case, and in fact, women with high scores for dietary restraint may be at increased risk for bone loss. Intervention and education may be warranted if the findings of the present study are found to persist over time as bone loss may lead to an increased risk for osteoporosis and subsequent fracture.

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Part 1.

Please circle whether the statements below are true (T) or false (F) for you.

				Do not use
1.	When I smell the aroma of my favourite food, I find it very difficult to keep from eating, even if I have just finished a meal	T	F	___
2.	I usually eat too much at social occasions, like parties and picnics	T	F	___
3.	I am usually so hungry that I eat more than three times a day	T	F	___
4.	When I have eaten my quota of calories, I am usually good about not eating any more	T	F	___
5.	Dieting is so hard for me because I just get too hungry	T	F	___
6.	I deliberately take small helpings as a means of controlling my weight	T	F	___
7.	Sometimes things just taste so good that I keep on eating even when I am no longer hungry	T	F	___
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	T	F	___
9.	When I feel anxious, I find myself eating	T	F	___
10.	Life is too short to worry about dieting	T	F	___
11.	Since my weight goes up and down, I have gone on reducing diets more than once	T	F	___
12.	I often feel so hungry that I just have to eat something	T	F	___
13.	When I am with someone who is overeating, I usually overeat too	T	F	___
14.	I have a pretty good idea of the number of calories in common food	T	F	___
15.	Sometimes when I start eating, I just can't seem to stop	T	F	___
16.	It is not difficult for me to leave something on my plate	T	F	___

17. At certain times of the day, I get hungry because I have gotten used to eating then ..... T F ___

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 ..... T F ___

19. Being with someone who is eating often makes me hungry enough to eat also ..... T F ___

20. When I feel blue, I often overeat ..... T F ___

21. I enjoy eating too much to spoil it by counting calories or watching my weight ..... T F ___

22. When I see a real delicacy, I often get so hungry that I have to eat right away ..... T F ___

23. I often stop eating when I am not really full as a conscious means of limiting the amount I eat ..... T F ___

24. I get so hungry that my stomach often seems like a bottomless pit ..... T F ___

25. My weight has hardly changed at all in the last two years ..... T F ___

26. I am always hungry so it is hard for me to stop eating before I finish the food on my plate ..... T F ___

27. When I feel lonely, I console myself by eating ..... T F ___

28. I consciously hold back at meals in order not to gain weight ..... T F ___

29. I sometimes get very hungry late in the evening or night ..... T F ___

30. I eat anything I want, any time I want ..... T F ___

31. Without even thinking about it, I take a long time to eat ..... T F ___

32. I count calories as a conscious means of controlling my weight ..... T F ___

33. I do not eat some foods because they make me fat ..... T F ___

34. I am always hungry enough to eat at any time ..... T F ___

35. I pay a great deal of attention to changes in my figure ..... T F ___

36. While on a diet, if I eat a food that is not allowed, I often then splurge and eat other high calorie foods ..... T F ___

Part II.

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 5 lbs affect the way you live your life?

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

39. How often do you feel hungry?

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

40. Do your feelings of guilt about overeating help you to 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 likely	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/week	almost daily	_____

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 weekly	_____

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? (please circle the number)

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 'giving in'
5 constantly limit food intake, never 'giving in' _____

51. To what extent does this statement describe your eating behaviour? "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	a little like me	pretty good description of me	describes me perfectly	_____

Part III.

Read each question and circle the number (0-5) which applies best for you. Please answer each question very carefully.

1. I eat sweets and carbohydrates without feeling nervous

0	1	2	3	4	5
never	rarely	sometimes	often	usually	always

2. I think that my stomach is too big

0	1	2	3	4	5
never	rarely	sometimes	often	usually	always

3. I wish that I could return to the security of childhood

0	1	2	3	4	5
never	rarely	sometimes	often	usually	always

4. I eat when I am upset

0	1	2	3	4	5
never	rarely	sometimes	often	usually	always

5. I stuff myself with food

0	1	2	3	4	5
never	rarely	sometimes	often	usually	always

6. I wish that I could be younger

0	1	2	3	4	5
never	rarely	sometimes	often	usually	always

7. I think about dieting

0	1	2	3	4	5
never	rarely	sometimes	often	usually	always

8. I get frightened when my feelings are too strong

0	1	2	3	4	5
never	rarely	sometimes	often	usually	always

9. I think that my thighs are too big

0	1	2	3	4	5
never	rarely	sometimes	often	usually	always

10. I feel ineffective as a person

0	1	2	3	4	5
never	rarely	sometimes	often	usually	always

11. I feel extremely guilty after overeating

0	1	2	3	4	5
never	rarely	sometimes	often	usually	always

12. I think that my stomach is just the right size

0	1	2	3	4	5
never	rarely	sometimes	often	usually	always

13. Only outstanding performance is good enough in my family

0	1	2	3	4	5
never	rarely	sometimes	often	usually	always

14. The happiest time in life is when you are a child

0	1	2	3	4	5
never	rarely	sometimes	often	usually	always

15. I am open about my feelings

0	1	2	3	4	5
never	rarely	sometimes	often	usually	always

16. I am terrified of gaining weight

0	1	2	3	4	5
never	rarely	sometimes	often	usually	always

17. I trust others

0	1	2	3	4	5
never	rarely	sometimes	often	usually	always

18. I feel alone in the world

0	1	2	3	4	5
never	rarely	sometimes	often	usually	always

19. I feel satisfied with the shape of my body

0	1	2	3	4	5
never	rarely	sometimes	often	usually	always

20. I feel generally in control of things in my life

0	1	2	3	4	5
never	rarely	sometimes	often	usually	always

21. I get confused about what emotion I am feeling

0	1	2	3	4	5
never	rarely	sometimes	often	usually	always

22. I would rather be an adult than a child

0	1	2	3	4	5
never	rarely	sometimes	often	usually	always

23. I can communicate with others easily

0	1	2	3	4	5
never	rarely	sometimes	often	usually	always

24. I wish I were someone else

0	1	2	3	4	5
never	rarely	sometimes	often	usually	always

25. I exaggerate or magnify the importance of weight

0	1	2	3	4	5
never	rarely	sometimes	often	usually	always

26. I can clearly identify what emotion I am feeling

0	1	2	3	4	5
never	rarely	sometimes	often	usually	always

27. I feel inadequate

0	1	2	3	4	5
never	rarely	sometimes	often	usually	always

28. I have gone on eating binges where I have felt that I could not stop

0	1	2	3	4	5
never	rarely	sometimes	often	usually	always

29. As a child, I tried very hard to avoid disappointing my parents and teachers

0	1	2	3	4	5
never	rarely	sometimes	often	usually	always

30. I have close relationships

0	1	2	3	4	5
never	rarely	sometimes	often	usually	always

31. I like the shape of my buttocks

0	1	2	3	4	5
never	rarely	sometimes	often	usually	always

32. I am preoccupied with the desire to be thinner

0	1	2	3	4	5
never	rarely	sometimes	often	usually	always

33. I don't know what's going on inside me

0	1	2	3	4	5
never	rarely	sometimes	often	usually	always

34. I have trouble expressing my emotions to others

0	1	2	3	4	5
never	rarely	sometimes	often	usually	always

35. The demands of adulthood are too great

0	1	2	3	4	5
never	rarely	sometimes	often	usually	always

36. I hate being less than best at things

0	1	2	3	4	5
never	rarely	sometimes	often	usually	always

37. I feel secure about myself

0	1	2	3	4	5
never	rarely	sometimes	often	usually	always

38. I think about bingeing (overeating)

0	1	2	3	4	5
never	rarely	sometimes	often	usually	always

39. I feel happy that I am not a child anymore

0	1	2	3	4	5
never	rarely	sometimes	often	usually	always

40. I get confused as to whether or not I am hungry

0	1	2	3	4	5
never	rarely	sometimes	often	usually	always

41. I have a low opinion of myself

0	1	2	3	4	5
never	rarely	sometimes	often	usually	always

42. I feel that I can achieve my standards

0	1	2	3	4	5
never	rarely	sometimes	often	usually	always

43. My parents have expected excellence of me

0	1	2	3	4	5
never	rarely	sometimes	often	usually	always

44. I worry that my feelings will get out of control

0	1	2	3	4	5
never	rarely	sometimes	often	usually	always

45. I think my hips are too big

0	1	2	3	4	5
never	rarely	sometimes	often	usually	always

46. I eat moderately in front of others and stuff myself when they're gone

0	1	2	3	4	5
never	rarely	sometimes	often	usually	always

47. I feel bloated after eating a small meal

0	1	2	3	4	5
never	rarely	sometimes	often	usually	always

48. I feel that people are happiest when they are children

0	1	2	3	4	5
never	rarely	sometimes	often	usually	always

49. If I gain a pound, I worry that I will keep gaining

0	1	2	3	4	5
never	rarely	sometimes	often	usually	always

50. I feel that I am a worthwhile person

0	1	2	3	4	5
never	rarely	sometimes	often	usually	always

51. When I am upset, I don't know if I am sad, frightened or angry

0	1	2	3	4	5
never	rarely	sometimes	often	usually	always

52. I feel that I must do things perfectly or not do them at all

0	1	2	3	4	5
never	rarely	sometimes	often	usually	always

53. I have the thought of trying to vomit in order to lose weight

0	1	2	3	4	5
never	rarely	sometimes	often	usually	always

54. I need to keep people at a certain distance (feel uncomfortable if someone tries to get too close)

0	1	2	3	4	5
never	rarely	sometimes	often	usually	always

55. I think that my thighs are just the right size

0	1	2	3	4	5
never	rarely	sometimes	often	usually	always

56. I feel empty inside (emotionally)

0	1	2	3	4	5
never	rarely	sometimes	often	usually	always

57. I can talk about personal thoughts or feelings

0	1	2	3	4	5
never	rarely	sometimes	often	usually	always

58. The best years of your life are when you become an adult

0	1	2	3	4	5
never	rarely	sometimes	often	usually	always

59. I think my buttocks are too large

0	1	2	3	4	5
never	rarely	sometimes	often	usually	always

60. I have feelings I can't quite identify

0	1	2	3	4	5
never	rarely	sometimes	often	usually	always

61. I eat or drink in secrecy

0	1	2	3	4	5
never	rarely	sometimes	often	usually	always

62. I think that my hips are just the right size

0	1	2	3	4	5
never	rarely	sometimes	often	usually	always

63. I have extremely high goals

0	1	2	3	4	5
never	rarely	sometimes	often	usually	always

64. When I am upset, I worry that I will start eating

0	1	2	3	4	5
never	rarely	sometimes	often	usually	always

65. I eat high fat foods without feeling guilty

0	1	2	3	4	5
never	rarely	sometimes	often	usually	always

Part IV

The questions in this scale ask you about your feelings and thoughts during the last month. In each case you will be asked how *often* you felt or thought a certain way. Although some of the questions are similar, there are differences between them and you should treat each one as a separate question. The best approach is to answer each question fairly quickly.

Please answer the following questions by circling the number above the response which best applies to you.

1. In the last month, how often have you been upset because of something that happened unexpectedly?

0	1	2	3	4
never	almost never	sometimes	fairly often	very often

2. In the last month, how often have you felt that you were unable to control the important things in your life?

0	1	2	3	4
never	almost never	sometimes	fairly often	very often

4. In the last month, how often have you dealt successfully with irritating life hassles?

0	1	2	3	4
never	almost never	sometimes	fairly often	very often

5. In the last month, how often have you felt that you were effectively coping with important changes that were occurring in your life?

0	1	2	3	4
never	almost never	sometimes	fairly often	very often

6. In the last month, how often have you felt confident about your ability to handle your personal problems?

0	1	2	3	4
never	almost never	sometimes	fairly often	very often

7. In the last month, how often have you felt that things were going your way?

0	1	2	3	4
never	almost never	sometimes	fairly often	very often

8. In the last month, how often have you found that you could not cope with all the things that you had to do?

0	1	2	3	4
never	almost never	sometimes	fairly often	very often

9. In the last month, how often have you been able to control irritations in your life?

0	1	2	3	4
never	almost never	sometimes	fairly often	very often

10. In the last month, how often have you felt that you were on top of things?

0	1	2	3	4
never	almost never	sometimes	fairly often	very often

11. In the last month, how often have you been angered because of things that happened that were outside of your control?

0	1	2	3	4
never	almost never	sometimes	fairly often	very often

12. In the last month, how often have you found yourself thinking about things that you have to accomplish?

0	1	2	3	4
never	almost never	sometimes	fairly often	very often

13. In the last month, how often have you been able to control the way you spend your time?

0	1	2	3	4
never	almost never	sometimes	fairly often	very often

14. In the last month, how often have you felt difficulties were piling up so high that you could not overcome them?

0	1	2	3	4
never	almost never	sometimes	fairly often	very often

Part V

Please record the appropriate answer per item, depending on whether you strongly agree, agree, disagree, or strongly disagree with it.

1 = Strongly agree

2 = Agree

3 = Disagree

4 = Strongly disagree

_____ 1. On the whole, I am satisfied with myself.

_____ 2. At times I think I am no good at all.

_____ 3. I feel that I have a number of good qualities.

_____ 4. I am able to do things as well as most people.

_____ 5. I feel I do not have much to be proud of.

_____ 6. I certainly feel useless at times.

_____ 7. I feel that I'm a person of worth, at least on an equal plane with others.

_____ 8. I wish I could have more respect for myself.

_____ 9. All in all, I am inclined to feel that I am a failure.

_____ 10. I take a positive attitude towards myself.

Part VI. Information About You

The following information will help us interpret the results of the questionnaire. It's very important that all questions be completed. If you don't know the exact value for any of the questions, give us your best estimate.

Demographic Data

What is your present age?

_____years

How tall are you (without shoes)?

_____cm, or ____feet____inches

What is your present weight (without clothes)?

_____kgs, or _____lbs

Weight History

What has been your highest adult (18 yrs. or older) weight?

_____kg, or _____lbs

What has been your lowest adult (18 yrs. or older) weight?

_____kg, or _____lbs

At what weight do you feel your best?

_____ kg, or _____lbs

Have you ever tried to lose weight?

_____yes

_____no

Are you presently trying to lose weight?

_____yes

_____no

How many times, in the past 2 years, have you lost more than 5 pounds? _____

Menstrual Cycle Information

Are you currently having menstrual cycles?

_____no (If you aren't having menstrual cycles, skip to the section called "Other Information")

_____yes, irregularly

_____ yes, regular cycles

Are you currently taking birth control pills?

_____no

_____yes

Have you taken birth control pills in the past 6 months?

_____no

_____yes

On what day did your last menstrual cycle begin?

_____

What is today's date?

_____

What is the average length of your menstrual cycle? (* note-this is **not** the number of days you menstruate for, but is how many days from the beginning of one menstrual cycle until the start of the next e.g. June 3-June 28 = 25 days)

_____

Have you ever been pregnant?

_____yes _____ no

Other Information

How many hours of exercise do you do each week? (by 'exercise' we mean activity of sufficient intensity to raise your heart rate)

_____hours

What type(s) of exercise do you participate in?

_____

_____

_____

Have you ever been diagnosed with or treated for an eating disorder? yes____ no____

Are you currently on any of the following diets?

Lacto-ovo vegetarian (no meat, poultry or fish but including dairy products such as milk, cheese, yoghurt and eggs) yes____ no____

Vegan (no animal products of any kind) yes____ no____

Other (please describe)

_____

_____

How many cups of caffeinated beverage (coffee or tea) do you drink in a day?

_____

Do you smoke cigarettes?

yes____ no____

What is the average number of drinks of alcohol you consume in a week? (eg 1 drink = 1 beer or cider, 3 oz (100 ml) wine, 1 oz (30 ml) hard liquor)

_____

Please list any medications you are currently taking:

_____

_____

_____

Are you currently taking any vitamin or mineral supplements?

yes____ no____

If yes, please list which vitamin and / or mineral (or in the case of a multivitamin the brand name), in what dosage and how frequently you take it (if known).

Vitamin/mineral name	Dosage	Frequency
(eg calcium)	(e.g. 500 mg)	(e.g. one per day)
_____	_____	_____
_____	_____	_____

PLEASE CHECK AND SEE THAT YOU HAVE ANSWERED ALL QUESTIONS!

THANK-YOU!

If you would like a summary of our results, please fill in this section. If you wish to maintain your anonymity, this section can be detached and handed in separately.

Name: _____

Permanent Address: _____

_____

_____

Appendix 2. Pre-test Questionnaire

We (Judy McLean, Ph.D. student & Dr. Susan I. Barr), are currently pre-testing a questionnaire which pertains to women's eating behaviour, related personality characteristics, and physical attributes. In order to determine the appropriateness of this instrument we are asking your assistance in completing the questionnaire and then answering the following questions.

How long did it take you to complete the questionnaire?_____

Was this a reasonable length of time?_yes____ no____

Were the instructions clear? yes____ no____

Did you find any of the questions offensive? yes____ no____

If yes, please state the Part # and Question #._____

_____

_____

_____

_____

Would this have prevented you from completing the questionnaire? yes____ no____

Did you find any questions difficult to understand? yes____ no____

If yes, please state the Part # and Question #._____

_____

_____

_____

Would you have answered this questionnaire if requested to under ordinary circumstances?

yes____ no____

Other comments (Please use the back if necessary):_____

_____

_____

Thanks for your help!

Appendix 5. The Restraint Scale Questions of the TFEQ

	Question	Percent completed
4.	When I have eaten my quota of calories, I am usually good about not eating any more.	95.9
6.	I deliberately take small helpings as a means of controlling my weight.	99.1
10.	Life is too short to worry about dieting.	99.1
14.	I have a pretty good idea of the number of calories in common food.	99.8
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.	94.9
21.	I enjoy eating too much to spoil it by counting calories or watching my weight.	98.9
23.	I often stop eating when I am not really full as a conscious means of limiting the amount I eat.	99.2
28.	I consciously hold back at meals in order not to gain weight.	99.1
30.	I eat anything I want, any time I want.	99.4
32.	I count calories as a conscious means of controlling my weight.	99.4
33.	I do not eat some foods because they make me fat.	99.5
35.	I pay a great deal of attention to changes in my figure.	99.5
37.	How often are you dieting in a conscious effort to control your weight?	99.5
38.	Would a weight fluctuation of 5 lbs affect the way you live your life?	99.7
40.	Do your feelings of guilt about overeating help you to control your food intake?	99.2
42.	How conscious are you of what you are eating?	99.5
43.	How frequently do you avoid 'stocking up' on tempting foods?	99.7
44.	How likely are you to shop for low calorie foods?	100

46.	How likely are you to consciously eat slowly in order to cut down on how much you eat?	100
48.	How likely are you to consciously eat less than you want?	100
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?	99.7

Appendix 6. The Disinhibition Scale Questions of the TFEQ

	Question	Percent completed
1.	When I smell the aroma of my favorite food, I find it very difficult to keep from eating, even if I have just finished a meal.	99.2
2.	I usually eat too much at social occasions, like parties and picnics.	99.7
7.	Sometimes things just taste so good that I keep on eating even when I am no longer hungry.	99.8
9.	When I feel anxious, I find myself eating.	99.4
11.	Since my weight goes up and down, I have gone on reducing diets more than once.	98.8
13.	When I am with someone who is overeating, I usually overeat too.	99.8
15.	Sometimes when I start eating, I just can't seem to stop.	100.0
16.	It is not difficult for me to leave something on my plate.	99.7
20.	When I feel blue, I often overeat.	99.5
25.	My weight has hardly changed at all in the last two years.	97.1
27.	When I feel lonely, I console myself by eating.	99.1
31.	Without even thinking about it, I take a long time to eat.	99.5
36.	While on a diet, if I eat a food that is not allowed, I often then splurge and eat other high calorie foods.	95.5
45.	Do you eat sensibly in front of others and splurge alone?	100
49.	Do you go on eating binges though you are not hungry?	100
51.	To what extent does this statement describe your eating behaviour? '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.'	99.7

Appendix 7. The Hunger Scale Questions of the TFEQ

	Question	Percent completed
3.	I am usually so hungry that I eat more than three times a day.	100
5.	Dieting is so hard for me because I just get too hungry.	96.2
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.	99.1
12.	I often feel so hungry that I just have to eat something.	99.2
17.	At certain times of the day, I get hungry because I have gotten used to eating then.	99.7
19.	Being with someone who is eating often makes me hungry enough to eat also.	99.2
22.	When I see a real delicacy, I often get so hungry that I have to eat right away.	98.3
24.	I get so hungry that my stomach often seems like a bottomless pit.	98.9
26.	I am always hungry so it is hard for me to stop eating before I finish the food on my plate.	98.9
29.	I sometimes get very hungry late in the evening or night.	99.4
34.	I am always hungry enough to eat at any time.	99.5
39.	How often do you feel hungry?	99.7
41.	How difficult would it be for you to stop eating halfway through dinner and not eat for the next four hours?	99.7
47.	How frequently do you skip dessert because you are no longer hungry?	97.9

Appendix 8. Rationale for Selected Scales

a.) Three-Factor Eating Questionnaire

Covered in the literature review section.

b.) The Eating Disorder Inventory (EDI)

The EDI is a widely used self-report measure of symptoms commonly associated with anorexia nervosa and bulimia nervosa (Garner DM et al, 1983). It consists of 64 items that provide standardized subscale scores on eight dimensions that are clinically relevant to eating disorders. These subscales are, Drive for Thinness, Bulimia, Body Dissatisfaction, Ineffectiveness, Perfectionism, Interpersonal Distrust, Interoceptive Awareness and Maturity Fears. The first three subscales assess attitudes and behaviours concerning eating, weight, and shape, while the last five subscales assess general psychological traits relevant to eating disorders.

A revised edition of the EDI (Garner DM & Olmstead MP, 1991), has added 27 items that comprise three additional scales (Asceticism, Impulse Regulation, and Social Insecurity). Most of the published research pertaining to the psychometric properties of the EDI has been conducted using the original version of the EDI. For this reason, and also out of concerns for the length of the questionnaire, the original version has been used.

Primarily the questionnaire will be used to provide comparative data between study population and other comparable studies of university women and eating related attitudes and behaviours. Also, participants with high scores on subscales strongly correlated with eating disorders will be carefully reviewed prior to acceptance into Part Two of the study as eating disorders are part of the exclusion criteria.

The following is a descriptive summary of the eight scales of the EDI.

1) Drive for thinness – Excessive preoccupation with weight and dieting, and intense pursuit of thinness.

2) Bulimia – Tendency towards episodes of uncontrollable overeating and self-induced vomiting.
3) Body dissatisfaction – Dissatisfaction with the *"maturational"* areas of the body (thighs, hips, etc.).
4) Ineffectiveness – Feelings of general inadequacy, insecurity , and not being in control of one's life.
5) Perfectionism – Excessive and unrealistic standards for one's behavior and achievements.
6) Interpersonal distrust – Tendency to avoid intimate, open communication and relationships with others.
7) Interoceptive awareness – Confusion and apprehension about emotional experience, and difficulty identifying emotions and bodily sensations.
8) Maturity fears – Yearnings for childhood, and reluctance to assume adult responsibilities.

c.) Perceived Stress Scale.

The Perceived Stress Scale (PSS) is a brief and easy-to-administer measure of the degree to which situations in one's life are appraised as stressful (Cohen S et al, 1983). PSS items were designed to tap the degree to which respondents found their lives unpredictable, uncontrollable, and overloaded. These three issues have been repeatedly found to be central components of the experience of stress.

The PSS has been shown to possess substantial reliability and validity and is, therefore, a useful tool for investigating the role of appraised stress in the etiology of disease and behavioural disorders. The PSS was designed for use with community samples with at least a junior high school education. The questions are quite general in nature and hence relatively free of content specific to any subpopulation group.

d.) Rosenberg's Self-esteem Scale

Rosenberg's Self-esteem Scale is the most widely used instrument for measuring the construct of self-esteem (Rosenberg M, 1965). It consists of 10 items which respondents rate on a 4-point Likert-type scale from strongly agree to strongly disagree. When coded according to Rosenberg's directions, scores range from 0-7. Lower scores indicate higher self-esteem.

Because the Rosenberg's Self-esteem Scale scale has been in existence for many years, norms from many samples have been produced from large sample sizes. The coefficient alpha for the scale on a sample of more than 5000 students was 0.77. A test-retest reliability coefficient of 0.73 was reported for a sample of 990 Canadian high school students. The Rosenberg's Self-esteem Scale has received strong support as a single-factor scale making it an appropriate tool for use in assessing self-esteem in this study.

Appendix 9. EDI Subscale Scores (mean ± SD) from Female College Sample (Garner DM & Olmstead MP, 1991) and Present Study

EDI subscale	Female College Group (n = 205)	Present Study (n = 278)
Drive for thinness	5.5 ± 5.5	4.4 ± 5.4
Bulimia	1.2 ± 1.9	1.2 ± 2.2
Body Dissatisfaction	12.2 ± 8.3	9.2 ± 7.9
Ineffectiveness	2.3 ± 3.6	2.8 ± 4.4
Perfectionism	6.2 ± 3.9	5.9 ± 4.2
Interpersonal distrust	2.0 ± 3.1	2.1 ± 2.7
Interoceptive awareness	3.0 ± 3.9	2.3 ± 3.6
Maturity fears	2.7 ± 2.9	3.5 ± 4.2

Appendix 10. Follow-up Letter A

Dear ------,

Thank-you very much for completing the Eating Behaviour, Personality Characteristics and Physical Attributes Questionnaire which was distributed in your classroom this fall. In particular, I would like to thank you for filling in the 'Interested In More' section. Based on the inclusion/exclusion criteria listed below it has been determined that you would be an appropriate candidate for this study.
Inclusion criteria include:

- 20-35 years of age
- not having given birth
- experiencing cycles of normal length (21-35 days)
- weight stable (weight change not > 2.5 kg in the past year)
- BMI between 18-25 kg/m^2
- stable exercise habits ($\leq$ 7 hours/week)

Exclusion criteria include:

- use of oral contraceptives within the past six months
- cigarette smoking
- use of glucocorticoids or other bone active drugs within the past 6 months
- chronic use of medications
- shift workers or other unusual sleep or waking patterns
- presently dieting
- overt eating disorders

I will be contacting you within the next ten days to discuss the study further and arrange a meeting time.

Thanks again!

Judy McLean

Appendix 12. Follow-up Letter C

Dear ------,

Thank-you very much for completing the Eating Behaviour, Personality Characteristics and Physical Attributes Questionnaire which was distributed in your classroom this fall. In particular, I would like to thank you for filling in the 'Interested In More' section. Based on the inclusion/exclusion criteria listed below it has been determined that you would be an appropriate candidate for this study.

Inclusion criteria include:

- 20-35 years of age
- not having given birth
- experiencing cycles of normal length (21-35 days)
- weight stable (weight change not > 2.5 kg in the past year)
- BMI between 18-25 kg/m^2
- stable exercise habits ($\leq$ 7 hours/week)

Exclusion criteria include:

- use of oral contraceptives within the past six months
- cigarette smoking
- use of glucocorticoids or other bone active drugs within the past 6 months
- chronic use of medications
- shift workers or other unusual sleep or waking patterns
- presently dieting
- overt eating disorders

Unfortunately, I am unable to finish the analysis of your questionnaire as there are one or more unanswered questions. I have highlighted the relevant questions and ask that you try and give the best possible answer and return the form to me in the enclosed envelope. After the analysis is completed I will be contacting you to discuss the study further, and arrange a meeting time.

Thanks again!

Judy McLean

Appendix 13. Interview Form

Name _____

Interview date _____

Questionnaire 2 completed _____

Cycle 1, Day 1 _____

Food record dates _____

Food record cycle days _____

Cycle 2, Day 1 _____

Study Day _____

DEXA _____

Comments _____

_____

_____

_____

_____

_____

_____

_____

_____

_____

-do not use medications which may affect bone (e.g. steroids)

-have not been diagnosed with or treated for an eating disorder

-not presently dieting

- consume $\leq$ 7 drinks of alcohol per week

-do not have unusual sleep or waking patterns

-do not have clinical hirsutism (excessive facial hair)

I understand that if I do not fit the above criteria I must be excluded from the study.

I understand that as a participant in this study, I will be required to:

1. Complete a questionnaire that will take about 20-30 minutes of my time.
2. Have my weight, height, waist and hips measured.
3. Complete a 3-day record of all dietary intake during the first eight days of a subsequent menstrual cycle.
4. Collect all urine for a single 24-hour period during the first eight days of a later menstrual cycle.
5. Consume only food that has been provided by the investigators and prepared at the Nutritional Sciences Building at U.B.C. for the 24-hour period of the urine collection.
6. Undergo bone density and body composition analysis by dual energy x-ray absorptiometry (DEXA) at Vancouver Hospital at date scheduled after the 24-hour urine collection day. (This is a noninvasive method for assessing bone mineral density and body composition through the use of a low dose of radiation. The amount of radiation received is equivalent to spending several hours outdoors.)

I understand that I will be requested to keep a menstrual cycle diary from now until my participation in the study is complete (approximately 3 months) but that this is not a requirement for participation. I understand that this will take about five minutes per day.

Appendix 15. Data Collection Sheet for Anthropometric Measurements

Name:_____ Age:_____

Date:_____

WEIGHT:

Trials: #1 _____ kg #2_____ kg

Average:_____kg

HEIGHT: #1 _____cm_____mm #2 _____cm_____mm

Average: _____cm_____mm

WAIST: _____cm

HIP:_____cm

WAIST: HIP RATIO _____

BMI = _____kg / m^2

Appendix 17. Rationale for Anthropometry

Anthropometry includes the measurement of body weight, height, waist and hip measurements. Measurement errors are the greatest sources of error in anthropometry (Gibson RS, 1990). Anthropometric measurements are important to this study for between group comparisons between women with high scores for dietary restrained and women with low scores for dietary restraint and to compare these values to those determined in other studies.

Body Mass Index (BMI)

The Body Mass Index (BMI – kg/m^2) is considered to be the best index for the assessment of obesity in adult population groups, as it is the least biased by height and is easily calculated (Gibson RS, 1990). It has been found to have a greater content validity than skinfold thickness measurements, but similar concurrent validity. BMI also presents a high degree of precision, reliability, accuracy, and client acceptability. It is easy to measure and not time consuming. This method makes no adjustment for age or sex, nor does it provide any indication of the amount of risk.

Waist/Hip Ratio

Since adiposity has been related to cardiovascular risk, there have been attempts to develop equations which would predict risk. It has been found that a ratio of waist circumference to hip circumference is a strong predictor of stroke and myocardial infarction in both sexes and of total mortality in women. When the ratio exceeds 1.0 in men and 0.8 in women, the risk rises steeply (Zeman FJ, 1991). The waist/hip ratio can be measured more precisely than skinfolds, and provides an index of both subcutaneous and intra-abdominal adipose tissue (Gibson RS, 1990).

Appendix 18. Three-day Dietary Intake Rationale

A 3-day dietary intake record is being used to compare participants' recorded food intake with their 24-hour consumption on the study day, and also to compare results with findings from other studies.

An advantage of food records is that they do not rely on memory for accuracy as intake is recorded at the time food is consumed. They also can provide information regarding subjects' food selections. Disadvantages include the following: inaccurate recording, alterations to normal intake patterns to reflect social desirability, alteration of eating patterns to facilitate completion of records, difficulties in estimating restaurant meal contents, and food records require highly motivated subjects. Underreporting is a common problem with all food records. In addition, a single 3-day food record will probably not reflect the true variability of the subjects' diets (Gibson RS, 1990).

A 3-day record was chosen over a longer time period to increase compliance and reduce the likelihood of subjects making alterations to their normal intake pattern. Again, although there are many inherent problems with food records they still provide useful information for between group comparisons regarding energy, macronutrient and fibre intake as well as food choices.

Appendix 19. Three-day Dietary Intake Guidelines

An accurately completed 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 consumed during this 3-day period.

Please keep a record of **everything** you eat or drink on the attached forms for three days in a row. **Please be as specific and detailed as possible.**

- To ensure accuracy please try to record immediately after eating.
- The more accurately you record, the more meaningful is 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 for assessment purposes that accurate measurements be recorded. It may be helpful to measure the volume of your regular glasses, bowls and cups before you begin.

- Use 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 if a tablespoon is 'heaping' as opposed to 'level'.

• Use WEIGHTS (ounces or grams) for meat, fish, poultry, cheese. Use the labels on packages to help you. If you are dining out, record the size of the piece of meat e.g. sirloin steak 3" by 4" by ½" , or hamburger patty 3" diameter by ½".

• Use SIZES for whole fruits, whole vegetables, cookies, cakes, eggs, cheese pieces etc. Either specify small, medium or large or give dimensions. In some cases it may be more appropriate to give size in relation to a whole.
e.g. ½ medium pepperoni pizza, cheddar cheese 2" by 3" by 1", 1 small apple, 1 large bran muffin

3. THE BRAND NAMES OR TYPE OF FOOD. For example:

- Kraft Dinner - 1 cup
- 1% milk
- Benny's whole wheat bagel
- 4 Oreo cookies

1. THE TIME OF DAY the foods and beverages were consumed.

Appendix 20. Three-day Food Record Forms

Name

Date	Time	Complete Description of Food or Beverage	Portion Size

Date	Time	Complete Description of Food or Beverage	Portion Size

Date	Time	Complete Description of Food or Beverage	Portion Size

Was this a fairly typical day? _____yes _____no

If not, please give reason(s):

Appendix 21. General 24-hour Menu Description

The general meal plan was designed to provide an appetising variety of foods that would allow subjects to make choices regarding the quantity of food consumed during this period as well as the types of food, particularly when it comes to high and low fat selections. The selection of dairy products included: whole, 2% and skim milk; regular and lite cream cheese; and butter or margarine. Also, higher fibre choices were available in the bread and cereal selections. Sandwich spread was available in low fat or regular.

In order to accommodate any vegetarians who may be participating in the study, selections were offered that did not include animal products. Snacks were to be provided for subjects to take away from the study centre although uneaten portions were to be returned. Consumption of any other food or beverages (other than water) other than what was provided was to be reported. The importance of compliance was stressed.

Appendix 22. Study Day Menu

Breakfast

Your choice of cold cereal; Raisin Bran, Sugar Frosted Flakes, Cheerios

Milk Selections; 2%, or skim

Bagels; multigrain or sesame with cream cheese (regular or lite) or butter and jam

Fruit; oranges, apples, bananas

Beverages; milk, pop, juices

Snacks

Assorted snack bars, cookies, veggie sticks, fruit, bagels, juices, pop

Lunch

Selections from our Sandwich Board:

Your Choice of bread; Multigrain or Sesame White

Fillings; cheese, ham, beef, smoked turkey breast, avocado,

lettuce, cucumbers, tomatoes

Plus; mayonnaise (regular or lite), butter or margarine, Dijon mustard

Dessert Choices; cake, cookies, fruit

Beverages; milk, pop, juices

Snacks As Above

Dinner

Penne Pomodoro (tube shaped pasta with tomato, basil sauce)

Grilled Lemon Herb Boneless Chicken Breast

Assorted breads

Mixed Greens with choice of dressing

Dessert Choices - cake, cookies, fruit

Beverages; milk, pop, juices

Snacks -as above

Appendix 23. Total 24-hour Dietary Intake Form

Name _____

Date	Time	Complete Description of Food or Beverage	Amount Taken	Remaining		Consumed	

Appendix 24. Urine Collection Instructions and Urine Collection Form

URINE COLLECTION INSTRUCTION

WHEN: All urine should be collected for the 24-hour period which has been identified as your 'study day'.

HOW: You will be given a large plastic collection bottle, a wide-mouthed jar and a large plastic funnel.

Upon rising on the study day, void and discard the first voided urine. Note the time below. Begin collecting for the 24-hour period. Thus, the final specimen would be collected at the same time as the first discarded void on the previous day - that is, exactly 24-hours later. Record the time which collection began and ended on the following form.

It is easiest to use the wide mouthed jar for collection and the plastic funnel to aid in transferring the urine to the plastic collection bottle.

It is not necessary to refrigerate the sample. Bring the collection bottle, jar and funnel to the study centre on the day following your study day. Alternatively, if you require the sample to be picked up simply notify the investigator, Judy Mclean.

Name:_____

I started my urine collection on (date)_____ at (time)_____.

I ended my urine collection on (date)_____at (time)_____.

Appendix 25. Urine Collection Rationale

A single 24-hour urine collection was chosen for following reasons:

1. Subjects are unlikely to comply to a longer time period.
2. The potential for collection error is increased with each day.
3. This time frame should be adequate to detect group differences in the proposed sample size.
4. A shorter time period would be influenced by diurnal variation.

In order to compare the urinary excretion of the cortisol and calcium to standards for this age group as well as for group comparisons, it is imperative that 24-hour urine collections be complete and accurately timed. In order to verify that the collection is complete creatinine excretion will be measured. Creatinine, which is excreted in the urine, is a breakdown product of creatine phosphate, a metabolite present primarily in the muscle. Because it is excreted at a relatively constant rate it is commonly used to monitor the completeness of 24-hour urine collection although it is acknowledged that these determinations will only detect gross errors (Gibson RS, 1990). Creatinine normally is formed in an amount proportionate to muscle mass, and its urinary excretion is related to the amount of skeletal mass. Creatinine excretion is considered to provide a reasonable approximation of total skeletal muscle mass (Rikimaru T et al, 1989). Several factors such as age, emotional stress, strenuous exercise, dietary intake of meat, and day-to-day variability are known to affect creatinine excretion (Gibson RS, 1990). A ratio of nutrient to creatinine (e.g. calcium/creatinine) will be calculated to adjust the values for lean body mass.

Among healthy adults in the steady-state who are consuming diets providing about 800 mg Ca/d the net intestinal absorption averages about 160 mg/d. In order to maintain the steady state with no net bone resorption or formation the kidneys must excrete 160 mg Ca/d. In fact, urinary Ca ranges from 40 to 300 mg/d due to individual variation in the efficiency of Ca absorption, net bone resorption, glomerular filtration rate and other dietary and hormonal

factors. Measurements of urinary calcium/creatinine provide useful information regarding bone metabolism. Fasting values for urinary calcium/creatinine in premenopausal amenorrheic women have been found to be significantly higher than in matched eumenorrheic controls (Goulding A et al, 1989).

The measurement of 24-hour urinary free cortisol provides a useful index of adrenal cortisol secretion in healthy subjects. Circulating cortisol follows a diurnal pattern in healthy individuals (Kathol R, 1991). Levels are highest in the morning after waking and lowest in the evening. A 24-hour urinary cortisol measurement is the method of choice because it is not subject to the diurnal pattern of secretion. The cortisol/creatinine ratio allows for differences in excretion and between individual comparisons.

Appendix 26. Bone Density and Body Composition by DEXA – Rationale

Dual Energy X-Ray Absorptiometry (DEXA)

Bone mineral analysis plays an important role in both detecting and managing osteoporosis and other forms of metabolic bone disease (Sartoris DJ & Resnick D, 1989). Bone densitometry has been found to be a sensitive, noninvasive method that permits early detection of trabecular bone loss before symptomatic disease appears. DEXA relies on the differential x-ray attenuation of tissues to provide estimates of bone mineral and fat. These systems emit x-rays at two different energies and as they pass through tissues they are attenuated relative to the tissue type's mass attenuation coefficient. In bone mineral, phosphorous and calcium have high mass attenuation and are easily separated from surrounding soft tissues using computer algorithms (Young H et al, 1993). Soft tissues also differ in their attenuation of x-rays due to their different basic composition. Fat and fat-free tissue can be differentiated due to the difference in x-ray attenuation of the two energies. Whole body estimates of fat, fat-free soft tissues, bone mineral mass and density can be made simultaneously with DEXA. The fat mass represents the total fat present in the body and the fat-free soft tissues are all nonmineral, fat-free tissues.

DEXA appears to be the most appropriate choice for accuracy, precision, stability, cost, subjects radiation dose (< 1 mrem) and compliance, freedom to select skeletal sites, and speed and ease of scanning (Sievanen H et al, 1992). It provides the ability to detect small changes in bone mineral with a precision of better than 1% and requires only about 30 minutes for completion.

Also, since modern commercial DEXA scanners are quite stable throughout their operating life, and since their precision and accuracy rely on high technology and advanced signal processing techniques, a scanners' effect on overall precision becomes relatively small and constant (Sievanen H et al, 1992).

Appendix 27. Menstrual Cycle Diary

UNDERSTANDING YOUR MENSTRUAL CYCLE

Menstrual Cycle Diary

The menstrual cycle is created by over a dozen hormones changing in a complex and coordinated manner. Hormones of the ovary, pituitary, and uterus work together to create cyclic symptoms and signs during your cycle. We are asking you to complete this form on a daily basis because you can learn to notice important features about your menstrual cycle.

Please start filling in the form on the evening of the first day of your period. The scale at the top is from 0 to 4; zero represents something you did not experience and four represents the worst it has ever been for you. The scale at the bottom uses letters to indicate as factors go up or down from your usual '(U)' or normal state. Although the form is mostly self-explanatory, a few explanations and samples are provided.

Flow:

You are requested to provide two indicators of menstrual flow. The first is the number of pads and/or tampons you use each day of flow. If you use a combination of pads and tampons, enter the combined total for that day (4 tampons/3 pads = 7). The second is your assessment of flow, from 0=none to 4=very intense. A "4" is clots or pad change every hour.

Name: _____ Month: March Year: 1993

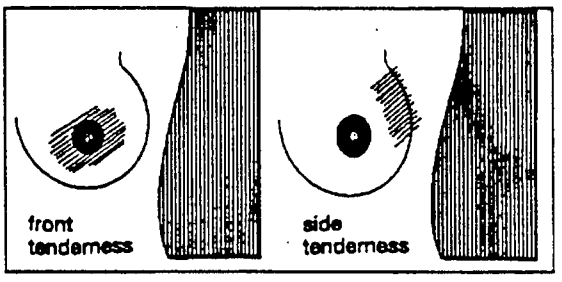
Cycle Day	1	2	3	4	5	6	7	8	9	10	11	12	13
Date	12	13	14	15	16	*Continued*							
Tampons/pads/day	4	4	3	2	0								

Record 0 = none, 1 = minimal, 2 = moderate, 3 = moderately intense, 4 = very intense

Amount Flow	3	3	2	1	0								

Breast Tenderness:

You are being asked to note both front and/or side breast tenderness. Below is a diagram of the general areas of your breast that you should touch firmly with the palm of your hand to determine if you have breast tenderness there. There may be very little soreness, but the pressure will feel different from the same pressure on your leg, for example.



Mucous Secretions:

The amount of the uterus (cervix) makes a clear stretchy fluid when estrogen levels are high. A "4" means you can stretch the mucus out for 6-8 cm (3-4") between pieces of toilet tissue paper.

Record 0 = none, 1 = minimal, 2 = moderate, 3 = moderately intense, 4 = very intense

Amount Flow	3	3	2	1	0	*Continued*						
Cramps	4	2	0	0	0							
Breast Tenderness: Front	0	0	0	0	0							
Breast Tenderness: Side	0	0	0	0	0							
Mucous Secretion	0	0	0	0	0							

Stress and Feelings:

You are asked to record how anxious you feel each day using 0-4 scale on the top section of the form. In addition, we would like you to evaluate the amount of outside stress in your life (Stress - work, home, etc.). These two things are sometimes different — your day may have been awful but you can still feel good about yourself and not depressed or anxious.

Please write your comments at the bottom of the column. This may include any particular event which influenced how you felt that day (eg illness, a job promotion, winning a major prize, argument with partner). Additional comments may be entered on the back of the form.

Record M = much less, L = a little less, U = usual, Y = a little increased, Z = much increased

Appetite	L	U	U	U	U	*Continued*							
Stress - work, home, etc.	U	U	U	U	Y								

Menstrual Cycle Diary

Name: _____ Month: _____ Year: _____

Cycle Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Date																															
Tampons/pads/day																															

Record 0 = none, 1 = minimal, 2 = moderate, 3 = moderately intense, 4 = very intense

Amount Flow																															
Cramps																															
Breast Sore: Front																															
Breast Sore: Side																															
Mucous Secretion																															
Feeling Anxious																															

Record M = much less, L = a little less, U = usual, Y = a little increased, Z = much increased

Appetite																															
Outside stresses																															
Comments (feeling sick, poor sleep, etc.)																															

Menstrual Cycle Diary

Name: _____ Month: _____ Year: _____

Cycle Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Date																															
Tampons/pads/day																															

Record 0 = none, 1 = minimal, 2 = moderate, 3 = moderately intense, 4 = very intense

Amount Flow																															
Cramps																															
Breast Sore: Front																															
Breast Sore: Side																															
Mucous Secretion																															
Feeling Anxious																															

Record M = much less, L = a little less, U = usual, Y = a little increased, Z = much increased

ppetite																															
Outside stresses																															
Comments (feeling sick, poor sleep, etc.)																															

Appendix 28. Reasons for Subject Exclusion from Analysis

1. Hospitalized – admitted to UBC Psychiatric.
2. BMI dropped to 17.2 kg/m^2.
3. Medication use – prednisone (Crohn's Disease).
4. Menstrual cycle length – from menstrual cycle records = average of 42 days.
5. Concerned about DEXA after Vancouver newspaper article.

Appendix 29. Physical Characteristics (mean ± SD) of Participants who Reported Exercising Minimally (0- < 2 hr/wk) or Moderately (2-7 hr/wk)

Characteristic	0- < 2 (hr/wk) (n = 20)	2-7 (hr/wk) (n = 42)	P value
Age (y)	21.2 ± 1.31	21.9 ± 2.9	0.185
Height (cm)	161.1 ± 7.1	164.1 ± 7.1	0.127
Weight (kg)	53.5 ± 7.2	57.0 ± 6.7	0.065
BMI (kg/m^2)	20.5 ± 1.7	21.1 ± 1.8	0.218
Highest BMI (kg/m^2)[a]	22.1 ± 2.6	22.5 ± 1.8	0.537
Lowest BMI (kg/m^2)[b]	19.6 ± 1.7	19.8 ± 1.7	0.698
Best BMI (kg/m^2)[c]	20.0 ± 1.3	20.1 ± 1.2	0.802
Waist (cm)	65.4 ± 4.6	67.2 ± 4.1	0.127
Hip (cm)	88.6 ± 6.0	89.6 ± 5.8	0.549
Waist/hip (cm/cm)	0.74 ± 4.9	0.75 ± 4.2	0.318
Menstrual cycle length (d)[d]	29.6 ± 3.3	28.1 ± 3.0	0.084
Menstrual cycle length (d)[e]	31.0 ± 3.5	28.7 ± 3.0	0.008[f]

[a] Calculated from weight given as 'highest adult weight'.
[b] Calculated from weight given as 'lowest adult weight'.
[c] Calculated from weight given as 'best adult weight'.
[d] Self-reported menstrual cycle length.
[e] Documented menstrual cycle length.
[f] Mean values differ significantly between groups (t-test).

Appendix 30. Lifestyle Characteristics of Participants who Reported Exercising Minimally (0- < 2 hr/wk) or Moderately (2-7 hr/wk)

Characteristic	0- < 2 (hr/wk) (n = 20)	2-7 (hr/wk) (n = 42)	P value
Coffee or tea (cups/d)[a]	0.9 ± 0.9	1.1 ± 1.0	0.416
Alcohol (drinks/wk)[a]	0.65 ± 1.4	1.1 ± 1.5	0.226
Exercise (hr/wk)[a]	0.9 ± 0.4	3.8 ± 1.4	0.000[b]
Vegetarian	15.0%	9.5%	0.524
Using vitamin/mineral supplements	40.0%	42.9%	0.831

[a] Mean ± SD.
[b] Mean values differ significantly between groups (t-test).

Appendix 31. Weight Fluctuation and Dieting History of Participants who Reported Exercising Minimally (0- < 2 hr/wk) or Moderately (2-7 hr/wk)

Characteristic	0- < 2 (hr/wk) (n = 20)	2-7 (hr/wk) (n = 42)	P value
Presently trying to lose weight	25.0%	54.8%	0.028[a]
Ever tried to lose weight	45.0%	88.1%	0.000[a]
Weight fluctuation[b,c]	1.1 ± 0.91	1.2 ± 0.82	0.552

[a] Percentages differ significantly between groups (chi-square).
[b] Mean ± SD.
[c] Number of times > 5 lbs lost during the past two years.

Appendix 32. TFEQ[a] Subscale, Perceived Stress Scale[b], Rosenberg's Self-esteem Scale[c] and EDI[d] Subscale Scores (mean ± SD) of Participants who Reported Exercising Minimally (0- < 2 hr/wk) or Moderately (2-7 hr/wk)

Characteristic	0- < 2 (hr/wk) (n = 20)	2-7 (hr/wk) (n = 42)	P value
TFEQ restraint	5.3 ± 5.9	11.1 ± 5.9	0.001[e]
TFEQ disinhibition	5.1 ± 3.7	5.9 ± 4.2	0.465
TFEQ hunger	6.4 ± 2.8	5.6 ± 3.3	0.394
Perceived stress	26.7 ± 6.7	27.0 ± 7.6	0.871
Self-esteem	1.2 ± 1.1	1.5 ± 1.6	0.364
EDI[f] drive for thinness	2.3 ± 4.9	4.9 ± 5.8	0.092
EDI bulimia	0.8 ± 1.5	0.8 ± 2.0	0.953
EDI body dissatisfaction	7.6 ± 8.6	9.4 ± 8.9	0.447
EDI ineffectiveness	1.0 ± 2.3	3.1 ± 4.8	0.026[e]
EDI perfectionism	5.6 ± 5.4	6.1 ± 5.0	0.790
EDI interpersonal distrust	1.2 ± 1.5	2.5 ± 3.3	0.030[e]
EDI interoceptive awareness	1.1 ± 1.9	2.3 ± 3.7	0.097
EDI maturity fears	3.8 ± 4.5	3.5 ± 3.4	0.782

[a] TFEQ = Three-Factor Eating Questionnaire (Stunkard AJ & Messick S, 1985).
[b] Perceived Stress Scale (Cohen S et al, 1983).
[c] Rosenberg's Self-esteem Scale (Rosenberg M, 1965). Lower scores indicate higher self-esteem.
[d] EDI = Eating Disorder Inventory (Garner DM & Olmstead MP, 1984).
[e] Mean values differ significantly between groups (t-test).

Appendix 33. Mean Energy and Nutrient Intakes from 3-day Food Records (mean ± SD) of Participants who Reported Exercising Minimally (0- < 2 hr/wk) or Moderately (2-7 hr/wk)

Characteristic	0- <2 (hr/wk) (n = 20)	2-7 (hr/wk) (n = 42)	P value
Energy (kcal)	2120.5 ± 495.9	2041.9 ± 472.4	0.549
Energy (kcal/kg body wt)	40.1 ± 9.6	36.1 ± 8.3	0.100
Carbohydrate (g)	288.1 ± 88.5	299.2 ± 80.0	0.622
Carbohydrate (%)	53.6 ± 5.6	58.1 ± 10.3	0.029[a]
Protein (g)	97.2 ± 69.7	81.0 ± 30.1	0.203
Protein (%)	16.1 ± 40.1	15.4 ± 4.1	0.530
Fat (g)	71.4 ± 20.2	61.6 ± 25.8	0.140
Fat (%)	30.0 ± 3.8	26.3 ± 8.0	0.018[a]
Cholesterol (mg)	204.0 ± 71.7	208.3 ± 128.4	0.888
Fibre (g)	17.2 ± 6.3	20.4 ± 8.6	0.145
Calcium (mg)	783.0 ± 381.8	820.3 ± 364.9	0.712
Calcium/protein (mg/g)	9.2 ± 4.6	11.0 ± 4.7	0.175
Sodium (mg)	2937. 3 ± 953.0	2988.3 ± 1217.6	0.870

[a] Mean values differ significantly between groups (t-test).

Appendix 34. Twenty-four Hour Energy and Nutrient Intakes (mean ± SD) of Participants who Reported Exercising Minimally (0- < 2 hr/wk) or Moderately (2-7 hr/wk)

Characteristic	0- <2 (hr/wk) (n = 20)	2-7 (hr/wk) (n = 42)	P value
Energy (kcal)	2305.1 ± 473.0	2221.8 ± 584.3	0.580
Energy (kcal/kg body wt)	43.4 ± 9.2	39.3 ± 10.7	0.143
Carbohydrate (g)	373.6 ± 88.2	369.9 ± 102.0	0.889
Carbohydrate (%)	62.4 ± 5.6	64.5 ± 6.3	0.212
Protein (g)	75.5 ± 20.5	73.7 ± 16.7	0.719
Protein (%)	12.5 ± 2.0	13.2 ± 2.1	0.238
Fat (g)	65.6 ± 20.4	58.2 ± 23.5	0.249
Fat (%)	25.0 ± 5.1	22.4 ± 6.0	0.103
Cholesterol (mg)	74.3 ± 42.7	53.5 ± 35.1	0.047[a]
Fibre (g)	25.0 ± 7.9	27.2 ± 8.8	0.332
Calcium (mg)	597.7 ± 304.6	610.1 ± 336.7	0.890
Calcium/protein (mg/g)	7.7 ± 2.8	8.2 ± 4.5	0.649
Sodium (mg)	2190.5 ± 567.3	2306.1 ± 634.4	0.491

[a] Mean values differ significantly between groups (t-test).

Appendix 35. Twenty-four Hour Urine Sample Analysis (mean ± SD) of Participants who Reported Exercising Minimally (0- < 2 hr/wk) or Moderately (2-7 hr/wk)

Characteristic	0- < 2 (hr/wk) (n = 19)	2-7 (hr/wk) (n = 39)	P value
Urine volume (ml)	1265.6 ± 513.1	1436.8 ± 559.6	0.266
Creatinine (mmol)[a]	9.0 ± 1.8	10.3 ± 1.7	0.006[d]
Cortisol (nmol)[b]	334.4 ± 74.2	412.7 ± 125.1	0.020[d]
Cortisol/creatinine (nmol/mmol)	38.4 ± 11.7	40.5 ± 11.6	0.538
Calcium (mmol)[c]	2.9 ± 1.6	3.4 ± 1.9	0.389
Calcium/creatinine (mmol/mmol)	0.34 ± 0.18	0.33 ± 0.18	0.801

[a] Reference interval: 7.0-16.0 mmol/24 hr.
[b] Reference interval: 80.0-600.0 nmol/24 hr.
[c] Reference interval: 2.5-7.5 mmol/24 hr.
[d] Mean values differ significantly between groups (t-test).

Appendix 36. Physical Characteristics (mean ± SD) of Participants who Reported Exercising Moderately (2-7 hr/wk) According to Restraint Group

Characteristic	Low restraint[a] (n = 14)	High restraint[b] (n = 28)	P value
Age (y)	23.1 ± 4.0	21.2 ± 1.8	0.108
Height (cm)	166.9 ± 6.6	162.7 ± 7.0	0.068
Weight (kg)	58.6 ± 8.2	56.2 ± 5.8	0.355
BMI (kg/m^2)	21.0 ± 2.2	21.2 ± 1.7	0.643
Highest BMI (kg/m^2)[c]	22.5 ± 2.2	22.5 ± 1.6	0.982
Lowest BMI (kg/m^2)[d]	19.3 ± 1.9	20.0 ± 1.6	0.212
Best BMI (kg/m^2)[e]	20.3 ± 1.4	20.0 ± 1.4	0.380
Waist (cm)	67.3 ± 4.9	67.2 ± 3.8	0.932
Hip (cm)	90.8 ± 6.4	89.0 ± 5.5	0.359
Waist/hip (cm/cm)	0.74 ± 3.7	0.76 ± 4.4	0.311
Menstrual cycle length (d)[f]	27.1 ± 3.5	28.6 ± 2.7	0.139
Menstrual cycle length (d)[g]	27.4 ± 3.5	29.3 ± 2.6	0.056

[a] Score 0-5 on the Three-Factor Eating Questionnaire (TFEQ) restraint scale (Stunkard AJ & Messick S, 1985).
[b] Score 13-21 on TFEQ restraint scale.
[c] Calculated from weight given as 'highest adult weight'.
[d] Calculated from weight given as 'lowest adult weight'.
[e] Calculated from weight given as 'best adult weight'.
[f] Self-reported menstrual cycle length.
[g] Documented menstrual cycle length.

Appendix 37. Lifestyle Characteristics of Participants who Reported Exercising Moderately (2-7 hr/wk) According to Restraint Group

Characteristic	Low restraint[a] (n = 14)	High restraint[b] (n = 28)	P value
Coffee or tea (cups/d)[c]	1.1 ± 1.2	1.1 ± 0.99	0.918
Alcohol (drinks/wk)[c]	1.6 ± 1.5	0.89 ± 1.5	0.134
Exercise (hr/wk)[c]	3.7 ± 1.5	3.8 ± 1.4	0.734
Vegetarian	7.1%	10.7%	0.710
Using vitamin/mineral supplements	50.0%	39.3%	0.508

[a] Score 0-5 on the Three-Factor Eating Questionnaire (TFEQ) restraint scale (Stunkard AJ & Messick S, 1985).
[b] Score 13-21 on TFEQ restraint scale.
[c] Mean ± SD.

Appendix 38. Weight Fluctuation and Dieting History of Participants who Reported Exercising Moderately (2-7 hr/wk) According to Restraint Group

Characteristic	Low restraint[a] (n = 14)	High restraint[b] (n = 28)	P value
Presently trying to lose weight	0%	82.1%	0.000[c]
Ever tried to lose weight	64.3%	100.0%	0.001[c]
Weight fluctuation[d,e]	1.0 ± 0.9	1.4 ± 0.8	0.187

[a] Score 0-5 on the Three-Factor Eating Questionnaire (TFEQ) restraint scale (Stunkard AJ & Messick S, 1985).
[b] Score 13-21 on TFEQ restraint scale.
[c] Percentages differ significantly between groups (chi-square).
[d] Mean ± SD.
[e] Number of times > 5 lbs lost during the past two years.

Appendix 39. TFEQ[a] subscale, Perceived Stress Scale[b], Rosenberg's Self-esteem Scale[c] and EDI[d] Subscale Scores (mean ± SD) of Participants who Reported Exercising Moderately (2-7 hr/wk) According to Restraint Group

Characteristic	Low restraint[e] (n = 14)	High restraint[f] (n = 28)	P value
TFEQ disinhibition	3.4 ± 2.8	7.2 ± 4.2	0.001[g]
TFEQ hunger	4.6 ± 2.0	6.1 ± 3.7	0.106
Perceived stress	24.0 ± 6.1	28.5±7.9	0.067
Self-esteem	0.7 ± 1.0	1.9 ± 1.8	0.007[g]
EDI drive for thinness	0.64 ± 1.7	7.1 ± 6.0	0.000[g]
EDI bulimia	0.0 ± 0.0	1.2 ± 2.4	0.017[g]
EDI body dissatisfaction	1.1 ± 2.1	13.8 ± 7.9	0.000[g]
EDI ineffectiveness	1.1 ± 2.9	4.2 ± 5.3	0.021[g]
EDI perfectionism	6.3 ± 4.6	6.0 ± 5.2	0.881
EDI interpersonal distrust	0.86 ± 2.2	3.4 ± 3.4	0.007[g]
EDI interoceptive awareness	0.93 ± 1.8	3.1 ± 4.3	0.083
EDI maturity fears	2.4 ± 2.7	4.0 ± 3.6	0.157

[a] TFEQ = Three-Factor Eating Questionnaire (Stunkard AJ & Messick S, 1985).
[b] Perceived Stress Scale (Cohen S et al, 1983).
[c] Rosenberg's Self-esteem Scale (Rosenberg M, 1965). Lower scores indicate higher self-esteem.
[d] EDI = Eating Disorder Inventory (Garner DM & Olmstead MP, 1984).
[e] Score 0-5 on the Three-Factor Eating Questionnaire (TFEQ) restraint scale (Stunkard AJ & Messick S, 1985).
[f] Score 13-21 on TFEQ restraint scale.
[g] Mean values differ significantly between groups (t-test).

Appendix 40. Mean Energy and Nutrient Intakes from 3-day Food Records (mean ± SD) of Participants who Reported Exercising Moderately (2-7 hr/wk) According to Restraint Group

Characteristic	Low restraint[a] (n = 14)	High restraint[b] (n = 28)	P value
Energy (kcal)	2250.9 ± 624.0	1937.3 ± 342.7	0.041[c]
Energy (kcal/kg body wt)	38.5 ± 9.7	34.9 ± 7.3	0.231
Carbohydrate (g)	320.0 ± 94.8	288.8 ± 71.0	0.238
Carbohydrate (%)	56.5 ± 5.8	59.0 ± 11.9	0.363
Protein (g)	81.6 ± 23.7	80.7 ± 33.3	0.924
Protein (%)	14.5 ± 2.6	15.9 ± 4.6	0.322
Fat (g)	74.5 ± 25.6	55.1 ± 23.8	0.020[c]
Fat (%)	28.6 ± 4.8	25.1 ± 9.1	0.107
Cholesterol (mg)	234.4 ± 140.0	195.3 ± 122.8	0.359
Fibre (g)	22.1 ± 8.2	19.5 ± 8.9	0.372
Calcium (mg)	914.2 ± 482.9	773.4 ± 288.1	0.328
Calcium/protein (mg/g)	11.5 ± 5.3	10.7 ± 4.3	0.610
Sodium (mg)	3270.7 ± 1625.0	2847.1 ± 958.1	0.293

[a] Score 0-5 on the Three-Factor Eating Questionnaire (TFEQ) restraint scale (Stunkard AJ & Messick S, 1985).
[b] Score 13-21 on TFEQ restraint scale.
[c] Mean values differ significantly between groups (t-test).

Appendix 41. Twenty-four Hour Energy and Nutrient Intakes (mean ± SD) of Participants who Reported Exercising Moderately (2-7 hr/wk) According to Restraint Group

Characteristic	Low restraint[a] (n = 14)	High restraint[b] (n = 28)	P value
Energy (kcal)	2599.4 ± 454.9	2033.0 ± 554.8	0.002[c]
Energy (kcal/kg body wt)	44.6 ± 7.2	36.6 ± 11.2	0.020[c]
Carbohydrate (g)	432.3 ± 86.4	338.7 ± 95.7	0.004[c]
Carbohydrate (%)	63.9 ± 4.2	64.8 ± 7.13	0.656
Protein (g)	77.4 ± 16.8	71.9 ± 16.7	0.222
Protein (%)	11.5 ± 1.9	14.0 ± 1.68	0.000[c]
Fat (g)	74.4 ± 17.3	50.0 ± 22.2	0.001[c]
Fat (%)	24.6 ± 3.4	21.3 ± 6.7	0.083
Cholesterol (mg)	67.8 ± 39.7	46.4 ± 30.8	0.062
Fibre (g)	30.0 ± 6.8	25.8 ± 9.4	0.146
Calcium (mg)	693.4 ± 352.3	568.5 ± 327.0	0.262
Calcium/protein (mg/g)	8.7 ± 3.2	8.0 ± 5.0	0.625
Sodium (mg)	2556.8 ± 555.1	2180.7 ± 643.3	0.070

[a] Score 0-5 on the Three-Factor Eating Questionnaire (TFEQ) restraint scale (Stunkard AJ & Messick S, 1985).
[b] Score 13-21 on TFEQ restraint scale.
[c] Mean values differ significantly between groups (t-test).