DIET, BODY WEIGHT PATTERNS AND MENSTRUAL STATUS OF COMPETITIVE FEMALE BODY BUILDERS

by

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(abstract)

The purpose of the study was to provide descriptive information on nutritional profiles and body weight (BW) patterns of 6 competitive female body builders (x age = 27) before, during and after a competition. Precompetition (-28 to -26 d); (-9 to -7 d), competition (-2 to 0 d) and post competition (+1 to +3 d); (+26 to +28 d) 3-d diet and BW records were recorded. Diet records were analyzed using the Nutripractor 6000 nutrient analysis system. Two weeks precompetition, percent body fat was estimated using skinfold measurements. All subjects completed a 60-item fixed choice and open-ended questionnaire concerning menstrual characteristics, training and dietary practices. A subgroup (n=2) agreed to collect daily urine samples for one month prior and one month after competition. Samples were analyzed for estradiol (E2) and progesterone (P4).

Repeated measures ANOVA indicated that BW loss was significant from (-28 to -26 d) to (-2 to 0 d) followed by a significant increase in BW from (-2 to 0 d) to (+1 to +3 d) and (+26 to +28 d). Percent bodyfat was estimated at 12.7 +/- 1.65%. Dietary results indicated that kilocalories increased significantly from (-28 to -26 d) and (-9 to -7 d) to (+1 to

+3 d) and (+26 to +28 d). Dietary protein intake was above the RDA throughout the study. Analysis of percent dietary composition indicated a significant decrease in percent protein from (-28 to -26 d) to (-2 to 0 d) with an increase in percent carbohydrate while percent fat intake remained low. At (+1 to +3 d) and (+26 to +28 d), the percentage of protein and carbohydrate decreased significantly being replaced with high fat foods. Hormonal analysis of urine samples illustrated an aberration from normal patterns of E2 and P4 in the cycle during competition. The results may encourage body builders to follow healthy diet and realistic weight loss plans prior to competition and illustrate the adverse effects of strict dietary practices on menstrual function.

To my husband, Bart:

for all of your encouragement,

love and patience.

To my mother and father:
for your encourgement as well as
your worrying; here it is,
the finished product.

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CHAPTER 1

Introduction

Since the 1970's, there has been an increasing number of women participating in athletics, either for general fitness or competition. This increased popularity and quality of competition of women's athletics may be attributed to changes in both the law and public attitude. What was once thought to be "unlady-like" or "unfeminine" is becoming the norm. More women than ever before are seen pounding the pavement in marathons, kicking up their heels in aerobics classes, or splashing their way to Olympic records. Whether it is for the thrill of competition, recreation, or to enhance physical appearance, the underlying goal of athletics should be the development of health. However, efforts to gain the edge over an opponent or obtain the ideal weight or physique may cause some athletes to be anything but healthy.

One sport, which has grown in popularity within the past ten years, is body building. Body building competitions have become "common sports events in major cities and have been the focus of several major sports and television programs" (Freedson et al., 1983). Where most sports use weights for the development of strength, body builders use weights to develop "muscular size, definition and a symmetrical whole body image" (Ryan, 1983). In preparation for a competition,

body builders employ strict dietary practices in order to decrease body fat and increase muscular definition. As they try to attain that ideal physique, which is "cut," "ripped" and ready by competition day, their nutritional status may be all but optimal. Their reduced food and water consumption prior to competition usually places them in a state of semi-starvation and dehydration. And, their level of body fat is usually below optimal levels. They seem to have forgotten the original goal of weight training, to develop a healthy body. Somehow, that idea must have been muscled aside.

Statement of the Problem

After a perusal of the literature, it was found that there is very little scientific information available on body builders. The studies that have been conducted have focused primarily on one of the following: psychological characteristics, cardiovascular parameters, muscular development, or blood lipid profiles, either within the sport or in comparison to aerobic athletes (Freedson et al., 1983; Elliott et al., 1987; Katch, Katch, Moffat and Gittleson, 1980). While there is little scientific information available on body building, most training techniques are usually obtained by "word-of-mouth." In other words, training techniques are obtained from someone who has been successful in the sport, especially when diet is concerned. Since an important part of body building is dieting, the strict dietary practices that they employ may cause adverse effects to

health. For example, in wrestling and ballet dancing the intensity of exercise is increased while food and water consumption are drastically reduced (Benson, Gillien, Bourdet and Loosli, 1985; Cohen, Potosnak, Frank and Baker, 1985; Houston, Marrin, Green and Thomson, 1981; Widerman and Hagan, 1982). The goal is to lose weight in order to compete. This is similar to the goal of the body builder. However, the wrestlers and ballet dancers usually achieve a level of body fat which is below the acceptable level for athletes (Freedson et al., 1983; Heck, 1980). It has been reported that wrestlers may lose from 9% to as much as 20% of body weight during the season (Zambraski et al., 1976). And, the majority of the weight is lost within several days before competition (Tipton and Teheng, 1970; Zambraski, Foster and Gross, 1976). Repeated weight loss is also common practice among some athletes (e.g. wrestlers). "Cutting weight" has been reported to occur in wrestlers as much as "15 times during each season" with weight fluctuations of "5.0 to 9.1 kg every week" (Brownell et al., 1987). These weight patterns seen in wrestlers may become apparent in body builders as more research is conducted.

Body builders may be more susceptible to the development of eating disorders. Eating disorders have been reported in the athletic population, especially ballet dancers and gymnasts (Benson, Gillien, Bourdet and Loosli, 1985; Loosli, Benson, Gillien and Bourdet, 1986). Body builders may develop

behaviors similar to those seen in anorexia and bulimia due to the importance of dieting to achieve extremely low levels of body fat.

It has been reported that a higher incidence of menstrual irregularity occurs in female athletes than in the general female population (Bonen and Keizer, 1984). Two factors associated with the development of menstrual disturbances are weight loss and low body fat. Since body builders lose weight and attain low body fat, they may be prone to menstrual disturbances. A recent study reported the occurrence of menstrual disturbances in body builders (Elliott and Goldberg, 1987).

With the increased participation of women in sport and the recent increase in the number of women body builders, there is a need for additional research. Information concerning the dietary practices and weight patterns of female body builders needs to be collected due to potential health risks. There is presently no scientific research on diet and weight loss practices of competitive female body builders.

Research Questions

The main purpose of this study was to provide descriptive information relevant to the dietary practices and weight patterns of competitive female body builders prior to, during, and after a competition. The following research questions were developed to further delineate the purpose of the study.

1. What was the mean percent body fat of competitive

female body builders prior to competition?

2. What was the composition of the diet of competitive female body builders before, during and after a competition?

3. What were the weight patterns of female body builders before, during and after a competition?

4. Was there a tendency for female body builders to display abnormal eating behaviors similar to anorexia nervosa or bulimia?

5. Were the urinary levels of progesterone and estradiol different in female body builders during one menstrual cycle prior to a competition and one cycle after competition?

Significance of the Study

This study was conducted to obtain descriptive information on competitive female body builders before, during and after a competition. Diet, body weight and exercise records were collected to provide baseline data on diet, exercise and body weight changes of female body builders before and after a competition. It was hoped that the information obtained relevant to dietary composition and weight changes would assist in future research and give indication of the safety of these practices. Once present trends are established, manipulations of the diet by researchers may provide body builders with information for adopting healthy nutritional and weight loss practices as they prepare for a competition. Since weight loss and low body fat are important aspects of body building, these athletes are

susceptible to menstrual disturbances. Urinary profiles of select reproductive hormones were obtained in order to assist in identifying possible hormonal dysfunctions.

Delimitations

1. All subjects were female and between 22 and 34 years of age.

2. All subjects were competitive body builders. Each subject had to be preparing for a competition at the time of the initial interview and actually performed in a body building competition.

3. The subgroup for urine collection consisted of all subjects who did not use oral contraceptives or who had not used oral contraceptives within the three months preceding competition.

Limitations

Listed below are limitations of the study which may have affected the results.

1. The low number of subjects (n=6) may have affected the power of the statistics, and therefore, limit inferences made to the sport of body building as a whole.

Basic Assumptions

1. It was assumed that all subjects were accurate in recording total exercise time and estimating rest time between sets during weight lifting sessions.

2. It was assumed that all subjects accurately recorded food and drink on the days assigned. And, it was assumed that

subjects accurately measured and estimated portion sizes of foods consumed.

3. The researcher was present during the administration of the questionnaire to clarify questions. Therefore, it was assumed that all subjects correctly interpreted the questionnaire. It was assumed that subjects were accurate in their recall of information when answering the questionnaire.

4. It was assumed that the subjects taking urine samples accurately followed detailed instructions for collection and storage of urine samples.

5. When analyzing the subjects diet records, it was assumed that the researcher correctly entered the data into the computer diet analysis system used.

6. It was assumed that the researcher performed the skinfold measurements and calculations accurately when estimating percent body fat.

Definitions and Symbols

Amenorrhea - refers to the cessation of menstruation for 12 or more months. In some studies, it refers to the lack of menses for 3 or more months.

Anorexia Nervosa - A syndrome characterized by self-starvation.

Athletic Menstrual Irregularity (AMI) - Sports related menstrual dysfunction such as amenorrhea and oligomenorrhea.

Body Density (BD) - refers to mass per unit volume of a human body. It is used to compute percent body fat.

Bulimia Nervosa - A syndrome of weight control which is characterized by binge/purge behaviors.

Competitive Body Builder - An individual who utilizes weights to develop muscular size, shape and definition to attain a well-proportioned or symmetrical body and performs in sanctioned body building competitions at the local, state or regional level.

"Cut" - a term used to describe the appearance of muscle when each muscle is clearly defined.

Estradiol (estradiol-17B, E2) - is a steroid hormone. In nonpregnant women, estradiol is produced mainly by the ovaries. Preovulatory levels provide an index of follicular maturation used to diagnose amenorrhea and monitor ovulation induction.

Eumenorrhea - refers to normal menstruation, having cycles occurring at consistent intervals of less than 36 days.

Food Efficiency - the degree of weight change per unit of food intake (Steen et al., 1988).

Oligomenorrhea - the condition of having menstrual cycles which occur at inconsistent intervals. Some individuals may have cycle lengths of 36 - 89 days or varying intervals which sometimes occur monthly or skips several months.

Percent Body Fat (%BF) - refers to the percentage of body mass that can be attributed to subcutaneous and nonessential lipids.

Progesterone (P4) - a hormone which is essential for

reproduction in female vertebrates; produced by the corpus luteum.

"Ripped" - a term used by body builders to describe the appearance of muscle when each individual muscular striation becomes visible under the skin.

Skinfold Measurements - measurements of fat folds at various sites on the body used to estimate percent bodyfat.

Summary

The main purpose of this study was to provide descriptive information on competitive female body builders before, during and after an actual competition. The specific topics to be addressed include: body weight patterns, weight cycling affects, dietary patterns, eating disorders and menstrual function. Literature on female body builders has not currently addressed these issues relative to pre-competition, competition and post-competition.

CHAPTER 2

LITERATURE REVIEW

The following review of literature includes scientific information available concerning body builders, weight regulation practices of athletes, eating disorders, and athletic menstrual disturbances. The review is divided into the following topics:

1) Physiological and Psychological Characteristics of Body Builders
2) Body Weight Patterns and Weight Control Practices in Athletes
3) Weight Cycling - Its Affects in Animals and Humans
4) Eating Disorders - Anorexia Nervosa and Bulimia
5) Athletic Menstrual Irregularity (AMI)
6) Dietary Patterns of Female Athletes

Physiological and Psychological Characteristics of Body Builders

After a perusal of the literature, it was found that there is very little scientific information available on body builders. The studies that have been conducted have focused primarily on physiological and psychological characteristics, either within the sport or in comparison to aerobic athletes. Literature on the physical characteristics revealed that most competitive body builders have low percentages of body fat,

low aerobic capacities with blood lipid levels within the normal range. Several studies have investigated percent bodyfat (%BF) in male body builders (Katch, Moffat and Gittleson, 1980; Spitler, Diaz, Horvath and Wright, 1980; Fahey, Akka and Rolph, 1975) while only a few addressed women body builders (Freedson, Mihevic, Loucks and Girandola, 1983; Elliott Goldberg, Kuehl and Catlin, 1987; Heyward, Sandoval and Colville, 1989; Lamar-Hildebrand et al., 1989; Heyward et al, 1989). Katch et al., (1980) reported that their male body builders averaged 9.3 %BF. Two other studies reported similar averages of 8.4 %BF (Fahey, Akka and Rolph, 1975) and 9.9 %BF (Spitler, Diaz, Horvath and Wright, 1980). An even lower mean of 6.1 %BF was reported by Elliott and colleagues (1987). Female body builders were investigated during this study and found a mean of 13.5 %BF. An earlier study by Freedson et al., (1983) reported a mean of 13.2 %BF in female body builders which was less than most other competitive athletes. However in comparison to gymnasts and long-distance runners, the body builders had more bodyfat (Freedson et al., 1983). In contrast, Elliott, Goldberg, Kuehl and Catlin (1987) reported that the body builders in their study had a bodyfat percentage approximately 2 percent less than a group of long-distance runners. In a recent study, (Heyward et al., 1989) 12 female body builders were reported to have a pre-competition level of 16% bodyfat. And at 24 to 48 hours prior

to competition, their bodyfat was reported to be only 9.5% being the lowest recorded for a group of female athletes. In comparison to other athletes, body builders are among the leanest (Elliott, Goldberg, Kuehl and Catlin, 1987).

Spitler, Diaz, Horvath and Wright (1980) investigated the aerobic capacity of 10 adult male national to international level body builders. When expressed relative to body weight, these body builders had an average VO2 max of 42.7 +/- 7.6 ml/kg/min. Fahey, Akka and Rolph (1975) found similar characteristics in their study on 10 highly-trained weight-lifters. Two subjects in this group were high caliber body builders who achieved a mean VO2 max of 41.5 +/- 14.5 ml/kg/min. In comparison to the other weight lifters, the body builders had the lowest aerobic capacity. In a recent study, Elliott, Goldberg, Kuehl and Catlin (1987) reported a VO2 max of 46.1 +/- 4.1 ml/kg/min in 16 male competitive body builders. Elliott et al., (1987) found an average of 39.5 +/- 3.6 ml/kg/min in 15 highly-competitive female body builders. In this study, both male and female body builders had lower aerobic capacities in comparison to long-distance runners. Therefore in spite of their rigorous training regimen, these results indicate that little time is devoted to aerobic exercise.

According to recent literature, body builders are characterized as being extroverted, highly self-motivated and

possessing "good mental health" (Freedson, Mihevic, Loucks and Girandola, 1983; Thirer and Greer, 1981). Literature in the past, however, cited that body builders displayed deviant personality traits such as latent homosexuality, masculine inadequacy, introversion and feelings of inferiority (Harlow, 1951; Henry, 1941).

An important aspect in the sport of body building is the diet (Spitler, Diaz, Horvath and Wright, 1980). However, only a few studies have addressed this topic. In the studies that have been conducted, most cite that body builders consume a high-fat, high cholesterol diet (Spitler, Diaz, Horvath and Wright, 1980; Faber, Benade and van Eck, 1986; Elliott, Goldberg, Kuehl and Catlin, 1987). Spitler, Diaz, Horvath and Wright (1980) interviewed 10 adult male body builders and asked them to recall their "typical daily dietary habits." The daily diet of this group of body builders consisted of: 85% protein, 10% fat and 5% or less complex carbohydrates. Their daily cholesterol consumption was two to three times above the American average. In another study (Short, 1983), 3-day diet records were collected from a group of body builders. This group had a cholesterol intake of 347 mg/dl which is below the American average. However, their diet consisted of a higher percentage of carbohydrate (48%) and fat (24%) and a lower percentage of protein (27%) than the body builders Spitler et al., (1980) investigated. Faber, Benade

and van Eck (1986) collected dietary data on a larger group of body builders (n=76). They "followed an atherogenic diet, characterized by a high-fat, high-cholesterol intake" (Faber, Benade and van Eck, 1986). The cholesterol in their diet came predominately from a high egg intake. Even though these body builders had a high cholesterol consumption, their average plasma total cholesterol level was well within normal limits (182.9 mg/dl) (Faber et al., 1986). In a more recent study, Elliott, Goldberg, Kuehl and Catlin (1987) investigated blood lipid values in both male and female body builders in comparison to a group of runners. They found that there was no significant difference between the two groups of athletes in lipid values (Elliott, Goldberg, Kuehl and Catlin, 1987). These results were consistent with previous studies, and therefore, suggest that body building may affect blood lipid levels in a similar manner as the effects of aerobic exercise (Elliott, Goldberg, Kuehl and Catlin, 1987).

These studies have all investigated the training diet of body builders. Two recent studies have addressed the diet of competitive female body builders. Heyward et al., (1989) collected pre-competition dietary intake between six to 17 weeks prior to competition. Their body builders consumed a diet that consisted of 102 g protein, 208 g carbohydrate and 42 g fat resulting in a 26%, 53% and 21% dietary composition. And at 24 to 48 hours prior to competition, they consumed 77

g protein, 261 g carbohydrate and only 15 g fat. The percent composition of the diet therefore consisted of 21%, 72% and 10% respectively. Lamar-Hildebrand et al., (1989) reported that their body builders consumed 76 g protein, 196 g carbohydrate and 21 g of fat eight weeks prior to competition. One month prior to competition, they consumed 48 g protein, 160 g carbohydrate and 9 g fat. And at one week pre, 67 g protein, 222 g carbohydrate and 20 g fat were consumed. During the weekend of competition, their body builders consumed 57 g protein, 359 g carbohydrate and 49 g of fat.

Body Weight Patterns and Weight Control Practices in Athletes

In the athletic population, there appear to be at least three different categories for athletes with regard to body weight (Brownell, Steen and Wilmore, 1987). The first group consists of those athletes who do not concentrate solely on body weight (e.g. baseball). A second group consists of those athletes who maintain low body weights or low percentages of body fat. This practice is either to enhance performance and/or appearance (e.g. ballet dancers, gymnasts, long-distance runners). The last category includes those athletes who participate in sports that impose specific weight limits (e.g. wrestlers). These athletes either lose weight during the season or they repeatedly gain and lose weight.

Zambraski, Foster and Gross (1976) reported that wrestlers may lose from 9% to as much as 20% of their body

weight during the season. The majority of this weight is lost within several days before competition (Tipton and Teheng, 1970; Zambraski, Foster and Gross, 1976). Some wrestlers engage in the practice of "cutting" weight which involves repeated bouts of gaining and losing body weight. It has been reported that wrestlers may "cut" weight as many as "15 times during each season" with weight fluctuations of "5.0 to 9.1 kg every week" (Brownell, Steen and Wilmore, 1987). The manner in which these athletes achieve weight loss is "either by dieting, exercise, and dehydration, or any combination of these procedures" (Widerman and Hagan, 1982).

Several studies have investigated weight loss practices in athletes, mainly wrestlers. Zambraski et al., (1976) reported that low body weight was "achieved via fluid restriction and dehydration." In another study, Houston, Marrin, Green and Thomson (1981) reported that weight loss by wrestlers was "usually accomplished by reducing food and water intake and in the final stages, by acute dehydration employing thermal and/or exercise stress." The athletes tried to "make weight" by "exercising in rubber suits, sitting in saunas, whirlpools or enclosed shower rooms" (Tipton and Teheng, 1970). There have been a few reports that wrestlers have even resorted to the use of laxatives, diuretics, appetite suppressants and self-induced vomiting (Tipton, 1980).

Similar practices have emerged in other sports where body

weight is a major concern. Druss (1979) conducted a survey study on a group of ballet dancers. The dancers reported that weight and diet were their primary concern. Benson et al., (1985) reported that in a group of professional ballet dancers, most weight control methods included: intentional dehydration, laxative abuse, fasting and self-induced vomiting. Ballet dancers, therefore, appear to be more "susceptible to bizarre eating habits" (Benson et al., 1985). Another study cited that a group of University Majorettes engaged in unhealthy weight control practices. Similar to wrestlers, the majorettes had to meet weight standards which "were enforced through weekly weigh-ins" (Humphries and Gruder, 1986). In order to attain their desired weight, these women would not eat anything and drink "very little" for two days prior to weigh-in. It was reported that they "exercised heavily, sat in saunas, and took diet pills and occasionally diuretics" (Humphries and Gruder, 1986). After weigh-in, they would usually gain back all of the lost weight within the next few days by binge eating. Several of these subjects displayed behaviors associated with bulimia (to be discussed later) such as binge eating and vomiting (Humphries and Gruder, 1986).

Rosen et al., (1986) investigated weight control behaviors in female collegiate athletes. They reported that "32% of their group practiced at least one of the weight control behaviors defined as pathogenic, which included self-

induced vomiting; binging more than twice weekly; and the use of laxatives, diet pills, and/or diuretics" (Rosen et al., 1986). In another study focusing on female athletes, it was reported that the majority of these women consumed diets low in calories and nutrients and therefore "not sufficient to meet the extra demands of training" (Welch et al., 1987; Loosli et al., 1986; Rosen et al., 1986).

Weight cycling - Its Affects in Animals and Humans

Several studies have investigated the effects of rapid weight loss and gain and repeated weight fluctuations in both animals and humans. This section of the literature review addresses the effects of weight cycling on body weight, body composition, food intake and efficiency of weight gain.

Body Weight and Body Composition - Bjorntorp and Yang (1982) conducted a study on male rats which investigated the effects of refeeding after fasting on body composition. After a 65 hour fast, the rats were allowed to eat ad libitum for eight days. During the fast, body weight decreased by a total of 25% which was mainly due to a loss of water. The remainder of weight loss was from protein and fat. Upon refeeding, the rats achieved baseline body weight and body composition within eight days. The regained weight was mostly water. In regard to energy lost and regained, fat was the major component. Almost two times the amount of energy from fat was lost and regained in comparison to energy from protein. Cleary (1986)

found similar results. In this study, a group of lean and obese Zucker rats was subjected to four cycles of restriction and ad-libitum refeeding. The lean rats regained weight to control levels. However, the obese female rats did not regain control body weight. The results reported by Bjorntorp and Yang (1982) and Cleary (1986) suggest that lean or normal weight rats will obtain baseline body weight and/or body composition levels upon refeeding after cycles of restriction and refeeding. However, weight cycling appears to affect the obese differently. These results are also in agreement with Harris and Martin (1984). They reported that body fat reached control level after female rats were "restricted and then allowed to feed."

Two recent studies reported similar results (Gray et al., 1988; Hill, Newby, Sykes and DiGirolamo, 1988). Gray et al., (1988) subjected rats to food restriction for 28 days and 22 days at 50% and 25% of control food intake. When the rats were allowed to feed ad-libitum, they gained weight rapidly. It was reported that the "time to reach control body weight was approximately equal to the length of time of restriction" (Gray et al., 1988). This occurred during both levels of restriction and refeeding. During continued observation (17 days), the rats did not gain weight above baseline levels. Similar to the results in Bjorntorp and Yang (1982), percent body fat was not different between restricted-refed and ad-

libitum-fed control animals (Gray et al., 1988).

Hill et al., (1988) compared three groups of male rats to investigate the effects of food restriction coupled with weight cycling. Group One acted as the controls and was allowed to feed ad-libitum throughout the study. Group Two and Three were restricted to 60% ad-libitum intake. Group Two received a constant amount of food each day. Group Three was subjected to four cycles of three days starvation and seven days refeeding. After the four cycles, an 18 day refeeding period began. It was reported that the body weight "of weight cycled rats did not differ from those of constant restriction rats" (Hill et al., 1988). This was true after each cycle and at the end of the study. During the refeeding period, weight cycled rats gained weight more rapidly than the constant restriction rats. However, the weight cycled rats did not have a significantly higher total weight gain in comparison to the constant restricted rats. In reference to body composition, the weight cycled rats gained more fat-free body mass during refeeding (22.2 +/- 2.4 versus 8.6 +/- 3.6 g) (Hill et al., 1988). During refeeding, the weight cycled rats gained more body fat than the constant restriction rats but the difference was not significant. The results were in accordance with a previous study by Hill et al., (1987) in which weight cycling did not have an effect on body weight or body composition. The results of these studies suggest that

after periods of restriction and refeeding, animals do not have a "tendency to overshoot control body weight" but regain the lost weight and body fat to control levels (Gray et al., 1988).

In contrast to the above studies, Ozelci et al., (1978) reported that body fat was greater in restricted-refed rats than in control rats. In this study, 150-g male rats were restricted for one week to 25, 50 or 75% of maintenance intake. At the end of a three-week refeeding period, the rats restricted to 50 and 75% intake weighed as much as controls but had a higher percent body fat. These results are similar to what was reported in humans. Keys et al., (1950) investigated the effects of prolonged caloric restriction on normal-weight young men. Upon refeeding, the subjects gained weight rapidly. Once they reached pre-restriction body weight, it was reported that they had an increase in body fat and a decrease in lean body mass (LBM) in comparison to baseline levels.

In present human literature, conflicting results have been reported. Steen, Oppliger and Brownell (1988) studied two groups of wrestlers. One group, characterized as weight cyclers, "'cut' weight 10 or more times each season" and lost 4.5 kg or more of body weight per week (Steen et al., 1988). The non-cyclers were defined as those wrestlers who "'cut' weight less than 5 times per season" (Steen et al., 1988).

Even after repeated bouts of body weight loss and gain, it was found that percent bodyfat was the same between cyclers and non-cyclers (Steen et al., 1988). These studies, therefore, suggest that frequent body weight cycling does not affect body composition (Brownell, Steen and Wilmore, 1987).

Food Intake and Efficiency of Weight Gain - Weight loss and gain can have effects on metabolic rate, the intake of food and in how food is used by the body. The negative consequences of food restriction have been documented extensively in the literature. However, the combined effects of dieting and exercise on metabolic rate have only recently been investigated.

Several studies have reported that basal metabolic rate (BMR) decreases from 15 to 30% in obese and in normal weight persons as a result of caloric restriction (Apfelbaum, 1978; Benedict, Miles, Roth and Smith, 1919; Bray, 1969; Drenick, and Dennin, 1973; Garrow, 1978). "The effect is measurable 48 hours subsequent to dieting and BMR may decline by 20% in 2 weeks" (Bray, 1969). It has been reported that the "decrease in BMR is larger than that predicted on the basis of actual weight loss, indicating that the body adapts to caloric restriction by lowering the metabolic activity of remaining tissue" (Apfelbaum, 1978; Van Itallie and Yang, 1977). Apfelbaum et al., (1969) reported that even if lean body mass is kept constant, a decrease in BMR still occurs.

As described by Lammert and Hansen (1982) "part of the regulation of body energy content takes place by way of a change in the efficiency of energy utilization." In their study, a group of non-obese individuals was subjected to three conditions, each lasting two weeks: 1) normal habitual energy intake; 2) overfeeding by 12 MJ/d; and 3) semi-starvation with an energy intake of 2.1 MJ/d. It was found that the drastic change in energy intake from the normal to the overfeeding period caused an increase in energy expenditure. After the semi-starvation period, "energy expenditure was lower than that obtained after the preceding overeating period" (Lammert and Hansen, 1982). Furthermore, the subjects that reacted with small increases in energy expenditure after overeating had small decreases in energy expenditure after semi-starvation. And in accordance with these results, subjects with greater increases had greater decreases in energy expenditure. It was reported that the subjects who had insignificant changes in energy expenditure had considerable changes in dry body weight. The reverse was reported in which those subjects with significant changes in energy expenditure displayed very little changes in dry body weight. Therefore, the results of this study found that there is considerable individual variation "with respect to the reaction towards a change in energy intake" (Lammert and Hansen, 1982).

Literature cites contradictory results concerning the

effects of diet and exercise on metabolic rate. Data in literature are inconclusive regarding the issue of whether or not exercise restores metabolic rate to normal, pre-dieting levels. In one study, Warwick and Garrow (1981) subjected three women to a 12 to 13 week diet consisting of only 800 kilocalories per day. The subjects alternated exercising for two hours per day or not exercising, for periods of three to four weeks. Throughout the study, BMR decreased even during the exercise periods. In another study, Krotkiewski et al., (1981) investigated two groups of obese women. Both groups dieted on 500 kilocalories per day for three weeks. One group exercised three times per week for an energy expenditure of 1,650 kilocalories per week. In the diet and exercise group, BMR decreased significantly. However, there was very little change in BMR from pre- to post-testing in the diet only group (Krotkiewski et al., 1981). The change in metabolic rate could not be attributed to a change in body composition since it was found that "the body weight, body composition, and body cell mass levels decreased equivalently for both groups" (Krotkiewski et al., 1981).

In contrast to the above results, Lennon et al., (1985) reported that exercise had a positive effect on the metabolic rate that was depressed due to caloric restriction. In this study, "subjects combined dietary restriction with either 30-minutes of self-selected aerobic exercise or a prescribed

exercise training regimen provided by the researcher" (Lennon et al., 1985). A third group acted as the control group and dieted but did not exercise. In all three groups, resting metabolic rate (RMR) increased, but the "increase was significantly higher for the prescribed exercise group" (Lennon et al., 1985). Therefore, the intensity of exercise may have to be high enough before RMR is affected.

Donahoe et al., (1984) conducted a study on overweight women. A total of 18 weeks was allotted for the study which included baseline, diet only, and diet and exercise phases. Exercise consisted of two days of self-selected exercise and two hours per week of supervised exercise. It was reported that RMR decreased during the diet only phase more than what was expected according to the amount of weight lost. However, during the diet and exercise phase, RMR increased to an appropriate level for their new body weight.

In contrast to these studies, Phyinney et al., (1984) reported that the opposite occurred. In their study, two groups of overweight women were subjected to four or five weeks of a 720 kilocalorie per day diet. One group participated in endurance exercise which consisted of 27.5 total hours at 50% maximum. They reported that after one week, RMR decreased by 10% in both groups. And by the third week, a further decrease in RMR (17%) was experienced by the diet and exercise group. The addition of exercise did not

enhance RMR as was hoped but caused a further decline.

Current literature is, therefore, "inconclusive regarding the metabolic benefits of exercise during caloric restriction" (Thompson and Blanton, 1987).

According to literature the "metabolic consequences of dieting may create a change in the efficiency of food utilization" (Thomson and Blanton, 1987). Boyle, Stolien and Keesey (1978) conducted a study on male rats. After a baseline food intake period, three groups were formed. Group One served as controls. Group Two under went a reduction in food intake to 60% of baseline while Group Three was restricted to 40% maintenance level. After six weeks, the rats were then refed for one week on pre-restriction amounts adjusted to their new body weight. The control group gained only 1.6 +/- 1.7 g on 156.1 g of food. The second group gained 21.4 +/- 1.1 g on 154.2 g of food while the third group gained 29.6 g on only 140.4 g of food (Boyle et al., 1978). Since the amount of food ingested was held constant, "all three groups should have gained the same amount of weight" (Boyle et al., 1978). However, it was found that weight gain was inversely related to food intake. Therefore, the efficiency of food utilization, expressed as the degree of weight change per unit of food intake was found to be an "increasing function of caloric restriction" (Boyle et al., 1978). The groups of rats that were restricted gained more

weight per unit of ingested food than the unrestricted group. And, the greater the caloric deficit, the greater the increase in food efficiency. This was concluded since the more severely restricted rats gained considerably more weight per unit food consumed.

Similar results were reported by Bjorntorp and Yang (1982). In this study, adult male rats were fasted for 65 hours and then refed ad-libitum for eight days. The fasted rats regained the lost weight within the eight days of refeeding. This accumulation in energy occurred without an increase in total energy consumed from baseline levels or in comparison to controls. During the eight day refeeding period, caloric intake for the refed rats (835 kilocalories) was similar to the control group (839 kilocalories). However, refed rats displayed a carry-over anorexia on the first day of refeeding since food intake was well below control level. It was not until the third day of refeeding that food consumption exceeded controls. This almost identical food intake "resulted in a food efficiency of the refed animals more than five times higher than in controls" (Bjorntorp and Yang, 1982).

In a more recent study, (Gray et al., 1988) allowed rats to become obese. The rats were then subjected to "two successive periods of severe food restriction..., each followed by ad-libitum refeeding...until control body weights

were achieved" (Gray et al., 1988). When allowed to eat, "food intake increased to twice control levels for six days before returning to control levels" (Gray et al., 1988). It was found that the efficiency of food utilization was greater in the refed rats in comparison to controls. In addition, Gray et al., (1988) added another group to the study to investigate the effects of weight cycling. These results "showed that repeat cycles of restriction and refeeding had no effect on the efficiency of weight gain during refeeding" (Gray et al., 1988). This was concluded since there was no significant difference between the rate of weight loss of rats subjected to one cycle than rats subjected to two cycles of weight loss. The group that was restricted for two cycles did not lose weight slower than the group that was only subjected to one cycle. These results conflict with those reported by Brownell et al., (1986).

Brownell et al., (1986) fed a high-fat diet to a group of male rats. After they reached an obese weight, food was restricted until normal weight was achieved. The rats were then subjected to an identical cycle of weight gain and loss. Even though caloric restriction was the same during both cycles, the rate of weight loss during the second cycle was 50% slower than the first cycle. Weight gain during the second cycle of re-gain occurred three times faster than in the first cycle of re-gain. Therefore, it was concluded that

there was a significant increase in food efficiency from the first cycle to the second cycle of loss and re-gain.

A more recent study reported different results. Hill et al., (1988) subjected a group of rats to four 10 day cycles. The 10 days consisted of three days starvation and seven days of 60% of baseline food intake. A second group was exposed to 60% baseline food intake during the four cycles. Both groups were then observed during an 18 day refeeding period. Food intake was not different between these two groups. However, both groups consumed 13 to 15 percent more food than control. The weight cycled rats "regained carcass energy with a greater efficiency than did constant restriction rats" during refeeding (Hill et al., 1988). During the four 10 day cycles, weight changes and food efficiency were analyzed. During cycle one, the weight cycled rats lost less weight and had a higher food efficiency compared to constant restriction rats. It was found that weight loss during the three day fast declined during the third and fourth cycles in comparison to the first and second cycles but weight regain was not affected. Food efficiency was higher during the third cycle than it was during the second or fourth cycles. These results suggest that weight cycling can affect the rate of weight loss but will not directly affect the efficiency of regain. These studies, therefore, reveal conflicting results on the effects of weight cycling and food efficiency.

Most of the investigations on weight cycling and food efficiency have been conducted on animals. However, a few studies have examined these effects in humans. Blackburn et al., (1987) studied a group of obese humans in a metabolic ward. All subjects received the same calorically-restricted diet during two phases of weight loss. It was reported that during the second diet, weight loss was substantially less than compared with the first phase (Blackburn et al., 1987). Liebel and Hirsch (1984) conducted a study on obese humans who were approximately 60% over-weight but had lost substantial weight (52 kg). After weight loss, caloric requirements were 28% lower than that required before weight loss. And according to body size, their caloric requirements were 25% lower than the estimated level. Even though the reduced obese weighed 60% more than the normal weight controls, their daily caloric needs were less (2,171 kcal/d vs 2,280 kcal/d). Therefore, the reduced obese were maintaining excess body weight on fewer calories than what would be predicted for their body weight. These results suggest that the reduced obese subjects utilized their food more efficiently than the normal weight controls.

These studies illustrate what is known about weight cycling and food efficiency in animals and humans, but what are the effects on athletes? Only a limited amount of research has addressed the issue of food efficiency in

athletes. Brownell, Steen and Wilmore (1987) found that it was "possible to calculate food efficiency from existing" food intake data. They used data from past studies and calculated "food efficiency as kilocalories per day per kilogram of body weight" (Brownell et al., 1987). For example in research conducted by Drinkwater et al., (1984), it was reported that the average caloric intake in a group of distance runners was 1,750 kilocalories per day. These women trained an average of 53.4 kilometers per week. With an average body weight of 56.2 kilograms, their calculated food efficiency was 31.9. Brownell et al., (1987) calculated food efficiencies in two other studies. One study was on female marathon runners who averaged more than 104 kilometers per week (Marcus, 1985). Their mean caloric intake was 1400 kilocalories per day and average body weight was 51.1 kilograms. This resulted in a food efficiency of 31.1 which is similar to Drinkwater et al., (1984). Nelson et al., (1986) also studied female runners. These women ran an average of 59 kilometers per week. Their mean caloric intake was 1990 kilocalories per day. With an average body weight of 56.5 kilograms, their food efficiency was calculated at 35.4. In review of these results, Brownell et al., (1987) proposed "that food efficiency is increased in athletes with low body weights." However, the results from other studies refute this notion. Blair et al., (1981) investigated the nutrient intake of male and female runners

and compared them to matched controls. They found that the caloric intake for the runners was significantly higher in comparison to the non-athletic controls.

Brownell et al., (1987) proposed that food efficiency should be higher in reduced athletes as compared to those competing at their natural weight. For example,

> two women runners may compete at a body weight of 50 kg. The 50 kg for one woman may be close to her comfortable weight if she were not athletic, while the other may be reduced from a natural weight of 60 kg.

Therefore, food efficiency "should be higher than the pre-training level for the reduced runner but not for the runner competing near her 'natural' weight" (Brownell et al., 1987).

Instead of calculating food efficiency from past data, a recent study investigated this issue. Steen, Oppliger and Brownell (1988) examined the "metabolic effects of repeated weight loss and regain in wrestlers." The purpose of their study was to determine if weight cycling was "associated with reduced energy requirements" (Steen et al., 1988). Two groups of wrestlers were formed. One group consisted of the weight cyclers. These wrestlers lost weight 10 or more times during the season, and lost 4.5 kilograms or more each week. The non-cyclers "cut" weight five times or less during the season and lost less than 1.4 kilograms per week. "There were no significant differences in age, height, weight, body surface area and percent body fat or lean body mass between cyclers

and non-cyclers" (Steen et al., 1988). However, resting metabolic rate (RMR) for the cyclers was significantly lower than for the non-cyclers. The weight cyclers had a 14% lower resting energy expenditure than the non-cyclers (Steen et al., 1988). In conclusion, the weight cyclers in this investigation had significantly lower energy requirements than the wrestlers who did not engage in this practice.

Therefore, the literature is inconsistent in citing the effects of weight cycling on body composition and food efficiency in athletes. However, another group of athletes which may provide additional information on the effects of weight cycling are body builders. These athletes may compete more than one time per year which would result in repeated bouts of weight loss and regain. Therefore, body builders may be at risk of the deleterious effects of weight cycling reported in literature.

Eating Disorders - Anorexia Nervosa and Bulimia

Within the past decade, eating disorders such as anorexia nervosa and bulimia have become a growing concern due to the increasing incidence in the population. Eating disorders typically affect people 15 to 26 years old but have been reported in people as "young as 11 and as old as 65" (Eating Disorders in Young Athletes, A Round Table, 1985). "It is a disease that affects women more than men at a ratio of 9 or 10 to 1" (Eating Disorders in Young Athletes, A Round Table,

1985). These women are usually young and range in age from 12 to 22 and come from middle or upper-class families. More and more cases are being reported in men, especially bulimia.

An estimated 1 in every 250 girls between 12 and 18 and as many as 1 in every 100 teenagers and young adult women are affected by anorexia nervosa (Bayer and Baher, 1985). Bulimia is more prevalent than anorexia nervosa. The prevalence of bulimia is somewhere around 1% which is more than that of anorexia nervosa (< 1%) (Eating Disorders in Young Athletes, A Round Table, 1985). It was reported that the "lifetime chance of a woman between 15 and 40 " years old "meeting the criteria for bulimia is about 10%" which is extraordinarily high (Eating Disorders in Young Athletes, A Round Table, 1985).

Characteristics of Anorexia Nervosa and Bulimia - Anorexia nervosa and bulimia are complex disorders with multiple causes and consequences. Anorexia nervosa is characterized by weight loss of greater than 25% of original body weight, a disturbance in body image, a refusal to maintain normal body weight according to age and height, and no known physical illness that would account for weight loss (Garner and Olmstead, 1984). This disease involves the restriction of food to the point of starvation and weight loss. In most cases, protein, vitamins and mineral intake is low (Brotman et al., 1985). Anorectics are usually

hyperactive despite their low caloric intake (Eating Disorders in Young Athletes, A Round Table, 1985). And, these individuals are generally perfectionists and self-critical (Brotman et al., 1985). Among the psychiatric disorders, anorexia nervosa, unfortunately, has the highest record of mortality and morbidity rates (Brotman et al., 1985). Brotman et al., (1985) reported that approximately "22% of patients" in follow-up studies have died. And "over the last 20 years, the average mortality rate was estimated at 6%" (Brotman et al., 1985).

Bulimia is associated with binge eating. Binge eating may be defined as the consumption of large quantities of food in a short period of time (Garfinkel and Garner, 1982). Bulimics are usually obsessed with food and eating, tend to be slightly overweight, and experience a sense of loss of control relative to eating (Garfinkel and Garner, 1982). A binge is typically followed by some form of purging such as laxative abuse, diuretic use, diet pills, excessive exercise, and/or self-induced vomiting (Brotman et al., 1985). The highest estimates of bulimia occurs in college women (19%) and college men (5%) (Brotman et al., 1985). However, this disorder can occur at any age and weight level.

To further exemplify characteristic behaviors, Mitchel, Hatsukami, Eckert and Pyle (1985) conducted a study on Bulimia patients. This study investigated their eating behaviors.

It was found that all of the 275 bulimia patients engaged in binge eating. Eighty-eight percent engaged in self-induced vomiting, 60% either abused laxatives or diuretics, and 65% reported that they chewed and spit out food. Approximately 50% of the subjects reported that they overate when they felt out of control. And, over one-third reported that they overate when they felt anxious, tense or unhappy.

Anorexia nervosa and bulimia have shared features. They are related in that both disorders display an intense fear of becoming fat with the pursuit of thinness, the preoccupation with weight and calories, and the use of food and weight control to deal with emotional distress or developmental changes (Garner and Olmstead, 1984). These disorders may occur independent of one another. But, these two disorders actually lie on a continuum because the usual occurrence is a transition between restriction and bulimia.

An example of how these disorders contrast each other lies in the realm of control. Whereas bulimics feel a loss of control and self-esteem due to their binging, anorectics gain a sense of achievement and self-control by their discipline and ability to fast (Levenkon, 1982).

Anorexia Nervosa and Bulimia in Athletes - Due to the increased incidence of anorexia nervosa and bulimia in the general population, several researchers have investigated the occurrence of these disorders in athletes. A few studies

suggest that the "prevalence of eating disorders in athletes may range from as high as 25% to less than 1%" (Thornton, 1990). Parr et al., (1980) conducted a survey study on 2,997 athletes. They reported that weight control was the number one nutritional concern of these athletes. Rosen et al., (1986) conducted a survey study on female athletes. The purpose of their study was to identify female athletes who displayed pathogenic weight control behaviors resembling anorexia nervosa and bulimia. They found that at least one behavior associated with anorexia nervosa and bulimia was practiced by 32% of the athletes (Rosen et al., 1986). The behaviors included self-induced vomiting, laxative abuse, use of diet pills and/or diuretics, and binging at least two or more times per week. Of these behaviors, "self-induced vomiting and laxative abuse occurred with almost equal frequency - 14% and 16%." And, diet pills were used on a regular basis by 25% of these athletes. The dieting athletes that lost more weight than intended resorted to vomiting, diuretics, diet pills or laxatives while 56% of them actually became anoretic. Seventy-five percent of these athletes reported that they continued weight loss because of an intense fear of losing control of eating habits once dieting stopped. These athletes resorted to behaviors associated with anorexia and bulimia in hopes of improving performance and not merely for aesthetic reasons.

In a follow-up study, Rosen et al., (1986) reported that pathogenic weight control behaviors were the highest in gymnasts (74%) and distance runners (47%) where there is an added pressure to achieve and maintain low body weight. For the competitive gymnast, training involves bouts of anaerobic exercise with a small amount of continuous energy expenditure. And, "the only way...to maintain low body weight required by their sport is to restrict caloric intake" (Loosli et al., 1986). Therefore, gymnasts usually struggle with the dilemma of trying to gain strength yet "remain thinner than most" athletes (Loosli et al., 1986). A more recent study on intercollegiate female gymnasts reported that all were presently dieting, "that 26 were using at least one form of pathogenic weight-control, and that 21 of 28 competitors who were told by their coach that they were overweight resorted to pathogenic weight-control behaviors" (Thornton, 1990). Similar to the gymnast, low body weight appears to be advantageous for the distance runner. It has been documented that "a higher percentage of eating disorders occurs in events like distance races, where initial weight loss may be advantageous" (Eating Disorders in Young Athletes, A Round Table, 1985).

Swimming is a sport where body weight is critical to performance. A recent study was conducted on the University of Texas Women's Swim Team (Thornton, 1990). Over an 18-month

period, 12 team members were diagnosed as having a serious eating disorder. Among the swimmers was a 1988 Olympic Gold Medalist who was treated for bulimia. Therefore, individuals who belong to sports or professional groups that demand low body weight or specific body weight as a condition for participation are at a greater risk of developing eating disorders. "The increasing demands...placed on athletes to improve their techniques and the physical state of their bodies" have lead many to resort to extraordinary measures to reduce body fat stores to improve performance (Rosen et al., 1986). Some athletes may become obsessed with the idea of "making weight" in wrestling or achieving the "aesthetic ideal" for their art form in ballet. Instead of adopting healthy nutritional habits, pathogenic weight-control behaviors may emerge.

Wrestlers, for example, have been reported to lose between 10% to 20% of their body weight within several days of competition to qualify for a lower weight class (Tipton and Teheng, 1970; Zambraski et al., 1976; Houston et al., 1981; Steen et al., 1986). In one study, 81% of the wrestlers reduced food intake while 21% resorted to food deprivation (Steen and McKinney, 1986). A high use of dehydration techniques were reported such as saunas (51%), fluid restriction (58%), wrestling in heated rooms (74%) and exercising in rubberized suits (42%) (Steen and McKinney,

1986). Several other studies have reported these practices in wrestlers (Tipton and Teheng, 1970; Tipton, 1980; Houston et al., 1981). These studies reported that wrestlers resorted to behaviors associated with anorexia and bulimia. Tipton (1980) reported the use of laxatives, diuretics, appetite suppressants and self-induced vomiting in his group of wrestlers. One wrestler actually became anoretic from repeatedly engaging in these practices (Tipton, 1980). Steen and McKinney (1986) reported that their group of wrestlers "used laxatives (5%), diuretics (5%), and vomiting (11%) to lose weight." These results suggest that the sport of wrestling may promote the adoption of pathogenic weight-control behaviors due to the demands to qualify for certain weight classes. These practices could make athletes more susceptible to developing anorexia nervosa and/or bulimia.

An aesthetic requirement for professional ballet dancers is to maintain a sylph-like body. Being tall and thin is essential for the portrayal of their art form. In their quest to maintain low body weight and body fat, ballet dancers may resort to unhealthy diet practices. It has been reported that the ballet population appears to be more susceptible to bizarre eating patterns. A survey study found that the primary concern among ballet dancers was weight control and diet (Druss, 1979). Instead of adopting sound nutritional habits, several studies reported that intentional dehydration,

laxative abuse, fasting and self-induced vomiting were all common weight control methods used by professional ballet dancers (Bensen et al., 1985; Maloney, 1983). Calabrese et al., (1983) reported the occurrence of self-destructive behaviors in a group of classical ballet dancers. They reported that self-induced vomiting, laxatives, and diuretics were used frequently for weight control.

Garner and Garfinkel (1978) conducted a study on a group of professional ballet dancers. They reported that the incidence of anorexia nervosa was 1 in 20 which is 100 times that of the general population. Ballet dancers, therefore, have a higher risk of developing an eating disorder due to the demands placed on them to maintain sylph-like bodies.

It appears that in sports where the maintenance of low body weight or low body fat is essential for participation, athletes may be more susceptible to developing an eating disorder such as anorexia nervosa or bulimia. Another group of athletes which may have an increased risk of developing one of these disorders is body builders. Since it is necessary for these athletes to diet prior to competition, pathogenic weight-control practices may be adopted in order to achieve low levels of body fat for competition.

Athletic Menstrual Irregularity (AMI)

In the past, normal menstrual function was reported in athletes (Ingmane, 1952; Erdelyi, 1962; Astrand et al., 1963;

Zaharieva, 1965). Concern has recently emerged relevant to the increasing occurrence of menstrual disturbances in athletic women. The prevalence of menstrual disturbances among exercising women ranges from 20 per cent to as high as 50 per cent in competitive athletes (Shangold, 1985). This is considerably higher than the prevalence in the general population which is estimated at five percent (Shangold, 1985). Since menstrual disturbances are more prevalent in the athletic population, it may be easy to attribute exercise as the cause. However, the exact mechanisms causing menstrual dysfunction in athletes have not yet been determined. This section of the literature review presents factors which may contribute to the development of athletic menstrual irregularity (AMI).

Classification - A search of the literature found that researchers are inconsistent when defining criteria for the determination of menstrual status. Normal menstrual cycles or eumenorrhea has been defined as menstruation which occurs at intervals less than 36 days (Lutter and Cushman, 1982), cycles between 21 and 34 days (Galle et al., 1982) and cycles between 23 and 35 days (Carlberg et al., 1983). In a more recent investigation, Noakes and van Gend (1988) consider eumenorrhea to be "of less than 35 days duration but longer than 23 days." In review of these definitions, researchers appear to agree that normal menstrual cycles occur at

consistent intervals of less than 36 days, usually between 21 to 35 days in length.

Classification of menstrual dysfunctions such as amenorrhea and oligomenorrhea are even more inconsistently defined in literature, especially oligomenorrhea. The definition of oligomenorrhea depends on how the researcher defines amenorrhea. The following presents a variety of criteria found in literature for the classification of menstrual status. Lutter and Cushman (1982) classified amenorrhea as amenses for 12 or more months. Oligomenorrhea was defined by the following criteria: having less than 2 menstrual periods per year, having cycles of 36 to 120 days which occur at inconsistent intervals, sometimes monthly and sometimes skipping several months. Galle et al., (1982) classified amenorrhea as cycles of more than 90 days in duration and oligomenorrhea as cycles of 35 to 89 days. Carlberg et al., (1983) defined oligo/amenorrhea as amenses for three to four months while Frisch et al., (1981) considered this to be the definition for oligomenorrhea. Frisch et al., (1981) defined amenorrhea as amenses for the past six months.

In review of these investigations, it appears that researchers agree that oligomenorrhea is classified as cycles of 36 to 89 days which occur at inconsistent intervals. Amenorrhea, however, is not as clearly defined. These

investigations suggest that amenorrhea is classified as amenses for three consecutive months (Galle et al., 1982), six consecutive months (Frisch et al., 1981) and 12 or more consecutive months (Lutter and Cushman, 1982).

Training - Training appears to be associated with athletic menstrual irregularity (AMI). Feicht et al., (1978) reported that the prevalence of amenorrhea in runners increased as weekly mileage increased. Lutter and Cushman (1982) conducted a survey study on 350 female runners. They found that oligomenorrheic runners ran more miles per week than eumenorrheic runners. Fifty-eight percent of oligomenorrheic runners averaged over 30 miles per week, and 14.9% ran 50 or more miles per week. The amenorrheic runners in this survey reported greater weekly mileage. Twenty-three percent averaged 31 to 50 miles per week while 61.5% averaged over 50 miles per week. Other literature reported that distance runners training less than 50 miles per week are less susceptible to menstrual irregularity than those running more miles per week (Feicht et al., 1978; Frisch et al., 1981).

Training as a factor in the development of AMI has been further supported by the appearance and disappearance of menstruation with a change in exercise. Cohen et al., (1982) reported that ballet dancers had fewer menstrual periods during the season than during the off-season. Frisch et al., (1981) reported that oligomenorrhea and amenorrhea increased

in college swimmers and runners with an increase in training. In contrast, Baker (1981) reported that runners training less than 40 miles per week had a higher incidence of amenorrhea than runners who trained more.

Age, Parity, and Menstrual History - According to literature, younger athletes have a higher incidence of menstrual disturbances than older athletes (Speroff and Redwine, 1980; Baker, 1981). Speroff and Redwine (1980) reported that women under the age of 35 were more prone to the development of menstrual disturbances. Incidence rates of amenorrhea have been found to be higher in runners under 30 than in those over 30 (Baker, 1981; Speroff and Redwine, 1980). Baker (1981) reported rates of 66.6% in women under 30 and only 9% in women over 30. Speroff and Redwine (1980) found lower rates of 8.8% versus 2.2%.

Several studies have reported a higher incidence of menstrual irregularity among athletes who began training prior to menarche. And, researchers have found that menarche is delayed in women who begin athletic training before menarche. Frisch (1981) conducted a study on college runners and swimmers. Pre-menarche trained athletes had a mean menarcheal age of 15.1 +/- 0.5 years which was older than the post-menarche trained athletes (12.8 +/- 0.2 years). Another study on amenorrheic runners reported a menarcheal age of 13.8 +/- 0.5 years in comparison to 12.2 +/- 0.3 years in eumenorrheic

runners (Baker et al., 1981). Cohen (1982) reported a menarcheal age of 14.2 +/- 2.8 years in a group of professional dancers. The dancers were compared to a control group who's menarcheal age was 12.5 +/- 1.4 years (Cohen, 1982).

Women who usually had irregular menstrual cycles prior to training are at a higher risk of developing AMI (Schwartz et al., 1981). Conflicting results were reported by Speroff and Redwine (1980). They reported that their group of amenorrheic runners had normal menstrual cycles prior to training.

Nulliparous athletes have been reported to be more prone to developing irregular menstrual cycles. According to one study (Loucks and Horvath, 1985), women who had not borne a child had a higher incidence of AMI than women who had borne a child. Menstrual dysfunction may be reduced in parous women due to a protective function associated with child birth (Baker, 1981).

Body Composition, Body Weight, and Weight Loss - Menstrual dysfunction in the athlete and non-athlete has been associated with low body weight and low body fat. A critical weight theory hypothesized that a certain weight:height ratio was necessary for the onset of menarche (Frisch, 1974). This hypothesis later evolved into the "critical fat" hypothesis which suggested that it was necessary to have at least 17

percent body fat for menstruation to begin and at least 22 per cent to maintain normal cycling (Frisch, 1974). Since low body weight and fat are common in the athlete, this hypothesis became an easy answer to the development of AMI. However, recent studies do not support the "critical fat" theory. In one study, both the eumenorrheic and amenorrheic runners had the same percent body fat (Sinning and Little, 1987). Baker et al., (1981) found a group of eumenorrheic athletes with low body fat. And, McArthur et al., (1980) found a group of amenorrheic athletes with high body fat and body weight.

It has been suggested that the absolute level of body weight or fat may not be as important as the "rate of weight loss or fat loss" (Ellison, 1981). As women initiate an aerobic exercise program, body fat and/or weight usually decreases. Speroff and Redwine (1980) suggested that losing more than 4.5 kilograms and weighing less than 52 kilograms after the initiation of training can increase the risk of developing menstrual irregularity. In fact, amenorrhea has been associated with simple weight loss and low body weight in women who do not exercise (Vigersky et al., 1979; Wertz, 1980).

Baker et al., (1981) compared a group of amenorrheic runners to eumenorrheic runners. Not only did the amenorrheic group weigh less (50 +/- 2 kg versus 53 +/- 1 kg) and have less body fat (14.1 +/- 1.2 % versus 17.7 +/- 0.8 %), they

reported a greater weight loss (2 to 7 kg versus 1 to 4 kg) than the cyclic runners. In contrast, Wakat et al., (1982) reported that a group of athletes regained normal menstrual cycles without a change in body weight.

Another investigation found additional effects of weight loss and exercise on the menstrual cycle. Bullen et al., (1985) subjected 28 untrained college women to an increasing amount of exercise over an eight week training period. One group acted as the weight-maintenance group. This group was paired to a weight-loss group. It was found that exercise compounded with weight loss resulted in a decrease in luteal phase length and anovulation. Sixty-six percent of the weight maintenance group and 63% of the weight-loss group developed abnormal luteal function. Forty-one percent of the weight maintenance and 81% of the weight-loss group developed anovulatory cycles due to a loss of the luteinizing hormone surge. As the amount of exercise increased and body weight decreased, menstrual disturbances increased.

In simple weight loss through dieting, metabolism is altered. And, it has been reported to "interfere with follicular development and ovarian estradiol (E2) production" (Pirke, 1985). Schweiger et al., (1987) reported that weight loss of only 1 kg per week may induce menstrual cycle disturbances. With this rate of weight loss, estradiol and progesterone were diminished during the luteal phase, and the

length of the luteal phase was shortened (Schweiger et al., 1987). Therefore, changes in body fat or weight may alter endocrine function (Fishmen et al., 1977).

Emotional Stress - According to results reported in several studies, amenorrheic athletes consider training to be more stressful and intense than eumenorrheic athletes (Baker, 1981). They also consider intense training to occur more months per year. While this factor may not be pertinent for all athletes, stress may affect some. An individual's response to the stress of competition or training may contribute to menstrual disturbances (Carlberg et al., 1983; Shangold, 1985).

Dietary Factors - The response of the menstrual cycle to exercise may be influenced by the diet. It has been reported in literature that an association exists between low fat and protein consumption with the occurrence of athletic amenorrhea. Schwartz et al., (1981) reported that between amenorrheic and eumenorrheic runners, total protein intake was the same. But, the amenorrheic runners consumed more total calories which created "a smaller percentage of total intake as protein" (Schwartz et al., 1981). Frisch and McArthur (1974) reported lower fat and protein intake among amenorrheic runners. This report suggests that an association may exist between fat and protein consumption and the "regulation of certain hormones" (Deuster et al., 1986).

Low caloric consumption in amenorrheic athletes as compared to eumenorrheic athletes has been reported (Frisch and McArthur, 1974). Both runners and ballet dancers have been shown to consume fewer total calories than recommended (Calabrese, 1982; Frisch, 1974). Menstrual disturbances were reported by these athletes (Frisch., 1974). Deuster et al., (1986) reported that caloric intake in amenorrheic runners was lower than that for eumenorrheic runners. Even when the mean caloric intake was expressed relative to body weight, the amenorrheic runners consumed fewer calories (Deuster et al., 1986). The higher incidence of AMI which occurs in runners and ballet dancers may be associated with energy drain. And, these athletes may "exhibit energy conservation by ceasing to menstruate" (Myerson, 1987). The same may be true for non-athletic amenorrheic women. Sedentary women with exceptionally low caloric intakes have been reported to be amenorrheic (Fishman et al., 1977). These women may conserve energy by ceasing to menstruate.

Menstrual dysfunction has appeared in vegetarian women. For example, it was reported in one study that a large number of oligo/amenorrheic athletes were vegetarian (Carlberg et al., 1981). Brooks et al., (1984) reported that eumenorrheic runners consumed more meat than their amenorrheic counterparts, preferably more red meat. In a group of cyclists, Slavin et al., (1984) reported that the amenorrheic

subjects consumed vegetarian diets. Hill et al., (1984) reported that a meatless vegetarian diet decreased the length of the menstrual cycle. Hormonal changes were reported which included a decreased release of luteinizing hormone (LH) and follicle-stimulating hormone (FSH) and an increased pituitary release of LH in response to LH releasing hormone (Hill et al., 1984). The duration of the follicular phase was decreased as well (Hill et al., 1984). In a more recent study by Hill et al., (1986), daily meat consumption increased the release of LH and increased menstrual cycle length. Thus, the consumption of meat may modify gonadotrophin release and follicular maturation (Hill et al., 1986).

Vegetarians usually consume less fat and more dietary fiber than omnivorous women (Goldin et al., 1982). Increased dietary fiber increases fecal output. One study reported a positive correlation between fecal output and estrogen excretion (Goldin et al., 1982). Since vegetarians consume more dietary fiber, more estrogen is excreted (Goldin et al., 1982). Increased dietary fiber alters the circulating level of estrogen. These factors may lead to the development of amenorrhea in both athletic and non-athletic women. Deuster et al., (1986) reported similar results in a group of amenorrheic runners. The amenorrheic runners consumed less fat and more fiber than the eumenorrheic runners (Deuster et al., 1986). In a recent study by Lloyd et al., (1987)

"increased dietary fiber intake" was associated with irregular menstrual cycles. This study supports the above findings that "dietary food habits and food fiber levels alter circulating estrogen levels (Lloyd et al., 1987).

Several factors have been associated with the occurrence of athletic menstrual irregularity. There does not seem to any one factor that causes AMI. Certain factors may affect individuals in different ways or a combination of the factors may act synergistically to result in menstrual dysfunction.

Only one study has reported the occurrence of menstrual disturbances in female body builders (Elliott and Goldberg, 1987). It is possible that in preparing for competition, female body builders may increase their risk of developing menstrual dysfunction. Amenorrhea and/or oligomenorrhea may occur due to training and dietary practices to lose body fat and/or weight during the competitive season.

Dietary Patterns of Female Athletes

This section of the literature review presents information available on the dietary patterns of female athletes concerning caloric intake, dietary composition, and vitamin/mineral deficiencies.

Caloric Intake - Even though athletes expend a great deal of energy participating in sports, the majority of women athletes consume diets low in calories. It has been reported that caloric intake of female athletes ranges from 1200 to

2135 kilocalories per day (Deuster et al., 1986). Loosli et al., (1986) reported that the average caloric intake of a group of adolescent gymnasts was 1838 kilocalories per day. This is approximately 300 calories less than the recommended 2100 kilocalories per day. An average caloric intake of 1673 +/- 450 kilocalories was reported in a group of professional ballet dancers (Cohen et al., 1985). Fifty percent of these women fell below the RDA for calories. Welch et al., (1987) found similar results in a group of female collegiate athletes. Pre-season intake averaged 1788 +/- 654 kilocalories per day while post-season intake averaged 1893 +/- 648 kilocalories per day (Welch et al., 1987). These women "did not meet the RDA of 2000 kilocalories per day for their age-group" (Welch et al., 1987).

Higher caloric intake in female athletes was reported in other studies. Deuster et al., (1986) found an average of 2397 kilocalories per day in a group of highly trained runners. And Jang et al., (1987) reported an intake of 2491 kilocalories per day in a group of swimmers and 2037 kilocalories per day in a group of runners. A study on university athletes reported that average caloric intake varied between sports (Short and Short, 1987). Ballet dancers consumed the least amount of calories per day (1909 kcal/day). The other athletes displayed comparable intakes. These included basketball players (2629 kcal/d), crew members (2339

kcal/d), lacrosse (2219 kcal/d), swimmers (2685 kcal/d) and volleyball players (2446 kcal/d). From these studies, it appears that caloric consumption is the lowest in sports where low body weight and/or body fat is essential.

Dietary Composition - For most athletes as well as the general population, the composition of the diet should consist of 15 to 20% protein, 30% or less of fat, and 50 to 60% carbohydrates, preferably complex carbohydrates. A few studies have assessed the composition of the diet of female athletes.

In a group of college athletes, Welch et al., (1987) reported that these women consumed 15% protein, 35% fat and 50% carbohydrate during the preseason and 14% protein, 35% fat and 50% carbohydrate during the off-season. Similar percentages were found in a group of highly trained runners. These women consumed 13% protein, 32% fat and 55% carbohydrates (Deuster et al., 1986). Cohen et al., (1985) found a distribution of 14% protein, 38% fat and 48% carbohydrate in the diets of professional ballet dancers. On the average, each of these studies reported a lower than recommended percentage of protein. In the study by Deuster et al (1986), 11% of the runners consumed less than the recommended amount of protein. And, three of the 12 ballet dancers where below the RDA for protein in Cohen et al.'s, (1985) study.

Loosli et al., (1986) investigated the dietary composition of gymnasts. These athletes consumed 15% protein, 36% fat and 49% carbohydrate which "compares favorably to the American Heart Association's" guidelines. However, the form of carbohydrate that was chosen was low in fiber. Only 3.6 grams per day were consumed compared to the recommended eight grams per day.

Short and Short (1987) conducted a study on collegiate athletes. Basketball players consumed 14% protein, 40% fat and 46% carbohydrates and 1% alcohol. Ballet dancers consumed 17% protein, 31% fat and 52% carbohydrate. Swimmers consumed 17% protein, 36% fat and 44% carbohydrate and 3% alcohol. None of these athletes had a low intake of protein relative to body weight.

Vitamin/Mineral Deficiencies - In one study, a group of female college athletes reportedly consumed foods low in calories and nutrients (Welch et al., 1987). This type of diet contributed "to less than acceptable levels of vitamins B-6 and B-12, folacin, calcium and iron." Perron et al., (1982) reported that a group of adolescent athletes consumed diets deficient in calcium (64% below RDA) and iron (65% below RDA). Similar results were found in ballet dancers. Their diets were deficient in vitamins B-6 and B-12, folic acid, niacin, pantothenic acid, biotin and iron (Cohen et al., 1985). And, the majority of the gymnasts in Loosli et al.'s,

(1986) study consumed less than two-third's of the RDA of vitamin B-6, folate, iron and zinc.

In contrast, highly trained runners consumed above the recommended amount of calcium, magnesium and iron and were within the safe and adequate range for copper (Deuster et al., 1986). Despite the high average iron intake in this group of runners (41.7 mg), more than 43% of them were consuming less than the RDA (Deuster et al., 1986).

The results of these studies reveal that female athletes consume diets low in calories coupled with an intake of foods low in essential nutrients.

SUMMARY

The number of studies on female body builders is limited. The studies that have been conducted have addressed the psychological and physiological characteristics of body builders. According to these studies, body builders have low functional capacities, normal blood values and low percentages of body fat. Psychologically, they are extroverted and highly self-motivated individuals.

Body builders who compete more than one time per year usually engage in repeated bouts of weight loss and regain which is similar to the wrestler. This practice of weight cycling may have the same deleterious effects as those reported in literature such as enhanced food efficiency and decreased ability to lose weight.

Since dieting is a major part of body building, bizarre eating behaviors may be encouraged. Body builders may adopt behaviors associated with anorexia and bulimia nervosa as they try to lose weight and/or bodyfat for a competition. In addition, several factors associated with the development of athletic menstrual irregularity are common to the sport of body building. These include: training, body composition, weight loss and stress of competition which have all been documented in other athletes to be associated with menstrual dysfunction.

Most of the literature on body builders has addressed their training programs. Only two recent studies have addressed pre-competition and competition body weight and diet intake of female competitive body builders. However, neither of the studies have addressed body weight patterns, weight cycling effects, eating disorders, menstrual dysfunction or dieting patterns in association with pre-competition, competition and post-competition. These issues remain to be investigated.

Chapter 3

JOURNAL MANUSCRIPT

Diet, Body Weight Patterns and Menstrual Characteristics of Competitive Female Body Builders

by

Cynthia Eckstein Edmunds

(abstract)

The purpose of the study was to provide descriptive information on nutritional profiles and body weight (BW) patterns of 6 competitive female body builders (x age = 27) before, during and after a competition. Precompetition (-28 to -26 d); (-9 to -7 d), competition (-2 to 0 d) and post competition (+1 to +3 d); (+26 to +28 d) 3-d diet and BW records were recorded. Diet records were analyzed using the Nutripractor 6000 nutrient analysis system. Two weeks precompetition, percent body fat was estimated using skinfold measurements. All subjects completed a 60-item fixed choice and open-ended questionnaire concerning menstrual characteristics, training and dietary practices. A subgroup (n=2) agreed to collect daily urine samples for one month prior and one month after competition. Samples were analyzed for estradiol (E2) and progesterone (P4).

Repeated measures ANOVA indicated that BW loss was significant from (-28 to -26 d) to (-2 to 0 d) followed by a significant increase in BW from (-2 to 0 d) to (+1 to +3 d) and (+26 to +28 d). Percent bodyfat was estimated at 12.7 +/- 1.65%. Dietary results indicated that kilocalories increased

significantly from (-28 to -26 d) and (-9 to -7 d) to (+1 to +3 d) and (+26 to +28 d). Dietary protein intake was above the RDA throughout the study. Analysis of percent dietary composition indicated a significant decrease in percent protein from (-28 to -26 d) to (-2 to 0 d) with an increase in percent carbohydrate while percent fat intake remained low. At (+1 to +3 d) and (+26 to +28 d), the percentage of protein and carbohydrate decreased significantly being replaced with high fat foods. Hormonal analysis of urine samples illustrated an aberration from normal patterns of E2 and P4 in the cycle during competition. The results may encourage body builders to follow healthy diet and realistic weight loss plans prior to competition and illustrate the adverse effects of strict dietary practices on menstrual function.

CHAPTER 3

INTRODUCTION

Since the 1970's, there has been an increasing number of women participating in athletics, either for general fitness or competition. One sport which has grown in popularity within the past ten years is body building. Body building competitions have become "common sports events in several major sports and television programs" (18). Where most sports use weights for the development of strength, body builders use weights to develop "muscular size, definition and a symmetrical whole body image" (35). In preparation for a competition, body builders employ strict dietary practices in order to decrease bodyfat and increase muscular definition. As they try to attain that ideal physique by competition day, their nutritional status may be all but optimal. Their reduced food and water consumption prior to competition usually places them in a state of semi-starvation and dehydration with a drastically lowered level of bodyfat.

Strict dietary practices used by body builders may cause them to be more susceptible to the development of eating disorders. These disorders have been reported in other sports where a great emphasis is placed on maintaining low body weight and/or bodyfat for example in gymnastics and ballet (2, 30). Body builders may develop behaviors similar to anorexia and bulimia due to the importance of dieting to achieve

extremely low levels of bodyfat.

A recent study reported the occurrence of menstrual disturbances in body builders (13). These disturbances may be attributed to weight loss, low body weight or improper nutrition.

Certain groups of athletes, for example wrestlers, repeatedly lose weight during the season (5). Depending on how many times per year body builders compete, their weight may fluctuate frequently throughout the season. Several recent studies have documented adverse effects of weight cycling such as depressed metabolic rate and enhanced food efficiency (5, 21, 42). These effects may make future attempts at losing weight frustrating to these athletes.

The main purpose of this study was to examine the nutritional practices of female body builders before, during and after an actual competition by assessing nutrient intake, body weight patterns, weight-loss methods and percent bodyfat.

METHODS

Subjects. Six competitive female body builders ages 22 to 34 years were recruited from weight lifting clubs in Virginia and Maryland. The subjects included one beginner, one city level and three state level competitors and had to meet the following criteria: 1) involved in weight training four to six days per week; and 2) were currently preparing to compete in a body building competition within the six months following initial contact with the investigator.

PROCEDURES

All subjects were contacted and asked to attend an initial individual meeting for the completion of informed consent, questionnaire completion and the presentation of detailed instructions for completing diet, exercise and body weight records. At the initial interview, subjects reported their height and body weight and that they were steroid-free.

Data collection schedules were given to each subject which illustrated exact dates for recording 3-day diet, exercise and body weight records. The data collection schedule included a date for body composition analysis. The subjects who agreed to collect urine samples were given detailed instructions for proper collection and storage of the samples.

Questionnaire. Subjects completed a 60-item fixed choice and open-ended questionnaire concerning menstrual status and history, present training status and history, and diet history. All subjects were initially grouped together for questionnaire analysis. Frequencies were obtained for each item on the questionnaire. Dietary questions addressed body weight history, dietary preferences, and behaviors associated with anorexia nervosa and bulimia. The questions were used to assess the affects of body building on body weight and to possibly identify characteristic behaviors associated with anorexia nervosa and bulimia. Questions pertaining to menstrual status and history were used to categorize subjects

into birth-control use (BC) or non-birth control use (NBC). These groups were denoted by each subject's response of "I am currently taking oral contraceptives," or "I am not currently taking oral contraceptives and have not taken them for the past three months." The (BC) group consisted of three subjects who used oral contraceptives and were not included in the evaluation of menstrual history. The second group (NBC) was not presently taking oral contraceptives, therefore, frequencies were obtained for questionnaire items concerning menstrual status, history and the effects of diet and/or exercise on the menstrual cycle. The NBC group was asked to take daily urine samples for the duration of the study; however, only two of the three eligible subjects agreed.

Diet Records. All subjects were instructed to record five 3-day diet records. A detailed data collection schedule was provided which illustrated the exact dates to record the diet. Subjects recorded diet four weeks prior to competition (-28 to -26 d) and one week before competition (-9 to -7 d). During the weekend of competition, two consecutive records were recorded representing competition (-2 to 0 d) and immediate post-competition (+1 to +3 d). The last record was taken four weeks after competition (+26 to +28 d). The 3-day records included two week days and one weekend day. Subjects were instructed to record all food and drink as accurately as possible using "typical household measures." Diagrams were provided to assist in the estimation of portion sizes, for

example, of meats. Subjects were contacted to clarify all record entries. The Nutripractor 6000 nutrient analysis system (Proctorcare, Inc., 10951 Sorrento Valley Road, San Diego, CA (1987)) was used to assess the diet records for total calories, protein, fat, carbohydrate and selected vitamins and minerals. Food items not listed in the database were added using the nutrient information available on the food package label.

Body Weight Records. On the same day that diet was recorded, body weight was recorded. Subjects were instructed to weigh themselves on the same scale and at the same time each day.

Body Composition Assessment. Body composition analysis was performed by the researcher via skinfold technique two weeks prior to each subject's competition date (26). Lange skinfold calipers were used to take skinfold measurements for the estimation of percent body fat. Measurements of skinfolds were taken at the triceps, suprailium and thigh on the right side of the body. The three skinfold sites were measured five times each. The average of the five measurements for each skinfold site was used to estimate body density (BD) and percent body fat (%BF) using the equation of Jackson, Pollock and Ward (26).

Urine Sample Collection. The two subjects were instructed to take daily urine samples for one month (30 days) or one menstrual cycle prior to their competition and after.

The eumenorrheic subjects began urine sample collection on day one of their next menstrual cycle prior to their competition and continued until one complete menstrual cycle after competition. Subjects were instructed to collect the urine sample from the first morning void (10). Samples were immediately frozen and stored until analysis.

Samples were analyzed for urinary-free estradiol (E2) and urinary-free progesterone (P4) levels using commercially available nonextraction radioimmunoassay (RIA) kits (Diagnostic Products Corporation, 5700 West 96th Street, Los Angeles, CA). E2 was analyzed to predict the luteinizing hormone surge while P4 was analyzed to evaluate ovulation and corpus luteal function. The assay protocol was used with the following modifications: 1) urine samples were used instead of serum or plasma and 2) 25 ul aliquot volume was used in the E2 assay instead of the prescribed 100 ul volume.

Before the urine samples were analyzed, validation tests were conducted to determine the accuracy of the assay to measure urinary hormone concentrations. The validation tests proved that hormone concentration in urine could be measured using RIA Kits which recommended plasma samples. Within assay coefficient of variation for P4 and E2 assays were 7.08% and 8.00%.

DATA ANALYSIS

Questionnaire. Frequencies were obtained for each item on the questionnaire for each group of subjects.

The Statistical Analysis System (SAS) was used to perform all statistical procedures. Statistical significance was set at the .05 level for all analyses.

Diet Records. Each of the five 3-day records was analyzed and averaged. Analyses of variance with repeated measures were used to test the statistical significance among record means for kilocalories, kilocalories per kilogram BW, protein, grams of protein per kilogram BW, carbohydrate, fat and percent composition of the diet. To examine the means of significant factors, post-hoc analyses were performed using the Duncan's Multiple Range Test.

Body Weight. An average for each of the five 3-day body weight records was used in the analysis. Repeated measures analysis of variance was used to test statistical significance among the record means. The Duncan's Multiple Range Test was performed if the factor was significant.

Urine Samples. Since urine samples were collected for only two subjects, statistical analysis was not appropriate.

QUESTIONNAIRE RESULTS AND DISCUSSION

Table 1 lists the training characteristics of the subjects. The subjects ranged from the novice body builder to the state level competitor. The majority of subjects (4) had competed one time per year. One subject reported competing two times per year and another reported competing two to three times per year. Both of these subjects reported that they typically compete one to two months apart. In

addition to weight training, the subjects reported that they engaged in aerobic exercise throughout the year. Some subjects only exercised aerobically prior to competition to aid weight loss and not on a regular basis. Therefore, the subjects' regular mode of exercise was weight lifting.

Body Weight. In comparing body weight from pre-season to previous competition day, the subjects reported an average weight loss of 7.7 kg (range 4.9 - 11.7). The reported body weight characteristics for each subject are listed in Table 2. At least half of the subjects gained and lost weight at an acceptable rate of 0.5 to 0.9 kg/week.

All subjects reported weight loss prior to previous competitions. On the average, subjects reportedly lost 13% of their original BW in order to compete (initial BW = 58 Kg; mean weight loss = 7.7 Kg). However, the rate of weekly weight loss was within recommended limits and should not cause metabolic changes that may limit weight loss or accentuate weight gain upon refeeding. It appears that in those subjects who compete more than one time per year, more dramatic weight changes occur. For example, the subject (S#1) who reported the quickest rate of weight loss also reported the fastest rate of weight gain after competition. She reportedly gained more BW than she lost before competition. This subject reported that she competes more than one time per year. In contrast, one subject (S#5) who has competed for the first time did not regain her lost body weight. She reported that

she regained only a portion of the weight she had lost prior to competition.

Similar results have been reported in literature revealing that there is considerable variation in both animals and humans with respect to the reaction towards a change in energy intake. Brownell et al., (4) reported that successive cycles of weight loss and regain alter the efficiency of food utilization in rats. However, another study reported that repeat cycles of restriction and refeeding do not have an affect on the efficiency of weight gain during refeeding (21).

One study on athletes was conducted on two groups of wrestlers, weight cyclers and non-weight cyclers (41). The weight cyclers had a 14% lower RMR than the non-cycled wrestlers. The authors suggest that the repeated weight loss may cause the reduced energy requirements and make it more difficult for the athlete to lose weight (41). It is possible that female body builders may experience a change in metabolic rate as a result of repeated weight loss. This effect would probably be more pronounced in the women who had undergone more cycles of weight loss.

Diet. With regard to diet, four subjects reported that they did not consume red meat, only chicken or fish. Two subjects reported the consumption of red meat at least one time per week but not during competitive months. All subjects took supplements which included: amino acids (100%), protein (50%), potassium (16.6%) and multi-vitamins with iron (100%).

Lamar-Hildebrand et al., (28) reported a diet similar to that consumed by the body builders in the present study. The competitive diet in the body builders they studied included chicken and fish (tuna) and no red meat. All of their subjects reported vitamin and mineral usage while only 66% reported using amino acid supplements.

Eating Behaviors. None of the subjects considered themselves to have been anorectic or bulimic. Table 3 lists characteristic behaviors and attitudes associated with eating disorders as reported by the subjects. However, the majority of these behaviors reportedly emerged only when the body builders were dieting prior to competition and then after competition when they tried to resume normal eating patterns. For example, after competition four subjects reported that they had binged after succumbing to their uncontrollable urges to eat. One subject (#1) reported that she consumed over 5000 kilocalories the day after competition while another subject (#2) consumed over 7000 kilocalories in one day one month after competition. It is surprising that none of the subjects reported that they had an impulse to purge themselves after they had a binge. Being terrified of fat, feeling fat despite others saying you are too thin and over-activity without enjoyment were associated attitudes and behaviors which were reported to occur outside of competition. Currently, no other studies have addressed this issue in competitive female body builders.

In the general population, bulimia is more prevalent than anorexia nervosa and occurs more in women than men (12). Rosen et al., (34) conducted a survey study to identify female athletes who displayed pathogenic weight control behaviors resembling anorexia nervosa and bulimia. They found that at least one behavior associated with these disorders was practiced by 32% of their subjects. It was reported that these behaviors were the highest in sports where there is an added pressure to achieve and maintain low body weight and/or bodyfat. Wrestling is a sport similar to body building in that both incur repeated cycles of dieting and/or weight loss prior to competition. Steen and McKinney (41) reported that their group of wrestlers used laxatives, diuretics and vomiting to lose weight prior to competing.

Menstrual History. Three of the subjects were currently taking oral contraceptives so their data were excluded from this section of the results. The three remaining subjects were classified as eumenorrheic based on their answers to questions regarding menstrual cycle length and regularity. Table 4 lists the menstrual history of the three subjects. The subjects reported that their menstrual cycles occurred at consistent intervals. The two subjects who had a missed period within the past year attributed it to dieting before competition and to the stress of the actual competition. Two subjects began sports before their first period. The youngest began sports at age 5 and did menstruate until age 17.

The subjects were asked several questions about diet and exercise and their possible relationship to the menstrual cycle. Two subjects reported no change in cycle length with an increase in exercise. Only one subject reported a decrease in the number of days between periods due to an increase in exercise. None of the subjects reported spotting or bleeding between periods. However, during the two months prior to competition, one subject reported one to two days of spotting instead of an average flow which occurred bi-weekly. All three subjects reported that an increase in exercise does not cause menstrual periods to become irregular. During a break from training, the menstrual cycle was reported to become more regular for two subjects and only sometimes for the third.

In reviewing these results, it became evident that the survey approach to menstrual classification is questionable due to the varying reports given by the subjects. Loucks and Horvath (31) and Bonen and Keizer (3) expressed their concern over the validity of a survey to assess menstrual dysfunction because the results were dependent on subject recall and the classification of menstrual status was inconsistent in literature.

The subjects in this study could be classified differently depending on which questions from the survey were used. For example, although all subjects initially reported normal menstrual cycles at consistent intervals, later answers to questions concerning the skipping of cycles or a change in

the cycle around competitions makes classification as eumenorrheic less straight forward.

A further error inherent in using a survey to classify menstrual status is in the inability to determine changes in hormonal status that precede obvious clinical dysfunction (3). For example, Bullen et al., (6) subjected 28 untrained college women to an increasing amount of exercise over an eight week training period. While all of the subjects continued to menstruate, a decrease in luteal phase length occurred in 18 subjects and several ceased ovulating. Longitudinal hormonal research on body builders prior to training and continuing throughout a competitive season would be required to determine if these changes were only characteristic of aerobic exercise.

The occurrence of menstrual disturbances in female body builders has been documented in two studies (13, 14). Elliot et al., (13, 14) reported that body builders have displayed menstrual abnormalities similar to those reported in endurance athletes. Factors associated with menstrual disturbances in endurance athletes have previously been reviewed in literature (1, 6, 8, 9, 11, 17, 19, 25, 32, 33, 36, 37, 40). These factors include low body fat, low body weight, weight loss, emotional stress, and changes in diet and hormone levels. These factors are all applicable to the female body builder.

OBSERVATIONAL RESULTS AND DISCUSSION.

Body Composition. Two weeks prior to each subject's competition, body composition was assessed. Results for body

weight (BW), percent body fat (%BF), and lean body mass (LBM) for all six subjects are listed in Table 5. The mean %BF for the subjects is below the 20% to 25% range presented for age-group norms. It is also well below the 28% presented for sedentary women (44).

The average %BF for competitive runners and gymnasts has been documented to be between 12.5% and 15.5 %BF (38, 44). A mean of 13.2 +/- 2.9 %BF was found in one group of female body builders (18). Elliot and Goldberg (14) reported a higher average of 18 %BF in their group of international level female body builders. However, these subjects would be expected to be fatter since they were analyzed during the off-season and not prior to competition. A more recent study by Elliot et al., (13) reported a mean of 13.5% BF in a group of female body builders. They compared their subjects to a group of long-distance runners and found that the body builders had approximately 2% less BF. In another study on female body builders, Heyward et al., (24) reported an average of 16.8% BF during the non-competitive season. However during competition (24 - 48 hours prior to competition), %BF was reported to be as low as 9.5% in these women.

Body weight. Body weight was analyzed for each of the five 3-day records to illustrate the pattern of body weight change before, during and after competition. Figure 1 illustrates the average BW changes of the subjects over the five records. Table 6 lists the average BW changes along with

the individual highest and lowest changes in BW. A significant decrease ($p>.01$) in BW occurred prior to competition followed by a significant increase ($p>.01$) after competition.

The subjects lost an average of 5% of their BW in order to compete. One subject (S #2) lost 11% of her BW between (-28 to -26 days) and competition (-2 to 0 days)(4 weeks). She weighed even more during her initial interview prior the first record (-28 to -26 days). If measured from this point to competition, she lost 14% of her BW.

After competition (+26 to +28 days), subjects exceeded their pre-competition BW (-28 to -26 days) by 2.2%. Therefore, the subjects regained more BW in less time in comparison to pre-competition weight loss. According to research, rapid weight loss usually results in rapid weight gain once refeeding is resumed (4). For example, one subject (#2) gained more weight than she lost within a shorter time period. She gained an additional 2.2 kg during the period from competition (-2 to 0 days) to post competition (+26 to +28 days). This is in comparison to the amount of weight she lost during the four weeks from pre-competition (-28 to -26 days) to competition (-2 to 0 days). Since this subject (#2) has competed several times, she has also completed several cycles of losing and gaining BW. According to Brownell et al., (5) her past cycles of weight gain and loss may have significantly lowered her energy requirements and thus favored

gain of body fat.

In a recent university study on local female body builders (ages 18 - 30), their subjects experienced more dramatic body weight changes (28). For example in comparing four weeks prior to competition, their subjects lost 3.6 kg while the present subjects lost 2.7 kg. At one week prior to competition, their subjects lost 2.3 kg while the present subjects only lost 0.98 kg. Their body builders gained an average of 8.6 kg over the 4 weeks (2.2 kg/wk) following competition whereas the present subjects gained 4.3 kg (1.45 kg/wk). Since their subjects' body weight histories were not provided, distinct conclusions or comparisons with the subjects in the present study cannot be accurate.

Diet Results: Diet records were analyzed for absolute calories (kcal), protein, fat, carbohydrates and selected vitamins and minerals. The percent composition of the diet and kilocalories per kilogram body weight (kcal/kg BW) were calculated. Table 7 lists the record means for Kcal, kcal/kg BW, grams of protein, fat, and carbohydrate (P/F/C), grams of protein/kg BW and the percent composition of the diet.

Kilocalories. Total caloric consumption of the subjects remained relatively constant prior to competition. In a recent study on female body builders, their caloric intake was 891 kilocalories 1 month prior to competition but then increased to 1283 kilocalories 1 week pre-competition (28). These energy levels were below what the subjects in the

present study consumed. At competition (-2 to 0 days), the body builders in our study consumed a comparable energy intake (2291.1 kcal) to their body builders (2228 kcal) (28). Another recent study reported a lower (24 - 48 hours) pre-competition energy intake of 1453 kcal (24). Even though the body builders in our study had a slightly higher energy intake while dieting in comparison to body builders in the literature (24, 28), they still over-compensated for the pre-competition energy reduction by increasing their energy intake after competition. However, the above studies did not provide post competition dietary data for comparison.

Protein. There were no significant differences in total protein consumed between records. When converted relative to body weight, none of the subjects were below the RDA for protein.

The body builders in the present study were consuming higher amounts of protein in comparison to body builders in recent studies (24, 28). Lamar-Hildebrand et al., (28) reported 48 gm and 67 gm of protein at 1 month and 1 week pre-competition. Their subjects were above the recommended intake of protein at 1 month prior to competition with 0.85 g/kg BW. Their average intake of protein at 1 week prior to competition had increased to 1.2 g/kg BW. By competition, their body builders were consuming 1.07 g/kg BW of protein which is above the RDA. Supplements were not included in their dietary analysis. However, Heyward et al., (24) included protein

powders in their analyses. They reported an intake of 77 gm of protein at competition for their body builders which was equivalent to 1.47 gm/kg BW. These results are above the RDA but are below what the body builders in the present study consumed. In our analyses, dietary supplement intake such as protein powders and amino acids were noted but not included in the dietary analysis. Therefore, intake of dietary protein alone by the body builders in our study was more than adequate throughout.

While protein is essential for synthesis and repair of muscle, a high protein intake is not beneficial to athletes (23, 27, 41). Once protein requirements are met, excess consumption is either used by the body as energy or stored as fat.

Fat. Fat intake increased significantly ($p>.01$) from pre-competition to post-competition records by almost four-fold. The subject (S#3) who consumed the lowest amount of fat prior to competition did not exceed 9 grams until competition day. (Refer to Table 8 for an actual food intake list for Subject #3). These results are similar to other studies on body builders. Lamar-Hildebrand et al., (28) reported a fat intake of only 9 gm and 20 gm at 1 month and 1 week pre-competition. After competition, the amount increased to 49 gm. Heyward et al., (24) reported a pre-competition fat intake of 15 gm by their subjects which is a large decrease from the intake of 42 gm prior to dieting for competition.

Past studies reported that male body builders consumed an atherogenic diet while in training which included a high-fat, high-cholesterol intake (16, 39). One study reported that their subjects consumed between 0 - 81 eggs per week with an average fat intake of 157 gm (16). An earlier study reported similar results in which their male body builders consumed an average of 176 gm of fat (39). Thus, it appears that male and female body builders may consume very different pre-competition diets.

Carbohydrates. Total carbohydrate intake increased significantly ($p>.05$) from pre-competition (-28 to -26 days); (-9 to -7 days) to competition (-2 to 0 days) and after (+1 to +3 days). After competition, intake remained relatively constant. Whereas endurance athletes 'carbo-load' prior to competition, body builders 'carbo-deplete.' For example, the subjects in the present study reported that they try to lower the amount of carbohydrate consumption during pre-competition dieting. One subject reported that she attempts to consume 90 g of carbohydrate for 3 days, 80 g for the next 3 days and 70 g for 4 days prior to competition while decreasing water intake. This subject stated that she wanted to minimize water retention in order to accentuate each muscular striation. However since each gram of carbohydrate stores 4 grams of water and glycogen is stored in the muscle, body builders should increase the amount of carbohydrate they consume as competition day approaches.

The amount of carbohydrate consumption reported by other body builders was comparable to what the present subjects consumed. One group consumed 222 g of carbohydrate at 1 week pre-competition (28) while another group consumed 208 g (24). At competition, both groups increased their consumption to 359 g and 261 g carbohydrate which was below the amount consumed by the present body builders.

Percent Composition. The percentage of protein decreased significantly ($p>.01$) while the percentage of carbohydrate increased ($p>.01$) from pre-competition (-28 to -26 days); (-9 to -7 days) to competition (-2 to 0 days). After competition, the percentage of carbohydrate decreased while the percentage of protein remained below pre-competition levels. The percentage of dietary fat increased significantly ($p>.01$) from pre-competition and remained high after competition.

In summary, dietary analysis indicated that the present body builders consumed a pre-competition diet that was adequate in carbohydrate, low in fat and high in protein compared to recommended intake. After the actual competition, there was a trend toward a decrease in carbohydrate and protein with an increase in fat. These results are similar to those found in literature. Lamar-Hildebrand et al., (28) reported a low percentage of fat intake (11%) prior to competition in their subjects. Fat intake increased at competition (17%) when subjects resumed eating. In Heyward

et al. (24), their subjects consumed 22.9% fat during non-competition diet. Prior to competition (24 - 48 hrs), their body builders consumed only 10.7% fat.

In order to lose excess body fat, body builders drastically reduce fat intake. After competition, they tend to 'crave' foods that have a higher fat content to help replace lost energy stores. Overall except for a low fat intake, the intake of macronutrients at competition for the subjects was similar to the typical American diet (41). A diet composed of 12% to 15% of calories from protein, 25% to 30% from fat, and 55% to 60% from carbohydrate is recommended for athletes (27).

Micronutrients. Table 9 lists the micronutrients and record means for the group of subjects along with the RDA. The number of body builders who fell below two-thirds the RDA for selected vitamins and minerals is listed in Table 10.

Dietary deficiencies occurred predominately during pre-competition dieting for the body builders. The majority of subjects were deficient in calcium. However by post competition, calcium intake was adequate. Most of the subjects tried to avoid dairy products prior to competition to minimize fat consumption. With the increase in fatty foods and dairy products, deficiencies were rectified.

Urine Sample Assay Results and Discussion.

Since only two subjects completed this portion of the study, detailed descriptions and diagrams of both subject's

results have been included. The results include the number of cycles, length of each menstrual cycle in days, characteristics of estrogen (E2) and progesterone (P4), and cycle phase lengths.

SUBJECT 2. Subject 2 had two complete menstrual cycles during the study. The first cycle was 22 days long which included four days of menses. Cycle 2 was 46 days long which began 17 days prior to competition. The subject reported having six days of 'regular' menstrual flow followed by 11 days of menstrual spotting which ceased the day of competition. Cycle 3 began the day after the final urine sample. The subject reported four days of menses.
Figure 2 illustrates the characteristic changes of E2 and Figure 3 illustrates the changes of P4 for this subject. Cycle 1 displayed relatively normal changes in E2 and P4 and consisted of six days of menses, approximately 10 days of follicular phase and a shortened luteal phase lasting approximately six days.

However, there was an aberration in the normal hormonal characteristics during Cycle 2, especially in E2. The E2 surge was less evident and the changes in P4 did not exhibit those similar to cycle 1. Toward the end of the cycle, a slight increase in E2 occurred which was followed by an increase in P4 representing the luteal phase (43). Cycle 2 appeared to have a long follicular phase, approximately 29 days, followed by a shortened luteal phase lasting

approximately six days.

After competition, it appeared that the body was going through a recovery phase in which it was trying to return to normal menstrual function. This recovery phase lasted approximately 28 days until the next menses. These changes in E2 illustrate the body's ability to withstand extreme stress and recover rapidly.

SUBJECT 5. Subject 5 also had two complete menstrual cycles during the course of the study. Cycle 1 was 23 days long which included four days of menses. Cycle 2 was 29 days long and also included four days of menses. Samples were taken for the first ten days of Cycle 3. Menses lasted four days.

Figure 4 illustrates the characteristic changes for E2 and Figure 5 illustrates P4 changes for this subject. Cycle 1 was illustrative of normal patterns for E2 and P4 and consisted of 4 days of menses, approximately seven days of follicular phase and a luteal phase length of approximately 11 days. During Cycle 2, the E2 surge could not be identified which may be due to the absence of urine sample collection during the mid-cycle (days 13 - 16). The E2 surge could have occurred between days 13 through 16. On days 18 through 24, P4 surged representing the normal elevation during the luteal phase. However, a parallel increase in E2 during this phase was not clearly identifiable. Cycle 2 consisted of four days of menses, approximately eight days of follicular phase and

approximately 13 days of luteal phase. These results were made with the assumption that the E2 surge occurred prior to mid-cycle during the days when samples were not collected by the subject.

Our results illustrate that the preparation for a body building competition caused an aberration in menstrual cycle function. For both subjects, cycle 1 was representative of normal patterns of E2 and P4. However, cycle 2 displayed marked alterations from the normal characteristic patterns for both hormones. These changes may have been caused by a change in BW or BF, dietary composition, or energy consumption.

Several studies have reported that the rate of weight loss or fat loss may be a factor in causing menstrual irregularity (15). For example, Speroff and Redwine (40) suggested that losing more than 4.5 kilograms and weighing less than 52 kilograms after initiation of a training program can increase the risk of developing menstrual irregularity. Simple weight loss through dieting may interfere with follicular development and the production of E2 (33). For example, Schwieger et al., (37) reported that weight loss of only 1 kg per week may cause estradiol and progesterone to be diminished during the luteal phase, and may shorten the length of the luteal phase. Bullen et al., (6) reported that exercise compounded with weight loss resulted in a decrease in luteal phase length and anovulation. Baker (1) reported that a group of amenorrheic runners weighed less, had less

body fat and also reported a greater weight loss than a group of eumenorrheic runners.

The above reports may compare with our results. Subject 2 lost a total of 6.4 kg during the four weeks prior to competition and then regained 8.5 kg over the three weeks post competition. As competition approached, hormone production appeared to become suppressed. As she regained BW it appeared that hormone levels increased. In comparison to cycle length, she appeared to have a shortened luteal phase. The luteal phase in Cycle 1 (22 days long) was approximately 6 days long while that in Cycle 2 (46 days long) was approximately 7 days long. This was illustrated by the small rise in E2 near the end of the cycle followed closely by a surge in P4 prior to menses. Subject 5 displayed suppressed levels of E2 during cycle 2 which increased dramatically during cycle 3.

The response of the menstrual cycle to exercise may be influenced by the diet. A few studies have suggested that an association may exist between fat and protein consumption and the regulation of certain hormones (11, 19). For example, Frisch reported lower fat and protein intake among amenorrheic runners in comparison to eumenorrhiec runners (19).

Body builders tend to consume foods that are rich in fiber such as rice, vegetables and baked potatoes. It has been reported that a low-fat, high-fiber diet may alter the menstrual cycle. High fiber consumption has been reported to cause more estrogen excretion as well as altering the

circulating level of estrogen (20). These results were found in vegetarian women. Similar results were reported in amenorrheic runners (11). The runners consumed less fat and more dietary fiber than the eumenorrheic runners. In a recent study, irregular menstrual cycles were associated with an increased dietary fiber intake (29).

Low caloric consumption in amenorrheic athletes as compared to eumenorrheic athletes has been reported (19). Both runners and ballet dancers have been reported to consume fewer total calories than recommended (7, 19). Deuster et al., (11) reported that amenorrheic runners consumed fewer calories than eumenorrheic runners. The higher incidence of AMI which occurs in runners and ballet dancers may be associated with energy drain. These athletes may "exhibit energy drain by ceasing to menstruate" (32). Similar to ballet dancers and runners, body builders have a low caloric intake during competitive months. Their low caloric intake prior to competition may have caused the alterations in hormonal patterns. And as caloric intake increased in the two body builders, hormone levels increased.

Several factors have been associated with the occurrence of AMI. There does not seem to be any single factor that causes AMI. Certain factors may affect individuals in different ways or a combination of factors may act synergistically resulting in menstrual dysfunction.

SUMMARY

In summary, the results of this study indicate that competitive female body builders are among the leanest athletes. Due to the importance of dieting and low body fat, body builders may be more susceptible to pathogenic weight-control behaviors. Over half of the body builders in the present study reported the occurrence of a behavior associated with anorexia nervosa and bulimia during the competitive season. In addition, body builders may experience several cycles of body weight loss and regain during the competitive season depending on the number of competitions. Body builders, like wrestlers, may experience adverse effects associated with weight cycling which may make future attempts at weight loss difficult.

Nutritionally, in preparation for competition, the majority of body builders did not consume two-thirds of the RDA for calcium. The percent composition of the diet for fat was below the recommended amount. However, as calories increased after competition, intake of most nutrients increased. After competition, fat intake increased substantially making this the preferred category of foods.

The results of the menstrual history and hormonal data indicate that body building may affect the menstrual cycle. All subjects reported some aberration in normal function. Hormonal results indicated that the preparation for a body building competition caused an aberration in normal menstrual

function by increasing the length of the menstrual cycle with an increase in the follicular phase and a decrease in the luteal phase. These hormonal alterations may have been due to a change in body weight, body fat, dietary composition, and/or caloric consumption.

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Table 1: Training Characteristics Reported By The 6 Female Body Builders.

	Mean (S.D.)*
Years of Weight Lifting	2.9 (1.15)
Number of Days Per Week Lifting	5.0 (0.41)
Number of Competitions	2.2 (0.98)
Aerobic Exercise	**(No. of Subjects)**
Stationary Cycling	5
Running	4
Aerobic Dance	4
Stationary Rowing	2
Swimming	2
Aerobic Exercise Before Competition Only	**(No. of Subjects)**
Stationary Cycling	2
Running	1
Stationary Rowing	2

* = mean with standard deviation in parentheses.

Table 2: Body Weight Characteristics Reported By The 6 Female Body Builders During Previous Competitions.

	Body Weight Changes			
	Pre-Competition Weight Loss		Post Competition Weight Gain	
	Total Kg	Kg/Week	Total Kg	Kg/Week
1	> 6.8	3.2 - 4.5	6.8	4.1 - 4.5
2	4.5 - 6.8	1.4 - 1.8	2.3 - 3.6	0.5 - 0.9
3	4.5 - 6.8	0.5 - 0.9	4.5 - 9.1	0.5 - 0.9
4	2.3 - 4.5	0.5 - 0.9	2.3 - 4.5	0.5 - 0.9
5	4.1 - 4.5	a	0.5 - 0.9	b
6	4.5 - 6.8	0.5 - 0.9	4.5 - 6.8	< 0.5

a = subject loses weight during week prior to competition.
b = subject regains weight very slowly.

Table 3: Eating Behaviors And Attitudes Of The 6 Female Body Builders Associated With Anorexia Nervosa and Bulimia.

Eating Behaviors		Number of Subjects
1. Used to aid weight loss:	Diet Pills	0
	Diuretics	1
	Laxatives	0
	Vomiting	0
2. Experienced uncontrollable urges to eat		2
3. Have ever become obsessed or preoccupied with thoughts of food.		4
4. Have binged and felt miserable and annoyed at themselves afterward.		4
5. Felt there were times when you could not voluntarily stop eating.		1
6. Engaged in exercise or over-activity without enjoyment.		4 *
7. Feel terrified of fat.		2 *
8. Feel fat despite others telling you that you are too thin.		2 *

* = these behaviors were reported to occur outside of the competitive season.

Table 4: Menstrual History Characteristics Of The 3 Female Body Builders Not Taking Oral Contraceptives.

	Subject Number 2	5	6	Group Mean *
Cycle Length	21	28	30	26.3 (4.73)*
Age at Menarche	12	13	17	14 (2.65)*
Age began Sports	12	15	5	10.6 (5.13)*
No. periods w/in past 3 months	3	3	2	2.67 (0.58)*
Missed period w/in past year (yes/no)	Y+	N	Y++	2 subjects
Parity (yes/no)	Y	Y	N	2 subjects

* = group mean with standard deviation in parentheses.
+ = missed period, attributed to stress of competition.
++ = missed period, attributed to dieting before competition.

TABLE 5: Descriptive Statistics by Subject and Group Averages.

Subject	Age	Height (cm)	Weight* (kg)	%BF	LBM (kg)
1	22	170.2	57.2	14.0	49.2
2	34	161.3	57.2	13.0	49.3
3	32	160.0	51.3	12.4	45.0
4	29	165.0	56.7	10.8	50.6
5	24	165.0	57.2	15.0	48.6
6	23	170.2	55.3	11.0	49.3
$\bar{X}$	27 (5.04)	165.0 (4.29)	55.8 (2.33)	12.7 (1.65)	48.7 (1.91)

%BF = percent body fat; LBM = lean body mass.
* = Body weight on day of %BF analysis.
$\bar{X}$ = mean value with standard deviation in the following row.

TABLE 6: Average Body Weight Changes Of The 6 Female Body Builders Between Records.

Days	Average BW Change	High	Low	Total Change	High	Low
-28 to -26	--	--	--	--	--	--
-9 to -7	-2.0	-3.8	-0.2	--	--	--
-2 to 0	-1.1	-2.6	-0.3	-3.1	-6.4	-1.4
+1 to +3	+2.2	+4.0	+0.9	--	--	--
+26 to +28	+2.1	+4.5	0.0	+4.3	+8.5	-2.3

BW = body weight.

Table 7: Comparison of Mean Dietary Parameters.

Dietary Parameter	Day of Record Collection -28	-9	0	+1	+26
Kilocalories	1629.6 [a,b] (478.7)	1536.1 [c,d] (447.1)	2291.1 (794.3)	3097.2 [a,c] (1169.2)	2790.2 [b,d] (1320.3
Kcal/kg BW	28.6 [a,c] (8.1)	28.1 [b,d] (8.5)	42.5 (14.2)	54.9 [a,b] (19.6)	47.4 [c,d] (21.3)
Total Protein (g)	116.7 (26.1)	131.3 (46.1)	81.2 (27.3)	129.2 (35.1)	117.5 (46.6)
Gm Protein/kg BW	2.1 (0.5)	2.4 (0.8)	1.5 (0.6)	2.3 (0.6)	2.0 (0.8)
Fat (g)	35.4 [a,b] (35.3)	28.4 [c,d] (28.6)	42.6 [e] (20.9)	124.6 [a,c,e] (61.5)	100.9 [b,d] (82.1)
Carbohydrate (g)	216.2 [a,d] (41.4)	202.7 [b,c] (78.7)	410.2 [a,b] (169.5)	377.1 [c,d] (156.4)	344.6 (152.1)
Protein (%)	30.6 [a,b,c] (8.6)	34.2 [d,e,f] (13.2)	14.7 [a,d] (5.3)	17.3 [b,e] (3.3)	18.7 [c,f] (6.0)
Fat (%)	13.6 [a,b] (12.9)	14.8 [c,e] (10.7)	16.7 [d,f] (5.8)	34.9 [a,c,d] (8.8)	28.7 [b,e,f] (15.6)
Carbohydrate (%)	55.8 [a] (7.8)	50.9 [b] (15.5)	68.6 [a,b,c,d] (10.2)	47.8 [c] (8.1)	52.6 [d] (12.5)

Values are means with standard deviations in following row.
Values in same row with same letter are significantly different.

Table 8: Pre-Competition Food Intake List for Subject #3.

TYPE	QUANTITY Number	Volume	BRAND NAME	PREPARED
egg whites	4	med.	kroger	boiled
wheat bread	2	slice	Merita Lite	toast
egg whites	7	lg.	kroger	boiled
broccoli spears	1	14 gm	Stockley's singles	micro-wave
chef salad	1	2 cups	Hardee's	no meat/ cheese
wheat bread	1	slice	Merita Lite	plain
potatoe	1	small	kroger	baked
chicken breast skinless & boneless	2	4 oz.		grilled
water	10	8 oz.		

Table 9: Average Intake of Micronutrients for All 6 Subjects With the RDA.

Vitamin	Day of Record Collection				
	-28	-9	0	+1	+26
A (IU)	4666.1 (2914.8)	4944.9 (3651.1)	746.7 (1469.7)	5731.4 (2036.8)	3451.4 (1500.8)
D (IU)	366.9 (890.5)	225.7 (539.7)	0.0	191.7 (353.3)	352. 9 (775.6)
C (mg)	73.7 (34.9)	98.7 (43.2)	229.0 (120.3)	110.3 (52.6)	148.8 (79.8)
Thiamine (mg)	1.4 (0.4)	1.2 (0.2)	2.1 (1.3)	1.9 (0.5)	3.3 (2.6)
B-12 (mg)	4.1 (3.5)	3.0 (1.6)	1.8 (2.3)	6.8 (3.3)	3.8 (5.4)
Ca (mg)	666.8 (493.1)	473.7 (306.4)	570.8 (349.1)	1150.0 (324.9)	1046.8 (599.6)
Fe (mg)	14.4 (3.9)	13.7 (4.5)	18.8 (5.0)	20.4 (4.8)	19.4 (9.4)
Mg (mg)	249.3 (112.6)	250.9 (117.5)	287.1 (111.4)	342.2 (96.6)	341.3 (122.3)

Values are means with standard deviations in parentheses in the following row.

RDA: Vitamin A, 5000 IU; Vitamin D, 400 IU; Vitamin C, 100 mg; Thiamine, 1.0 mg; Vitamin B-12, 3.0 mg; Calcium, 1000 mg; Iron, 15 mg; Magnesium, 300 mg.

TABLE 10: Number of Subjects Below Two-Thirds RDA for Select Vitamins and Minerals.

NUTRIENT	DAYS				
	-28	-9	0	+1	+26
Ca	4	5	5	0	1
Fe	1	1	0	0	0
Mg	2	3	1	0	1
A	2	2	3	1	3
D	5	5	6	5	5
C	3	1	0	1	2
Thiamine	0	0	0	0	0
B-12	1	2	4	0	4

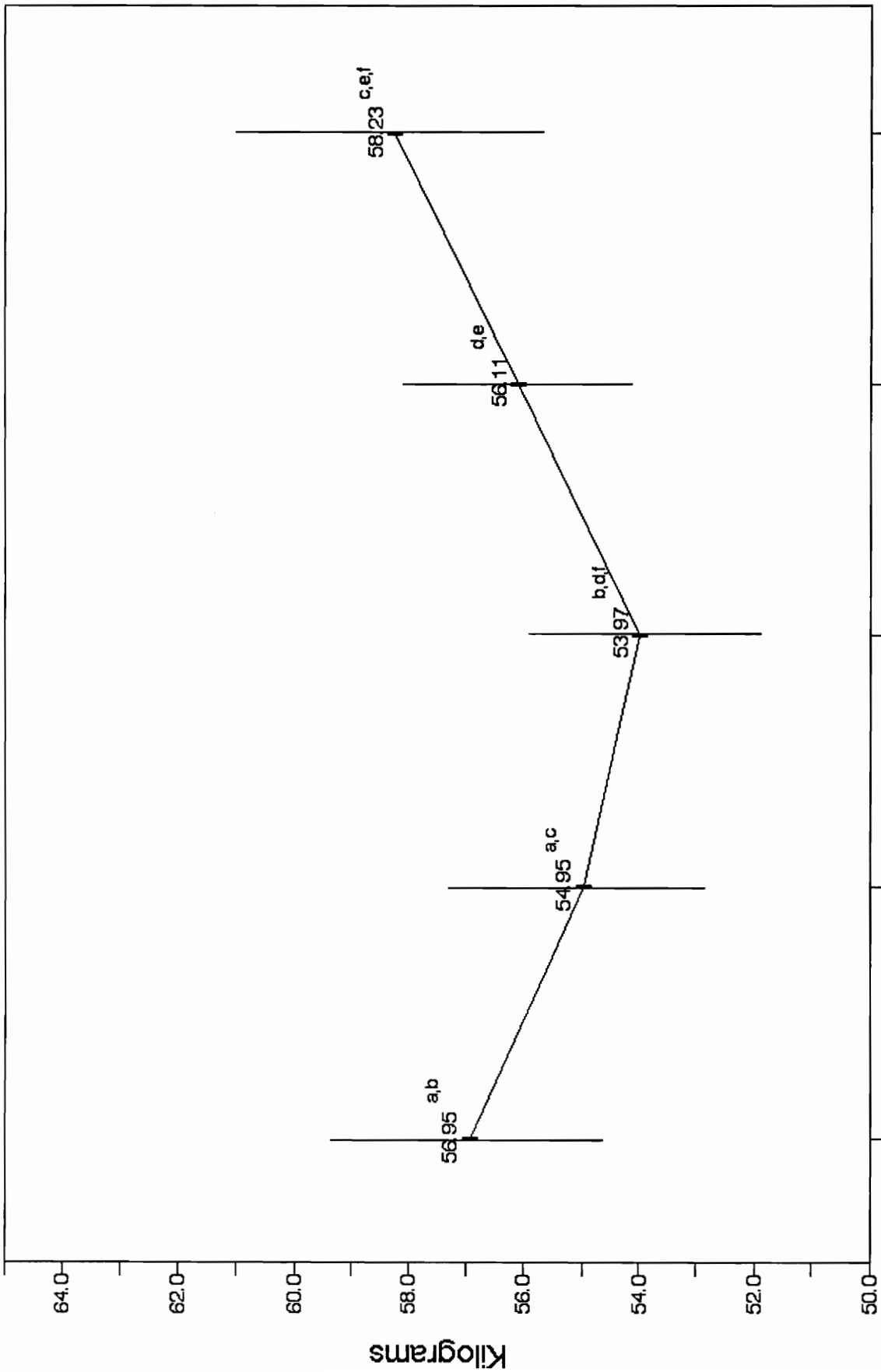

Figure 1:Group Mean Body Weight Changes
(Same letter indicates signif. diff.)

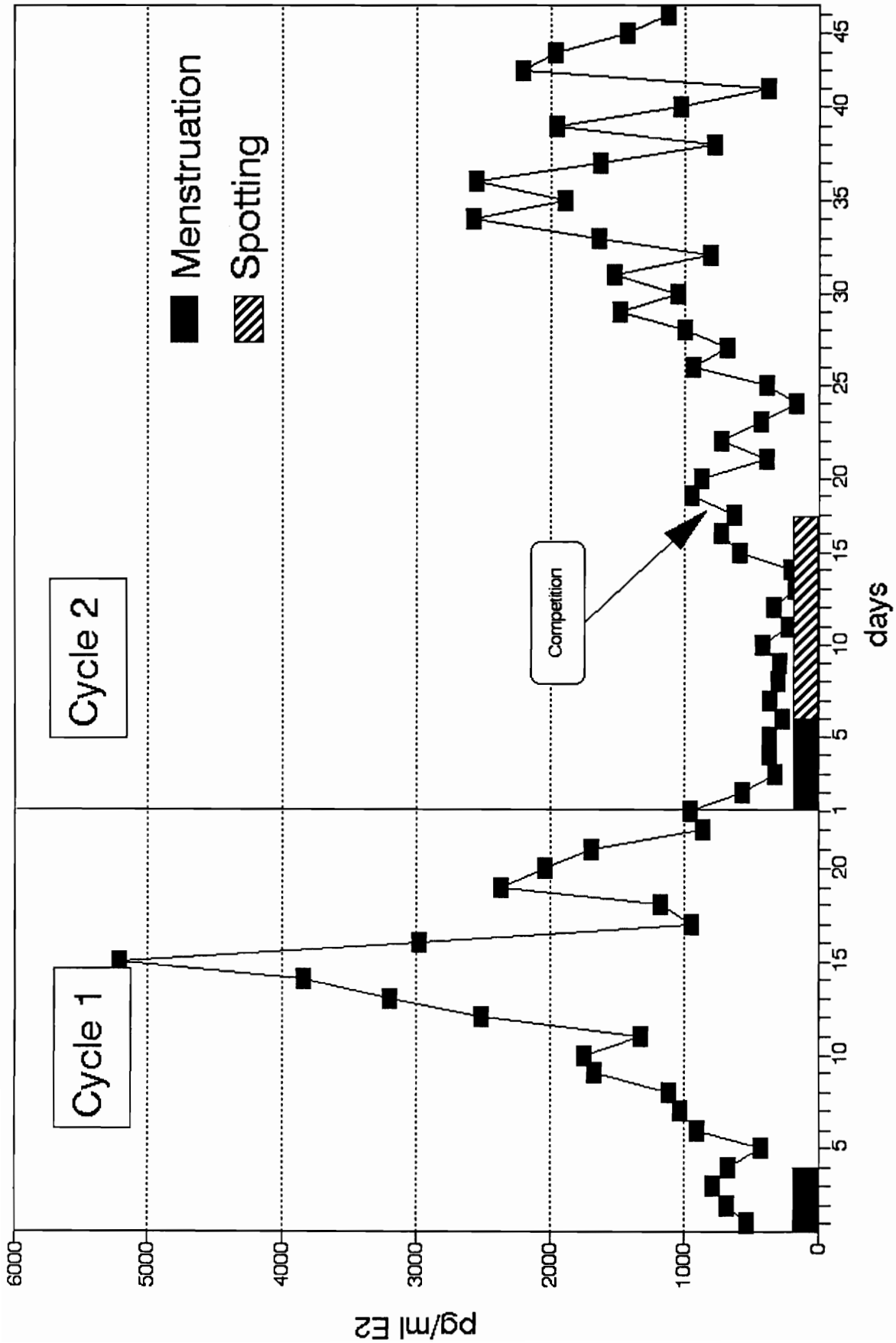

Figure 2: Characteristic Changes of E2 over time for Subject #2.

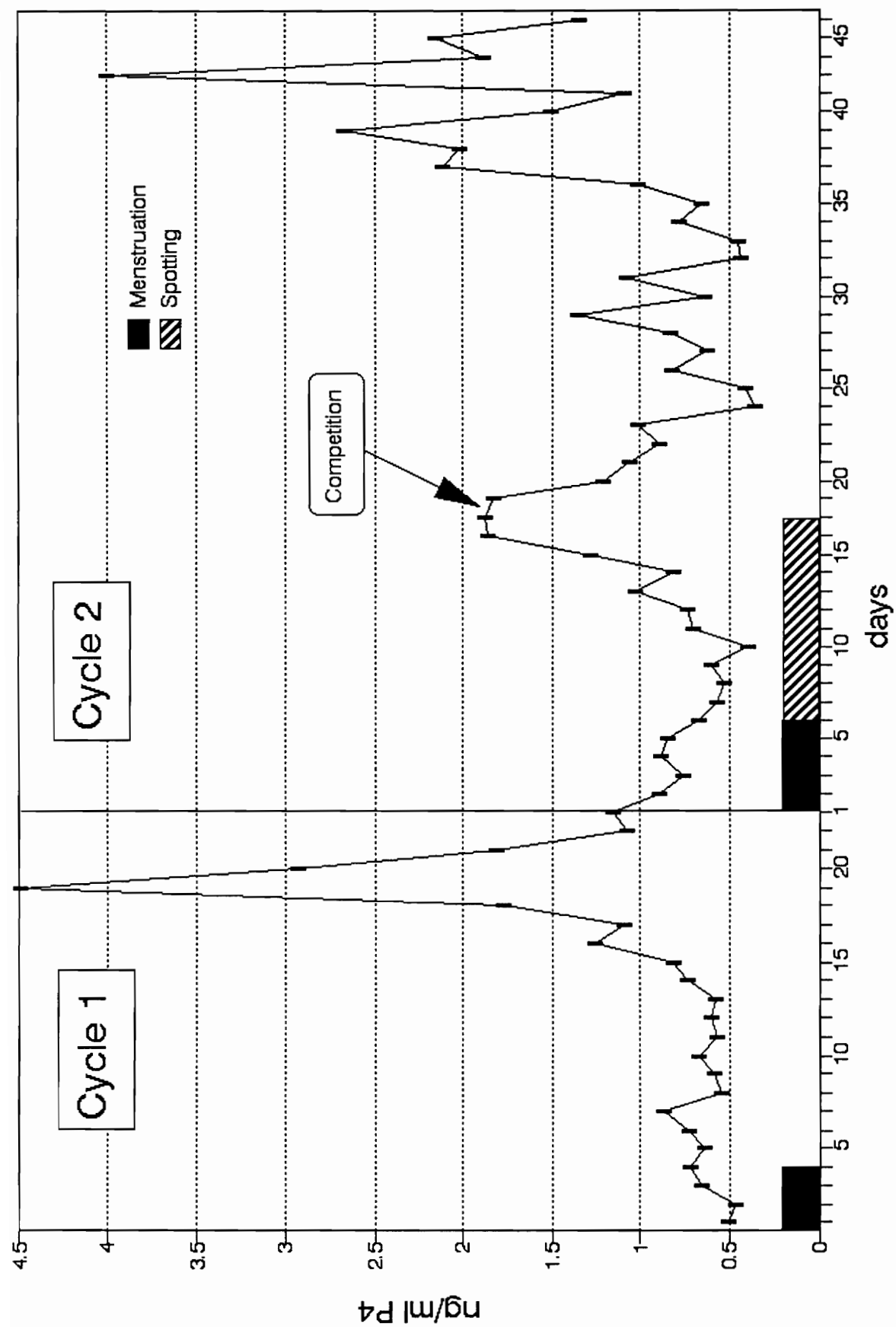

Figure 3: Characteristic Changes of P4 over time for Subject #2.

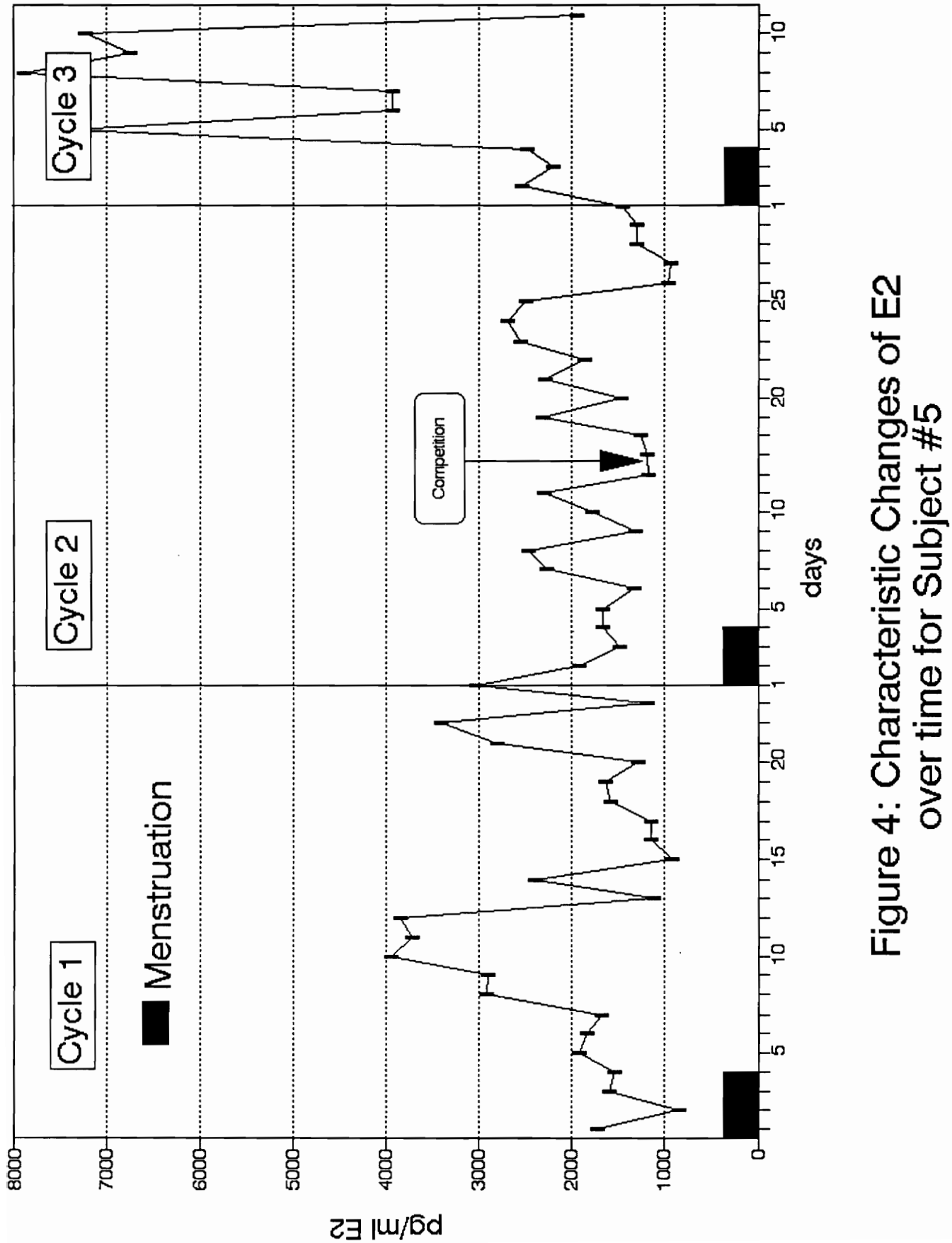

Figure 4: Characteristic Changes of E2 over time for Subject #5

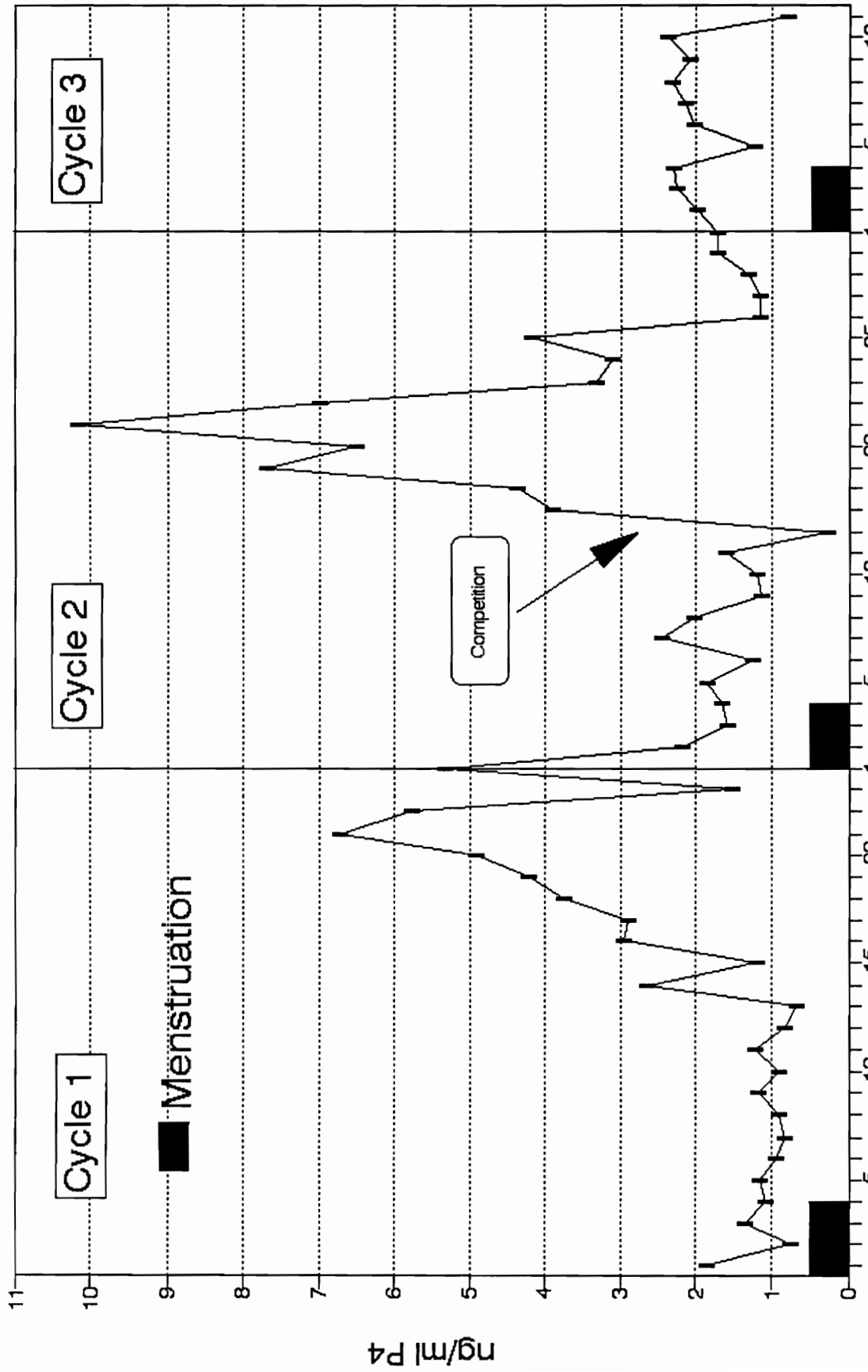

Figure 5: Characteristic Changes of P4 over time for Subject #5

CHAPTER 4

SUMMARY

The sport of body building has increased in popularity within the past decade. Both men and women are seen competing at the local to international level. Body building is definitely a unique sport where the main goal is to attain the ideal physique which is muscularly symmetrical and well proportioned. In addition, bodyfat must be low to accentuate each muscular striation.

With the increased participation of women in the sport of body building, it was thought that additional research was necessary since available literature on the topic is limited. This study was conducted to obtain descriptive information on competitive female body builders concerning their body weight patterns, dietary practices and menstrual characteristics before, during and after an actual competition.

To obtain information on training regimes, menstrual history and dietary practices, a survey questionnaire was developed and administered to female body builders (ages 22 - 34) who were currently preparing to enter a body building competition within six months from the initial interview.

The group of subjects ranged from the novice to the state level competitor with weight lifting being their main form of exercise. The majority of the subjects participated in aerobic activities to aid weight loss prior to competitions only.

Literature presents age-group norms for %BF to range between 20% to 25%. It is not surprising that the female body builders in the present study were below this range with a mean of 12.7 %BF. Previous studies on female body builders have reported higher levels of bodyfat. Freedson, Mihevic, Loucks and Girandola (1983) reported a mean of 13.2 %BF in their national caliber female body builders. Elliott and Goldberg (1983) reported a higher average of 18 %BF in their group of international level female body builders. All of these subjects were analyzed during the off-season and not prior to competition. A later study by Elliott et al., (1987) reported a mean of 13.5 %BF in their group of female body builders. In comparison to these research results, the present subjects had the lowest percentage of bodyfat. However, a recent study reported only 9.5 %BF between 24 to 48 hours pre-competition. This is the lowest scientifically recorded percentage for female body builders at this writing (Heyward et al., 1989).

An examination of the dietary analyses provided some interesting results. The increase in total caloric intake from pre-competition to post competition was expected. However, caloric intake at competition was not significantly different from pre or post competition caloric intake. This was probably due to the high caloric intake immediately after the competition being averaged with the extremely low intake two days prior to competition.

In comparison to a recent study on female body builders, the present subjects consumed more calories during both one month and one week pre-competition (Lamar-Hildebrand et al., 1989). However during competition, both groups were consuming comparable amounts. Another recent study reported a 24 - 48 hour pre-competition caloric intake that was lower than the level consumed by the present subjects at competition (Heyward et al., 1989). Even though the subjects under study had a higher caloric intake while dieting in comparison to literature, they still over-compensated for pre-competition caloric restriction by increasing their energy intake almost two-fold after competition.

In comparison to body builders in recent studies, the present subjects were consuming higher amounts of protein. Protein intake for the subjects was constantly above 1.5 g/kg BW and four out of the five records listed intakes above 115 grams. Lamar-Hildebrand et al., (1989) reported 48 gm and 67 gm of protein at 1 month and 1 week pre-competition. Their subjects were above the recommended intake of protein at 1 month prior to competition with 0.85 g/kg BW. And at one week pre-competition, protein intake had increased to 1.2 g/kg BW. At competition, their body builders were consuming 1.07 g/kg BW of protein. Therefore, their protein intake was above the RDA even though supplements were not included in their dietary analyses. However, Heyward et al., (1989) included protein powders in their analyses. They reported an intake of 77 gm

of protein at competition for their body builders which is equivalent to 1.47 g/kg BW. These results were above the RDA but were below what the present body builders consumed. In our analyses, dietary supplement intake such as protein powders and amino acids were noted but not included in the dietary analysis. Therefore, intake of dietary protein alone by the body builders was more than adequate throughout the study.

While protein is essential for synthesis and repair of muscle, a high protein intake is not beneficial to athletes (Hecker, A.L., 1984; Katch and McArdle, 1983; Steen and McKinney, 1986). Once protein requirements are met, excess consumption is either used by the body as energy or stored as fat (Hecker, 1984; Katch and McArdle, 1983; Steen and McKinney, 1986).

Throughout our study, fat intake was similar to recent reports in the literature on female body builders. Post-competition fat intake by the subjects increased four times above pre-competition levels. Lamar-Hildebrand et al., (1989) reported a fat intake of only 9 grams and 20 grams at 1 month and 1 week pre-competition which was lower than the intake by the subjects in the present study. After competition, intake increased to 49 grams. Heyward et al., (1989) reported a 24 - 48 hour pre-competition fat intake of 15 grams by their subjects and a pre-season intake of 42 grams. These levels are below what the present body builders consumed.

Whereas endurance athletes 'carbo-load' prior to competition, body builders 'carbo-deplete.' The trend among the subjects in the study was to decrease the amount of carbohydrate consumed during pre-competition dieting. One subject reported that she wants to minimize water retention in order to accentuate each muscular striation. However since each gram of carbohydrate stores four grams of water and glycogen is stored in the muscle, body builders should try to increase carbohydrate consumption prior to competition. The increased amount of glycogen stored in the muscle would provide muscle bulk.

Carbohydrate consumption reported by other studies on female body builders was comparable to what the present subjects consumed. One group consumed 222 g of carbohydrate at 1 week prior to competition (Lamar-Hildebrand et al., 1989) while another group consumed 208 g carbohydrate (Heyward et al., 1989). At competition, both groups increased their consumption to 359 g and 261 g carbohydrate. The subjects in the present study had an even higher carbohydrate intake at competition which remained constant after competition.

Our dietary analysis indicated that the present body builders consumed a pre-competition diet that was adequate in carbohydrate, low in fat and high in protein compared to recommended intake. Even when analyzed relevant to the percent contribution of the diet for protein, fat and carbohydrate, the percent of fat was low while protein ranked

high. After competition, their was a trend toward a decrease in carbohydrate and protein with an increase in fat. These results are similar to those found in literature. Lamar-Hildebrand et al., (1989) reported a low percentage of fat intake (11%) prior to competition in their subjects. Fat intake increased at competition (17%) when subjects resumed eating. In Heyward et al., (1989) their subjects consumed 22.9% fat during their non-competition diet. Prior to competition (24 - 48 hrs), their body builders consumed only 10.7% fat.

Our results as well as those cited in literature suggest that body builders drastically reduce dietary fat intake in order to reduce excess body fat. After competition, the body builders 'craved' foods that were high in fat content to help replace lost energy stores. Overall, the body builders' intake of macronutrients after competition was comparable to the typical American diet. One that is composed of 10% to 15% of calories from protein, 25% to 30% from fat, and 55% to 60% from carbohydrate is recommended (Miller and Allen, 1982).

Deficiencies in micronutrients in the present body builders occurred predominantly during pre-competition dieting. The majority of subjects were deficient in both calcium. Most of the subjects tried to avoid dairy products prior to competition to reduce fat intake. However after competition, the subjects were consuming sufficient amounts of calcium.

Prior to previous competitions, all of the body builders reported body weight loss. Their reported amount and rate of body weight loss was well within recommended limits and should not cause metabolic changes that may limit weight loss or accentuate weight gain upon post competition refeeding. However, it appeared that in those subjects who competed more than one time per year, more dramatic weight changes occurred.

Actual mean body weight changes were not surprising since it was expected that body weight would decrease prior to competition and then increase after competition. The average rate of weight loss for all subjects was within recommended guidelines. However, the changes that occurred between competition (-2 to 0 days) and post competition (+1 to +3 days) illustrated an increase in body weight above recommended levels.

Overall, the subjects lost an average of 5% of their body weight in order to compete. After competition, subjects exceeded their pre-competition BW by 2.2% Therefore, the subjects gained more weight in less time in comparison to pre-competition BW loss. For example, one subject (S#2) regained an additional 2.2 kg between competition (-2 to 0 days) and post competition (+26 to +28 days) which is in comparison to the weight lost from (-28 to -26 days) pre to competition (-2 to 0 days). Since this subject has competed several times, she has completed several cycles of losing and regaining BW. Her past cycles of weight gain and loss may have significantly

lowered her energy requirements and thus favored gain of body fat (Brownell et al., 1987; Steen et al., 1988). It is interesting to note that this subject did not report rapid BW changes prior to her previous competitions. In contrast, another subject (#1) reported rapid BW changes before and after previous competitions. However, her actual rate of BW loss and gain was within the acceptable range. One subject (#5) who competed for the first time did not regain her lost weight.

Similar to our results, several studies have reported that there is considerable variation in one's reaction to a change in energy intake. Brownell et al., (1987) reported that successive cycles of weight loss and regain alter the efficiency of food utilization in rats. However, another study reported that repeat cycles of restriction and refeeding do not have an effect on the efficiency of weight gain during refeeding (Gray, 1988).

One study on athletes was conducted on two groups of wrestlers, weight cyclers and non-weight cyclers (Steen and McKinney, 1986). The weight cyclers had a 14% reduction in RMR below the non-cycled wrestlers. This lowered energy requirement increased their efficiency of food utilization above the non-cycled wrestlers (Steen and McKinney, 1986).

In comparison to the present subjects, the body builders in one recent study were reported to experience more dramatic body weight changes (Lamar-Hildebrand et al., 1989). Their

subjects lost approximately 1 kg more than our subjects one month prior to competition. However during the week prior to competition, their subjects lost 2.3 kg whereas the present subjects lost 0.98 kg. After competition, their subjects gained an average of 8.6 kg over 4 weeks (2.2 kg/wk) whereas the present subjects gained 4.3 kg (1.45 kg/wk). Without sufficient body weight histories, a comparison with the subjects in the present study cannot be accurate.

With regard to eating behaviors, none of the subjects considered to themselves to have been anoretic or bulimic. Over half of the subjects reported that they had experienced certain behaviors and attitudes associated with these disorders. The majority of these behaviors and attitudes emerged when the body builders were dieting prior to competition and then after competition when they tried to resume normal eating patterns. After competition, the majority of our subjects reported that they binged after succumbing to uncontrollable urges to eat. Only a few adverse behaviors and attitudes were reported to occur outside of competition. Currently, no other studies have addressed this issue relative to the competitive female body builder.

In the general population, bulimia is more prevalent than anorexia nervosa and occurs more in women than men (Eating Disorders in Young Athletes: A Round Table, 1985). Rosen et al., (1986) conducted a survey study to identify female athletes who displayed pathogenic weight control behaviors

resembling anorexia nervosa and bulimia. They found that at least one behavior associated with these disorders was practiced by 32% of their subjects (Rosen et al., 1986). It was reported that these behaviors occurred most frequently in sports where there is an added pressure to achieve and maintain low body weight and/or body fat (Rosen et al., 1986). Wrestling is a sport similar to body building in that both incur repeated cycles of dieting and/or weight loss prior to competition. Steen and McKinney (1986) reported that their group of wrestlers used laxatives, diuretics and vomiting to lose weight prior to competing. Only one of our subjects reported using any of these methods. She reported using a diuretic several days prior to competition to eliminate excess body fluids. Our results suggest that the strict reduction in caloric intake prior to competition may cause body builders to display pathogenic weight control behaviors similar to anorexia nervosa and bulimia but only in relation to competition.

Half of the subjects provided information concerning past menstrual characteristics. These subjects would have been characterized as eumennorheic based on reported cycle length and consistency. However, further examination of the survey revealed menstrual abnormalities such as a change in the cycle around competitions or the skipping of cycles.

Two of the body builders agreed to collect daily urine samples for the purpose of assessing the characteristic

changes over time of estrogen and progesterone. The results suggest that preparation for a body building competition may cause an aberration in normal menstrual cycle function. For both subjects, the cycle prior to competition was illustrative of normal patterns for estradiol and progesterone. However, the following cycle displayed marked alterations from the normal characteristic patterns for both hormones. During the cycle after competition, it appeared that the body was going through a recovery phase in which it was trying to return to normal menstrual function. These changes may have been caused by a change in BW or BF, dietary composition, or energy intake.

Several studies have reported that the rate of body weight loss or fat loss may be a factor in causing menstrual irregularity (Ellison, 1981). For example, Speroff and Redwine (1980) suggested that losing more than 4.5 kg and weighing less than 52 kg after initiation of a training program can increase the risk of developing menstrual irregularity. Simple weight loss through dieting may interfere with follicular development and the production of estradiol (Pirke et al., 1985). For example, Schweiger et al., (1987) reported that weight loss of only 1 kg per week may cause estradiol and progesterone to be diminished during the luteal phase, and may shorten the length of the luteal phase (Schweiger et al., 1987). Bullen et al., (1985) reported that exercise compounded with weight loss resulted

in a decrease in luteal phase length and anovulation. Baker (1981) reported that a group of amenorrheic runners weighed less, had less body fat and reported a greater weight loss than a group of eumenorrheic runners.

These results may hold true for our subjects. Subject 2 lost (6.4 kg) and regained (8.5 kg) a large amount of BW from pre to post competition. Hormone levels appeared to become suppressed during weight loss. As BW increased, it appeared that hormone levels also increased. The luteal phase appeared to become shortened. Cycle 1 which was 22 days long had a luteal phase of approximately 6 days. In comparison, Cycle 2 was 46 days long with a luteal phase approximately 7 days long. Subject 5 displayed suppressed levels of estradiol during Cycle 2 which increased dramatically during Cycle 3.

The response of the menstrual cycle to exercise may be influenced by the diet. A few studies have suggested that an association may exist between fat and protein consumption and the regulation of certain hormones (Deuster et al., 1986; Frisch et al., 1974). A lower fat and protein intake was reported among amenorrheic runners in comparison to eumenorrheic runners (Frisch et al., 1974).

Body builders tend to consume foods that are rich in fiber such as rice, vegetables and baked potatoes. It has been reported in vegetarian women that a low-fat, high-fiber diet may affect the menstrual cycle by altering the circulating level of estrogen or increasing estrogen excretion

(Goldin et al., 1982). Deuster et al., (1986) reported that their amenorrheic runners consumed less fat and more dietary fiber than the eumenorrheic runners. Therefore, increased dietary fiber intake may cause irregular menstrual cycles (Lloyd et al., 1987).

Low caloric intake in amenorrheic athletes as compared to eumenorrheic athletes has been reported (Frisch and McArthur, 1974; Deuster et al., 1986). Both runners and ballet dancers have been reported to consume fewer total calories than recommended (Calabrese et al., 1982; Frisch and McArthur, 1974). The higher incidence of AMI in runners and ballet dancers may be associated with energy drain. These athletes may "exhibit energy drain by ceasing to menstruate" (Myerson et al., 1987). Since body builders also experience low caloric intake during competitive months, hormonal patterns may be altered causing menstrual abnormalities. Therefore, the present body builders' low caloric intake prior to competition may have caused the alterations in hormonal patterns.

The occurrence of menstrual disturbances in female body builders have been documented in two studies (Elliot et al., 1987; Elliot and Goldberg, 1983). Elliot et al., (1987 and 1983) reported that body builders have displayed menstrual abnormalities similar to those reported in endurance athletes. Factors associated with menstrual disturbances in the endurance athlete have previously been reviewed in literature.

These factors include low body fat, low body weight, weight loss, emotional stress, and changes in diet and hormone levels (Calabrese et al., 1982; Frisch and McArthur, 1974; Sinning and Little, 1987; Calabrese et al., 1982 and 1983; Carlberg et al., 1981; Wentz, 1980; Pirke et al., 1985; Schwieger et al., 1987; Wentz, 1980; Vigersky et al., 1977; Loucks et al., 1987; Deuster et al., 1986; Baker, 1981; Bonen and Keizer, 1984; Goldin et al., 1982; Hill et al., 1984). These factors are all applicable to the body builder.

Research Implications

Since dieting is a primary component of the sport of body building, it is important for the body builder to have healthy eating and weight loss habits. The body builder should have an individualized plan which would provide proper guidelines for body weight loss at an acceptable rate. The plan should provide nutritional information or even counseling to improve the quality of the diet to ensure adequate intake of calories and nutrients while dieting and competing.

With the incidence of eating disorders in athletics, it is important for coaches and trainers to be familiar with their associated characteristics. The coach or trainer may then recognize these athletes and provide needed assistance to remedy the problem. Since dieting and weight loss are important aspects of body building, abnormal weight control behaviors may have the potential to emerge.

Menstrual dysfunction in endurance athletes has been well

documented in literature. Body builders, similar to the endurance athlete, are susceptible to menstrual irregularities. Recent literature reported the occurrence of oligo-/amenorrhea in female body builders (Elliot and Goldberg, 1983; Elliot et al., 1987). However, these abnormalities should not be dismissed as being sports related. Abnormalities in the menstrual cycle may be caused by ovarian failure, pituitary tumors, hypothyroidism and pregnancy. These possibilities must first be investigated.

Amenorrheic women are thought to be at a greater risk of developing osteoporosis. Jones et al., (1985) reported that women with weight-loss associated amenorrhea and premature ovarian failure are at a significant risk for bone loss. This study reported that there was a significant correlation between months of amenorrhea and decrease in bone density. Athletic women who are amenorrheic are at a risk for osteoporosis. Drinkwater et al., (1986) found a group of amenorrheic athletes to have a lower vertebral bone mineral density than a group of matched eumenorrhic athletes. The subjects who remained amenorrheic had a further decrease in bone mineral density while the women who regained menses showed a significant increase in the density of the lumbar vertebrae. Amenorrheic body builders may be at risk for osteoporosis and should, therefore, be aware of this risk. Treatment should be initiated immediately to prevent or reverse bone loss.

Recommendations for Future Research

Since our study only had six subjects, the addition of more subjects is needed to increase the statistical significance of the results. With the increased participation of women in body building, this may be possible. By increasing the number of subjects, the relationship between body building and oligo-/amenorrhea may be better investigated.

In order to investigate this relationship it would be necessary to conduct a longitudinal study of competitive female body builders during the off-season and continue through competition. Analyses of estradiol, progesterone, LH and FSH would reveal hormonal alterations and identify anovulation and cycle phase lengths.

During this study, bone mineral density could be assessed to identify the effects of dieting, weight loss and weight training on bone mineral content.

Body fat analyses throughout the investigation may provide information relevant to menstrual changes and the effects of weight cycling on body composition. With regards to weight cycling, weight cycled body builders would be matched to non-weight cyclers. The analysis of metabolic rate among these subjects may reveal metabolic changes associated with repeated cycles of body weight loss and regain in those subjects who compete several times.

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APPENDIX A

METHODOLOGY

Subjects

Six competitive female body builders ages 22 to 34 were recruited from weight lifting clubs in Virginia and Maryland. The subjects included one beginner, one city level and three state level competitors and had to meet the following criteria: 1) involved in weight training 4 - 6 days per week; and 2) were currently preparing to compete in a body building competition within the six months following initial contact with the investigator.

Sampling Procedures

Subjects completed a 60-item fixed choice and open-ended questionnaire concerning menstrual status and history, present training status and history, and diet history (see Appendix B). Subjects were asked to elaborate their answers to any questions if the given choices were not accurate. For example, several subjects provided additional information on questions pertaining to eating disorders. Several subjects reported that tendencies toward eating disorders occurred while dieting prior to competition or after competition when they increased food intake. All subjects were initially grouped together for questionnaire analysis. Frequencies were obtained for each item on the questionnaire.

After preliminary analysis of the questionnaire, the subjects were grouped according to birth control use. These

groups were denoted by each subject's response of "I am currently taking oral contraceptives," or "I am not currently taking oral contraceptives and have not taken them for the past three months" prior to the initial meeting. One group consisted of three subjects who were presently taking oral contraceptives. The second group consisted of the other three subjects who were not presently taking oral contraceptives. Frequencies were then obtained for each item on the questionnaire concerning menstrual status, menstrual history and the effects of diet and/or exercise on the menstrual cycle. The birth-control group was not included in the results which concerned menstrual characteristics.

The non-birth control group was asked to take daily urine samples for the duration of the study. Only two of the three eligible subjects agreed. These subjects formed the urine sample group.

Since a portion of the questionnaire dealt with the menstrual cycle, subjects were further classified according to menstrual status. Menstrual status was determined by interval regularity and cycle length. Menstrual cycle lengths of 21 to 35 days which usually occurred at regular intervals were classified as eumenorrheic. Oligomenorrhea was classified as having cycles of 36 to 89 days which usually occurred at consistent or inconsistent intervals, or cycles that were difficult to assess. Since none of the subjects reported their cycles to be 90 or more days, a specific

classification for amenorrhea was not needed.

Categories of subjects to be discussed are: 1) a Combined Group, 2) Birth Control Use - Birth Control (BC) or No Birth Control (NBC), 3) Menstrual Status, 4) Urine Sample Group.

Human Subjects Committee and Informed Consent

Since the study involved human subjects, it was reviewed by and then approved by the Virginia Polytechnic Institute and State University Institutional Review Board (IRB). All subjects were required to sign an informed consent which explained the risks involved with participating in the study (see Appendix C).

Experimental Procedures

All subjects were contacted and asked to attend an initial individual meeting for the completion of informed consent, questionnaire completion and the presentation of detailed instructions for completing 3-day diet, exercise and body weight records. At the initial interview, subjects reported their height and body weight and also that they were steroid-free.

Data collection schedules were given to each subject which illustrated exact dates for recording five 3-day diet, exercise and body weight records (refer to Appendix B). The data collection schedule also indicated a date for body composition analysis. The subjects who agreed to collect urine samples were given detailed instructions for proper collection and storage of the samples.

Diet Records

All subjects were instructed to record five 3-day diet records. A detailed data collection schedule was provided which illustrated the exact dates to record diet before, during and after competition. Subjects recorded diet four weeks prior to competition (-28 to -25 days) and again one week before competition (-9 to -7 days). Two consecutive records were recorded during the weekend of competition. The record that included competition day (-2 to 0 days) began two days prior to competition (Thursday, Friday, Saturday). The following record included the three days immediately after competition (Sunday, Monday and Tuesday) (+1 to +3 days). The last record was collected three weeks later (+26 to +28 days).

The 3-day records included two weekdays and one weekend day. Subjects were instructed to record all food and drink as accurately as possible. The subjects were asked to record the quantity, brand name and method of preparation. The quantity of food was estimated by including the number, volume and/or size of the item consumed. Subjects were instructed to use "typical household measures" to assist in estimating the volume of foods. Diagrams were provided to assist in the estimation of portion sizes, for example, of meats (refer to Appendix B for example instructions and record sheets). The subjects were asked to clarify all record entries. The Nutripractor 6000 nutrient analysis system (Proctorcare, Inc., 1987, 10951 Sorrento Valley Road, San Diego, CA) was used to

analyze and average each three day diet record for kilocalories, grams of protein, fat and carbohydrate and selected vitamins and minerals (refer to Appendix B for individual subject data). Food items not listed in the database were added using the nutrient information available on the food package label.

Exercise and Body Weight Records

On the same day that diet was recorded, exercise and body weight were recorded. Subjects were instructed to record the type and amount of exercise performed. The amount of exercise referred to the duration or total time that each exercise was performed. For weight lifting exercise, subjects were asked to record the total time spent lifting plus the approximate length of time allotted for rest periods between each set.

Subjects were instructed to weigh themselves on the same scale and at the same time each day (refer to Appendix B for example instructions, record forms and subject data).

Body Composition Assessment

Body composition analysis was performed via skinfold technique two weeks prior to each subject's competition date (Jackson, Pollock and Ward, 1980). Lange skinfold calipers were used to take skinfold measurements for the estimation of percent body fat. Measurements of skinfolds were taken of the triceps, suprailium and thigh on the right side of the body. The three skinfold sites were measured five times each. The average of the five measurements for each skinfold site was

used to estimate body density (BD) and percent body fat (%BF). All measurements were performed by the researcher. Generalized equations for women from Jackson, Pollock and Ward (1980) were used to calculate body density (BD).

$$BD = 1.0994921 - 0.0009929\ (X3) + 0.0000023\ (X3)^2 - 0.0001392\ (AGE)$$

(X_3) = Sum of triceps, suprailium and thigh

Percent body fat (%BF) was calculated using the Siri (1956) formula.

$$\%BF = \frac{4.570}{BD} - 4.143$$

(refer to Appendix B for form.)

Urine Sample Collection

The two subjects were instructed to take daily urine samples for one month (30 days) or one menstrual cycle prior to their competition and to continue until one complete menstrual cycle after their competition. The eumenorrheic subjects began urine sample collection on day one of their next menstrual cycle prior to their competition and continued until one complete menstrual cycle after competition. The oligo-/amenorrheic subjects began urine sample collection one month (30 days) prior to competition and continued until one month (30) days after competition. Subjects were instructed to collect urine samples from the first morning void

(Chattoraj, 1976). Samples were immediately stored at -20 degrees celsius or below and maintained until analysis.

Samples were analyzed for urinary-free estradiol (E2) and urinary-free progesterone (P4) levels using commercially available nonextraction radioimmunoassay (RIA) kits (Diagnostic Products Corporation, 5700 West 96th Street, Los Angeles, CA; Category No. TKE21 (Estradiol), TKPG1 (Progesterone)). The assay protocol was used with the following modifications: 1) urine samples were used instead of serum or plasma and 2) 25 ul aliquote volume was used in the E2 assay instead of the prescribed 100 ul volume.

Before the urine samples were analyzed, validation tests were conducted to determine the accuracy of the assay to measure urinary hormone concentrations. Table 11 lists the results of the validation tests for P4 (A) and E2 (B). The standard curves for both assays were linear; therefore, the assays were over-estimated. The percent estimation of the actual amount of P4 in the urine sample was only slightly over-estimated (Table 11-A). The highest percentage recorded was 149% and the lowest was 94%. For the E2 validation test, the assay was greatly over-estimated (Table 11-B). At least 2.5 to 5 times higher than normal values were recorded. The highest recorded percent estimation of the actual amount of E2 was 500% and the lowest was still high at 241%. The assays were able to measure the relative changes over time of P4 and E2. The validation tests proved that hormone concentration

in urine could be measured using RIA kits which recommended plasma samples.

Within assay coefficient of variation for P4 and E2 assays were 7.08% and 8.00% (Table 11-A and 11-B).

Urine samples were used because daily blood samples are difficult to obtain for prolonged periods using human subjects (Czekala et al., 1988). Both the luteinizing hormone (LH) surge and subsequent luteal phase function may be predicted from estrogen excretion during the follicular phase (Czekala et al., 1988). Progesterone levels were assessed to evaluate ovulation and corpus luteum function as described by Chattoraj et al., (1976). Daily urinary progesterone excretion was used because the pattern is similar to that of plasma levels of progesterone and more convenient for the subjects than serum collection (Chattoraj et al., 1976).

Data Analysis

Questionnaire - Frequencies were obtained for each item on the questionnaire for all subjects. The subjects were then grouped according to oral contraceptive use. Frequencies were then obtained for each questionnaire item.

Diet Records - After all diet records were assessed nutritionally, they were analyzed using the Statistical Analysis System (SAS). Repeated measures analyses of variance were used to test significance among the five record means for kilocalories (Kcal), kilocalories per kilogram bodyweight (kcal/kgBW), protein (g), fat (g), carbohydrate (g), grams of

protein per kilogram bodyweight (gmPro/kgBW), and percentage of protein, fat and carbohydrate. To examine the means of significant factors, the Duncan's Multiple Range Test was performed. Each subject's diet records were analyzed for the following vitamins and minerals: calcium (Ca), iron (Fe), Magnesium (Mg), phosphorous (P), potassium (K), sodium (Na), zinc (Zn), copper (Cu), manganese (Mn), chlorine (Cl), chromium (Cr), iodine (I), molybdenum (Mo), fluoride (F), selenium (Se), Vitamins A, E, D, C, B-6, and B-12, thiamine, riboflavin, niacin, pantothenic acid, biotin, and folacin. The group mean was assessed for select micronutrients for the five records (refer to Table 9). The subjects who were two-thirds below the RDA for select vitamins and minerals were determined (refer to Table 10).

Body Weight - Body weight records were analyzed across all five 3-day records. Each 3-day record was averaged to represent one body weight. Repeated measures analysis of variance was used to test for statistical significance among all five record means followed by a post-hoc analysis using the Duncan's Multiple Range Test.

Statistical significance for all analyses was set at the 0.05 level.

Urine Samples - Since urine samples were collected for only two subjects, statistical analysis was not appropriate.

TABLE 11-A: Accuracy of Progesterone (P4) Measurement from Human Urine.

Hormone Standard (ng)	Estimated Total Hormone (ng +/- SEM)	Estimated Hormone Recovered (ng +/- SEM)	Difference (ng)	% Est (%)
0.05	0.181 +/- .009	0.068 +/- .067	.018	136
0.20	0.411 +/- .013	0.298 +/- .013	.098	149
1.00	1.411 +/- .219	1.290 +/- .210	.290	129
2.00	1.994 +/- .001	1.881 +/- .001	-.119	94
Within Assay CV: 7.08%				

TABLE 11-B: Accuracy of Estradiol (E2) Measurement from Human Urine.

Hormone Standard (pg)	Estimated Total Hormone (pg +/- SEM)	Estimated Hormone Recovered (pg +/- SEM)	Difference (pg)	% Est.
2.0	117.6 +/- 77.6	7.75 +/- 77.7	5.75	388
5.0	134.9 +/- 5.5	24.98 +/- 5.51	19.98	500
15.0	163.4 +/- 62.1	53.53 +/- 62.05	38.53	357
50.0	230.3 +/- 17.1	120.45 +/- 17.5	70.45	241
Within Assay CV: 8.00%				

TABLE 12: Mean Body Weight By Record

SOURCE	DF	SS	F-VALUE	PR > F
TIME	4	66.65305	10.48 *	0.0001
SUBJECT	5	100.77006	12.67 *	0.0001
ERROR	20	31.81		
TOTAL	29	199.24		

* p < .01

TABLE 13: Total Kilocalorie Intake By Record

SOURCE	DF	SS	F-VALUE	PR > F
TIME	4	11425437.67	4.14 *	0.0132
SUBJECT	5	7061173.90	2.05	0.1151
ERROR	20	13786605.93		
TOTAL	29	32273217.50		

* p < .05

TABLE 14: Kilocalories per Kilogram Body Weight by Record

SOURCE	DF	SS	F-VALUE	PR > F
TIME	4	3335.627	4.16 *	0.0130
SUBJECT	5	1884.019	1.889	0.1430
ERROR	20	4007.728		
TOTAL	29	9227.375		

* p < .05

TABLE 15: Grams of Protein by Record

SOURCE	DF	SS	F-VALUE	PR > F
TIME	4	9739.29	2.37	0.0868
SUBJECT	5	14228.93	2.77	0.0463
ERROR	20	20524.79		
TOTAL	29	44493.01		

p > .05

TABLE 16: Grams of Protein per Kilogram Body Weight

SOURCE	DF	SS	F-VALUE	PR > F
TIME	4	2.650987	1.80	0.1692
SUBJECT	5	3.960417	2.15	0.1015
ERROR	20	7.38		
TOTAL	29	13.99		

$p > .05$

TABLE 17: Grams of Fat by Record

SOURCE	DF	SS	F-VALUE	PR > F
TIME	4	45254.64	5.49 *	0.0038
SUBJECT	5	23992.33	2.33	0.0804
ERROR	20	41187.13		
TOTAL	29	110434.09		

* p < .01

TABLE 18: Grams of Carbohydrate by Records

SOURCE	DF	SS	F-VALUE	PR > F
TIME	4	216336.49	3.85 *	0.0178
SUBJECT	5	139905.28	1.99	0.1241
ERROR	20	281193.58		
TOTAL	29	637435.35		

* p < .05

TABLE 19: Percent Composition of Protein in the Diet by Record

SOURCE	DF	SS	F-VALUE	PR > F
TIME	4	1817.145	6.93 *	0.0011
SUBJECT	5	297.945	0.91	0.4952
ERROR	20	1311.83		
TOTAL	29	3426.92		

* p < .01

TABLE 20: Percent Composition of Fat in the Diet by Record

SOURCE	DF	SS	F-VALUE	PR > F
TIME	4	2158.57	7.20 *	0.0009
SUBJECT	5	1675.43	4.47 *	0.0068
ERROR	20	1499.92		
TOTAL	29	5333.92		

* $p < .01$

TABLE 21: Percent Composition of Carbohydrate by Record

SOURCE	DF	SS	F-VALUE	PR > F
TIME	4	1546.387	6.55 *	0.0015
SUBJECT	5	1936.831	6.56 *	0.0009
ERROR	20	1180.69		
TOTAL	29	4663.903		

* p < .01

APPENDIX B

INDIVIDUAL SUBJECT DATA

HORMONAL DATA: Subjects #2 and #5

QUESTIONNAIRE

Individual Subject Information Sheet

Worksheet for Bodyfat Estimation

Diet Record Instructions and Data Sheet

Exercise and Body Weight Record Instructions and Data Sheet

Urine Sample Collection Instructions

Data Collection Calendar

TABLE 21: Subject Data

SUBJECT #1

	RECORD 1	RECORD 2	RECORD 3	RECORD 4	RECORD 5
KiloCalories	1182.6	1288.0	3695.5	4477.3	3126.6
Protein(g)	83.7	134.3	127.1	153.5	78.9
Fat(g)	27.1	18.7	80.8	214.6	114.1
CHO(g)	195.8	229.3	659.5	469.3	339.2
%Protein	24.6	33.1	13.1	13.9	11.7
%Fat	17.9	10.4	18.8	44.0	38.0
%CHO	57.5	56.5	68.1	42.0	50.0
Kcal/KgBW	20.3	22.5	65.7	75.9	53.5
gmProt/KgBW	1.4	2.4	2.6	2.6	1.4
Vitamin A	710.5	384.8	2365.1	5598.6	5212.6
Vitamin D	16.5	0.0	0.0	76.9	66.7
Vitamin C	23.7	26.6	443.0	80.8	142.9
Thiamine	1.4	1.1	4.7	2.3	8.3
Vitamin B-12	2.4	3.6	4.3	11.9	1.2
Ca	220.3	203.2	1267.1	1614.0	975.3
Fe	9.2	8.3	22.9	21.9	13.3
Mg	116.4	174.7	257.4	372.3	261.6
Body Weight	58.3	57.2	56.3	59.0	58.5

TABLE 21: Subject Data (Cont.)

SUBJECT #2

	RECORD 1	RECORD 2	RECORD 3	RECORD 4	RECORD 5
KiloCalories	1844.6	1498.0	2264.4	4358.6	4957.3
Protein(g)	150.4	217.3	94.3	173.8	135.4
Fat(g)	47.9	27.3	42.4	173.8	241.9
CHO(g)	176.4	86.4	382.8	602.5	608.3
%Protein	44.5	59.5	16.5	14.9	10.5
%Fat	3.2	16.8	16.7	33.5	42.3
%CHO	52.0	23.6	66.9	51.6	47.2
Kcal/KgBW	31.2	27.1	43.0	76.9	81.0
gmProt/KgBW	2.5	3.9	1.8	3.1	2.2
Vitamin A	8256.0	6586.6	4765.3	5552.0	4729.3
Vitamin D	0.0	0.0	0.0	0.0	100.0
Vitamin C	126.5	109.9	128.5	198.5	203.9
Thiamine	2.1	0.9	2.1	2.5	2.5
Vitamin B-12	2.7	2.2	0.3	4.4	2.1
Ca	840.7	275.3	532.2	1227.3	1544.6
Fe	14.3	12.0	19.8	22.7	23.4
Mg	226.5	269.5	257.4	487.5	507.5
Body Weight	59.1	55.3	52.7	56.7	61.2

TABLE 21: Subject Data (Cont.)

SUBJECT #3

	RECORD 1	RECORD 2	RECORD 3	RECORD 4	RECORD 5
KiloCalories	1594.6	1736.6	2427.7	2553.0	1071.3
Protein(g)	118.9	121.2	61.2	97.8	62.6
Fat(g)	6.8	8.6	17.6	78.9	5.1
CHO(g)	263.3	291.3	524.9	364.8	196.3
%Protein	29.9	28.1	9.8	15.3	23.1
%Fat	3.8	4.5	6.3	27.7	4.3
%CHO	66.3	67.5	83.9	57.0	72.6
Kcal/KgBW	30.2	34.1	48.0	48.5	19.9
gmProt/KgBW	2.3	2.4	1.2	1.9	1.2
Vitamin A	1715.0	429.3	1597.6	2945.6	1081.0
Vitamin D	0.0	0.0	0.0	20.5	0.0
Vitamin C	87.1	105.5	142.9	78.9	53.7
Thiamine	1.3	1.4	1.8	1.4	1.1
Vitamin B-12	1.3	1.8	0.2	2.9	1.2
Ca	555.7	537.7	476.3	949.3	509.7
Fe	17.3	19.8	24.7	18.9	11.2
Mg	440.2	463.3	472.1	371.0	325.5
Body Weight	52.8	51.0	50.6	52.6	54.0

TABLE 21: Subject Data (Cont.)

SUBJECT #4

	RECORD 1	RECORD 2	RECORD 3	RECORD 4	RECORD 5
KiloCalories	1263.3	1102.3	1369.6	2118.0	1964.6
Protein(g)	87.8	81.0	77.6	98.1	97.2
Fat(g)	24.1	25.6	37.0	109.4	84.3
CHO(g)	180.0	139.3	183.0	183.8	194.9
%Protein	27.3	29.2	22.6	18.6	20.2
%Fat	16.8	20.7	24.2	46.6	39.4
%CHO	55.9	50.1	53.2	34.8	40.4
Kcal/KgBW	21.7	19.8	24.7	37.3	33.0
gmProt/KgBW	1.5	1.5	1.4	1.7	1.6
Vitamin A	5034.6	7277.3	3679.6	5276.0	3044.0
Vitamin D	0.0	26.9	0.0	45.1	16.7
Vitamin C	87.4	99.8	144.6	59.5	53.8
Thiamine	1.0	1.0	0.7	1.5	1.2
Vitamin B-12	2.1	1.5	0.6	5.8	2.0
Ca	561.3	392.4	348.0	899.0	920.0
Fe	11.1	10.0	10.4	12.0	11.8
Mg	187.0	140.9	211.6	200.9	184.9
Body Weight	58.1	55.8	55.5	56.8	59.6

TABLE 21: Subject Data (Cont.)

SUBJECT #5

	RECORD 1	RECORD 2	RECORD 3	RECORD 4	RECORD 5
KiloCalories	2477.3	2331.3	1732.0	1684.0	3177.3
Protein(g)	130.6	126.1	77.3	97.7	187.8
Fat(g)	100.4	84.1	33.6	46.6	120.8
CHO(g)	271.1	272.3	284.9	223.3	343.2
%Protein	20.8	21.5	17.7	22.9	23.4
%Fat	36.0	32.2	17.3	24.6	33.9
%CHO	43.2	46.3	65.1	52.4	42.7
Kcal/KgBW	42.6	42.2	31.5	30.2	56.9
gmProt/KgBW	2.3	2.3	1.4	1.8	3.4
Vitamin A	5525.3	6026.3	3336.2	5717.3	2725.3
Vitamin D	2184.6	1327.0	0.0	909.1	1934.0
Vitamin C	61.1	162.2	246.3	96.0	199.7
Thiamine	1.7	1.4	1.7	2.5	2.9
Vitamin B-12	10.8	5.8	5.3	9.2	14.9
Ca	1560.6	1054.3	343.4	789.5	1944.0
Fe	19.7	17.8	17.3	26.2	35.5
Mg	310.5	277.1	164.1	279.9	463.1
Body Weight	58.1	55.3	54.9	55.8	55.8

TABLE 21: Subject Data (Cont.)

SUBJECT #6

	RECORD 1	RECORD 2	RECORD 3	RECORD 4	RECORD 5
KiloCalories	1415.3	1260.6	2257.4	3392.4	2444.0
Protein(g)	128.7	107.9	49.4	154.6	143.3
Fat(g)	6.4	6.2	44.4	124.3	39.1
CHO(g)	210.9	197.9	426.4	419.0	386.0
%Protein	36.4	33.8	8.6	18.1	23.2
%Fat	4.0	4.3	17.0	32.8	14.2
%CHO	59.6	61.9	74.1	49.1	62.5
Kcal/KgBW	25.6	22.9	41.9	60.8	40.5
gmProt/KgBW	2.3	2.0	0.9	2.8	2.4
Vitamin A	6755.1	8965.3	736.2	9298.6	3916.0
Vitamin D	0.0	0.0	0.0	98.4	0.0
Vitamin C	56.4	94.2	268.9	148.1	238.9
Thiamine	1.1	1.0	1.7	1.6	3.7
Vitamin B-12	5.2	3.3	0.2	6.6	1.7
Ca	262.3	379.2	457.8	1421.0	387.3
Fe	14.5	14.2	17.5	20.5	21.1
Mg	215.5	180.3	359.7	341.3	305.1
Body Weight	55.3	55.1	53.9	55.8	60.3

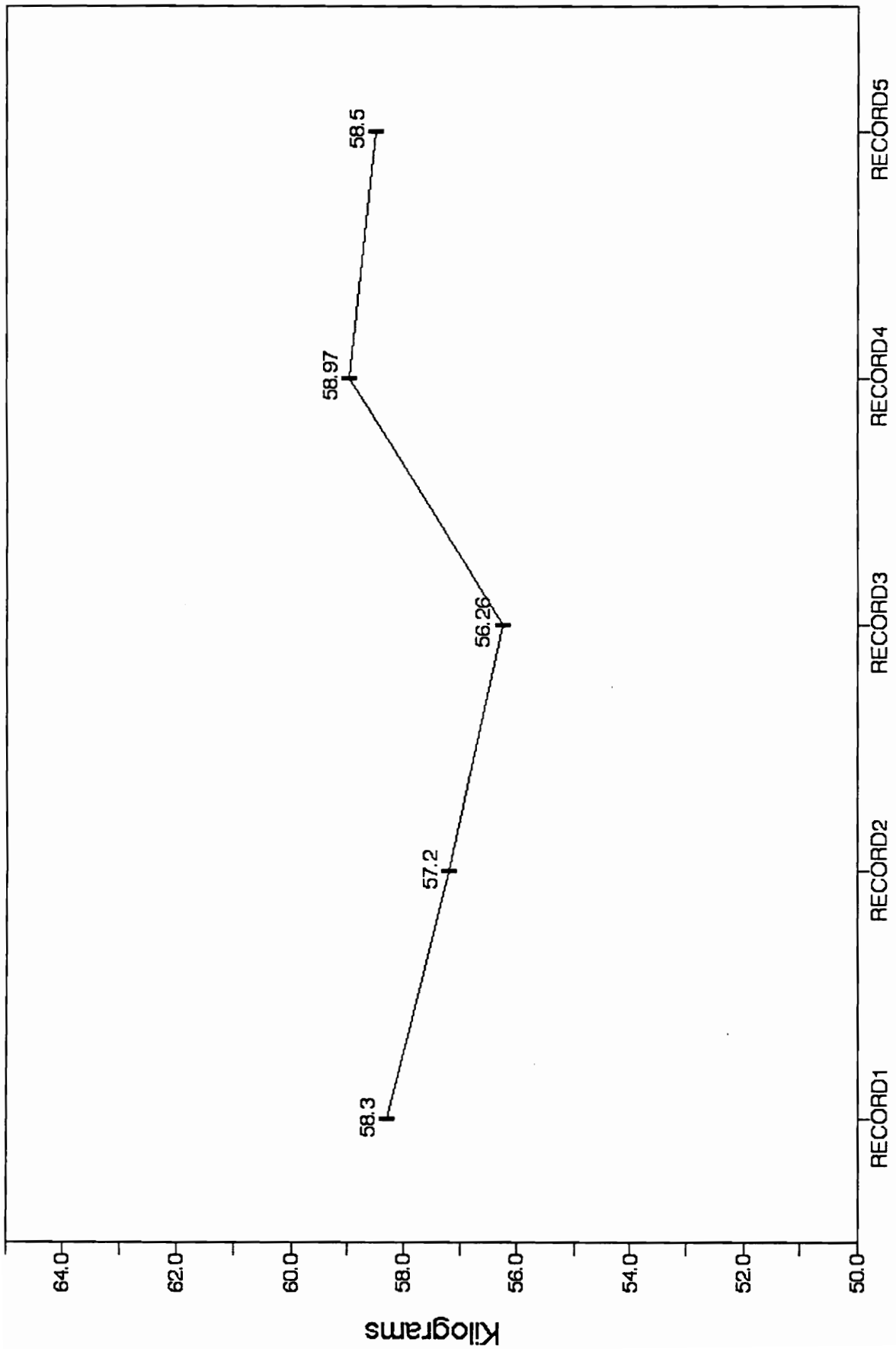


Figure 6a: Body Weight Changes for Subject #1

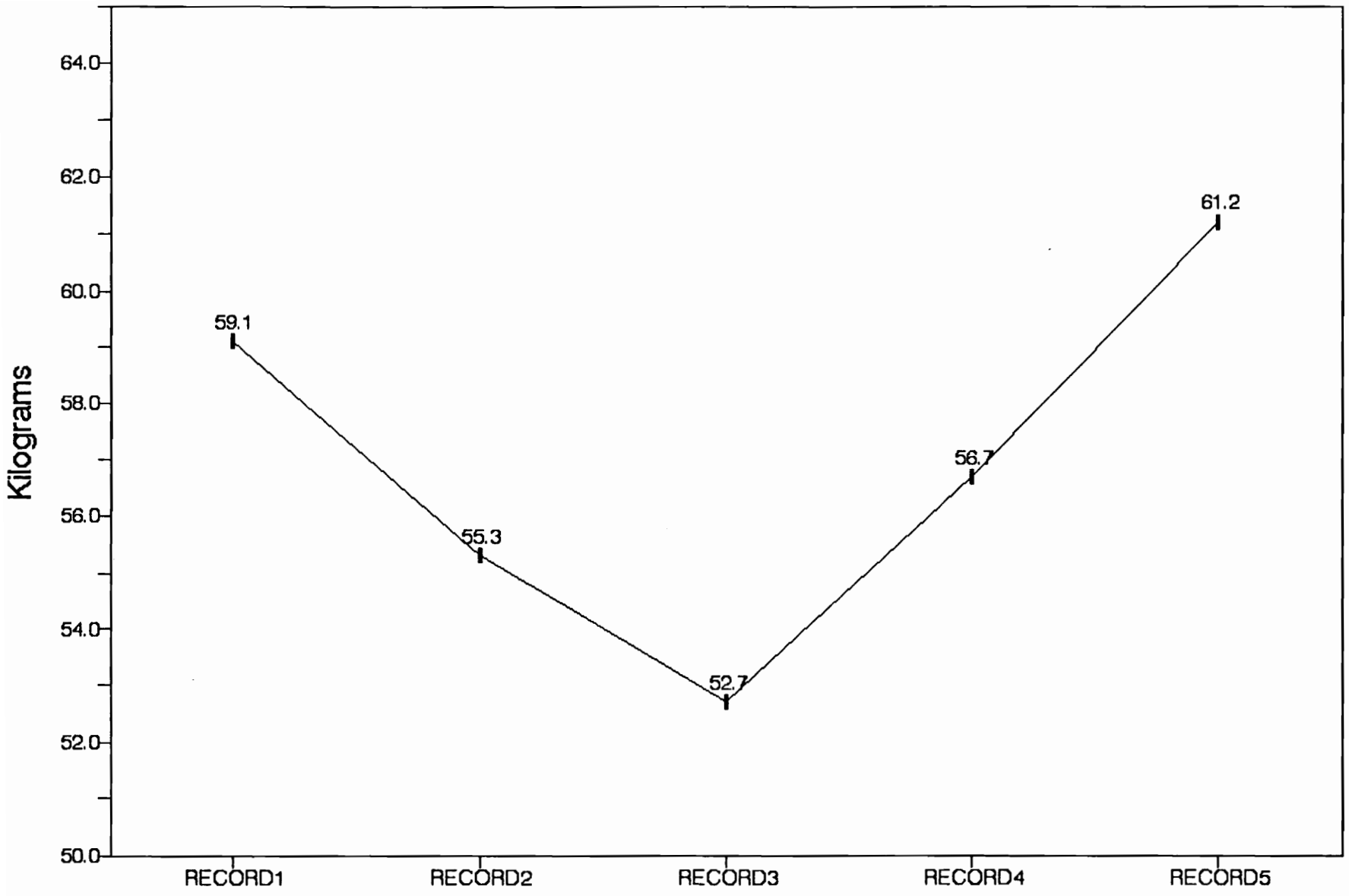


Figure 6b: Body Weight Changes
for Subject #2

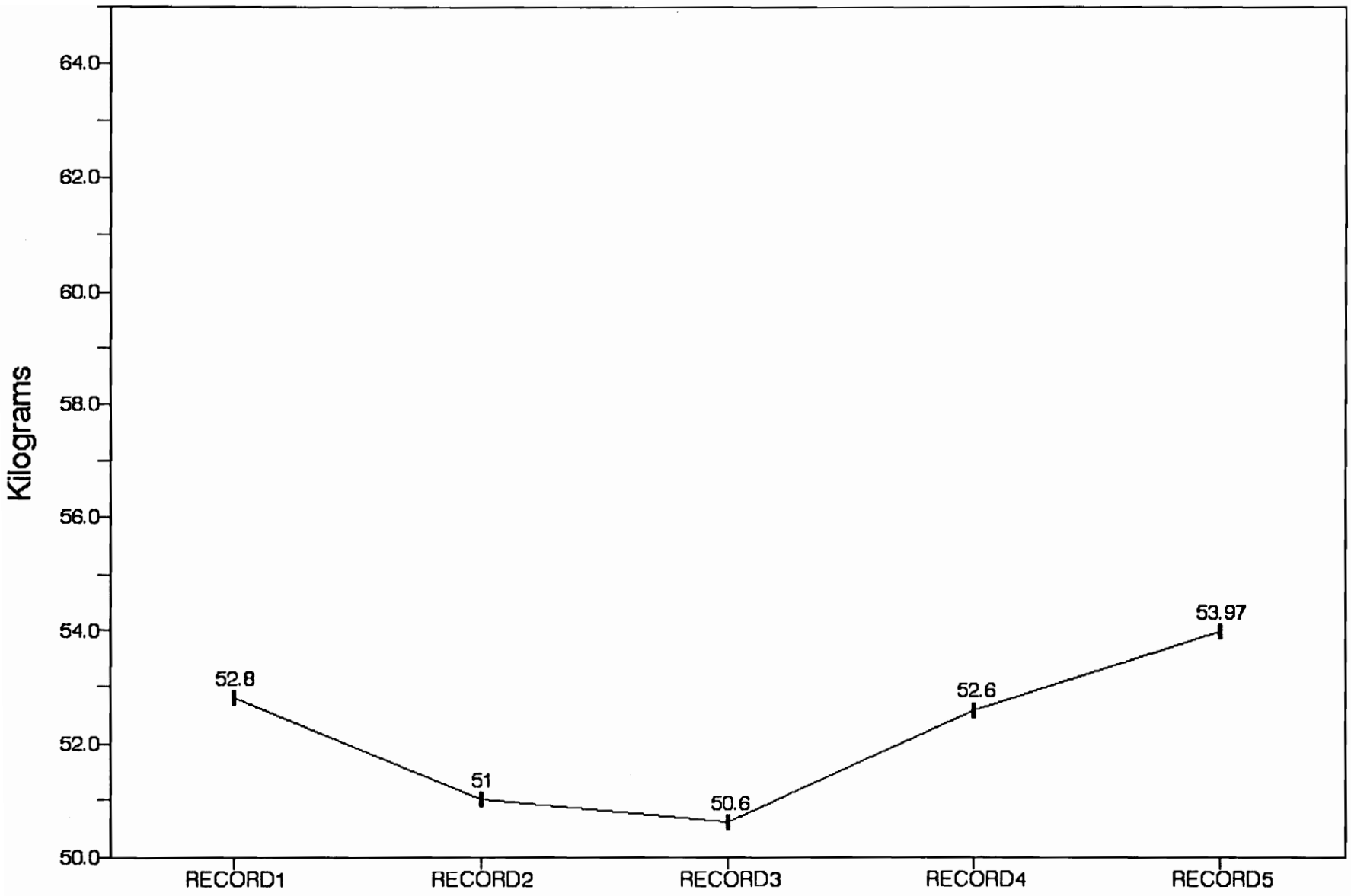


Figure 6c: Body Weight Changes for Subject #3

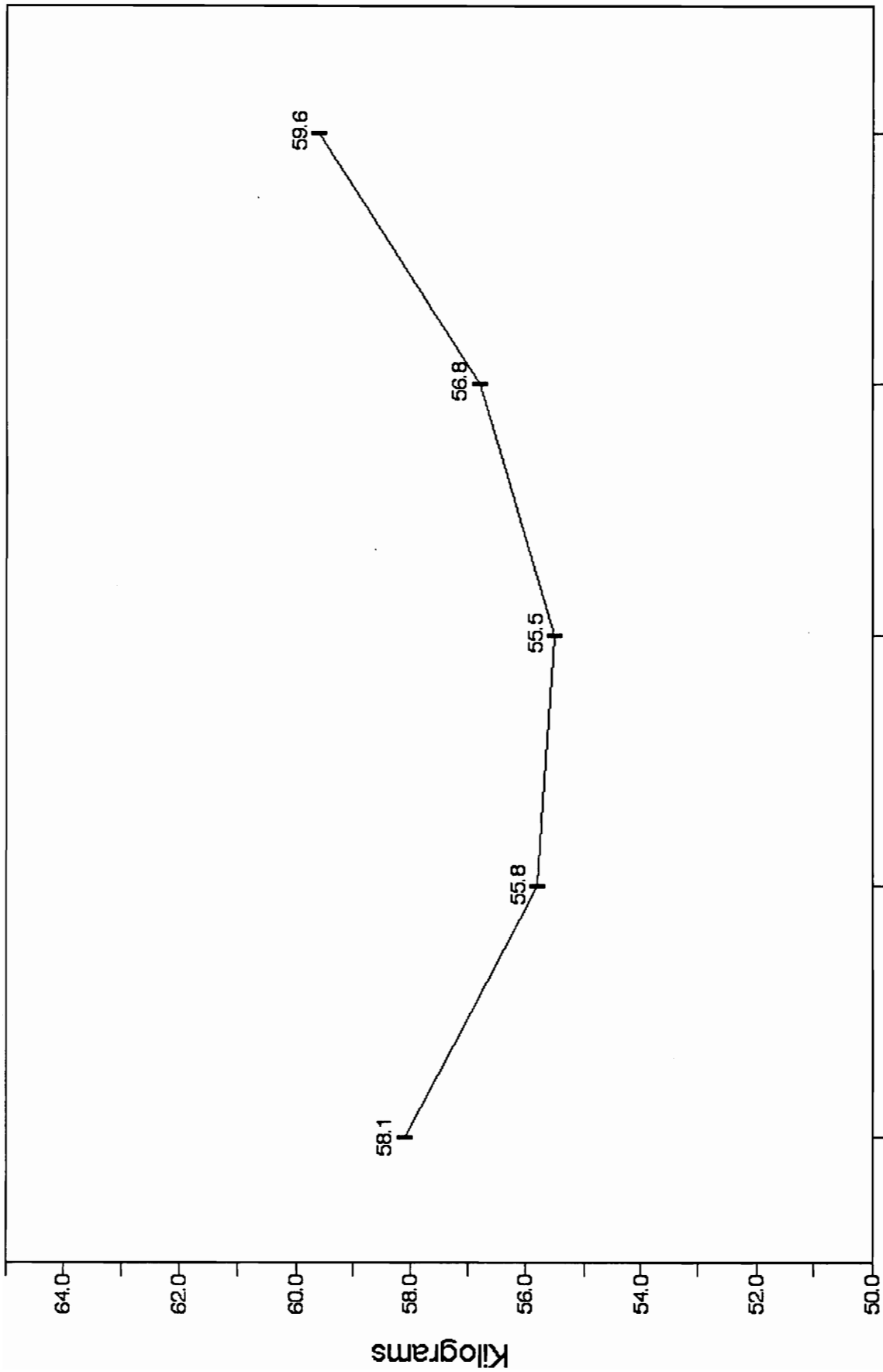


Figure 6d: Body Weight Changes for Subject #4

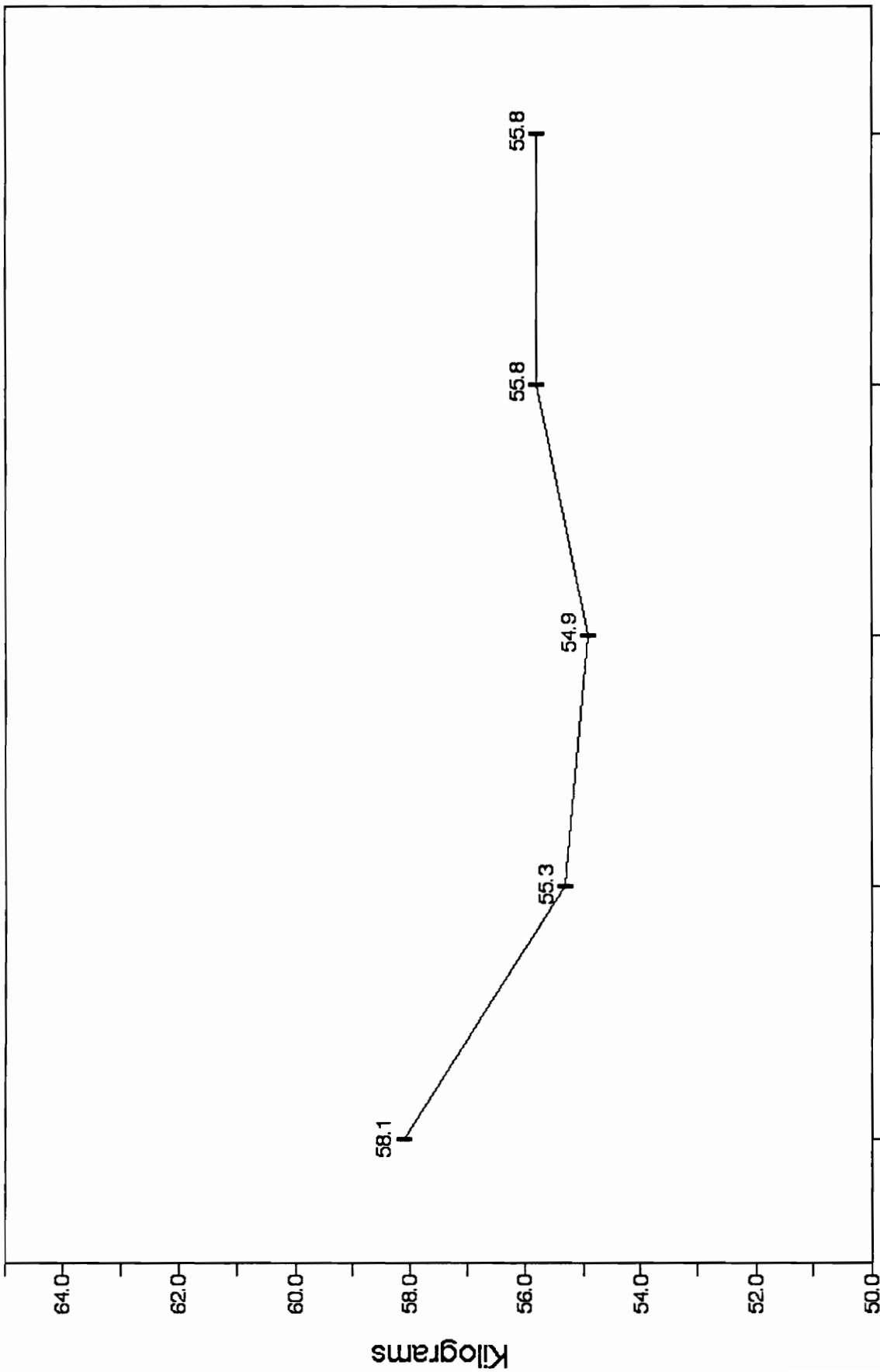


Figure 6e: Body Weight Changes for Subject #5

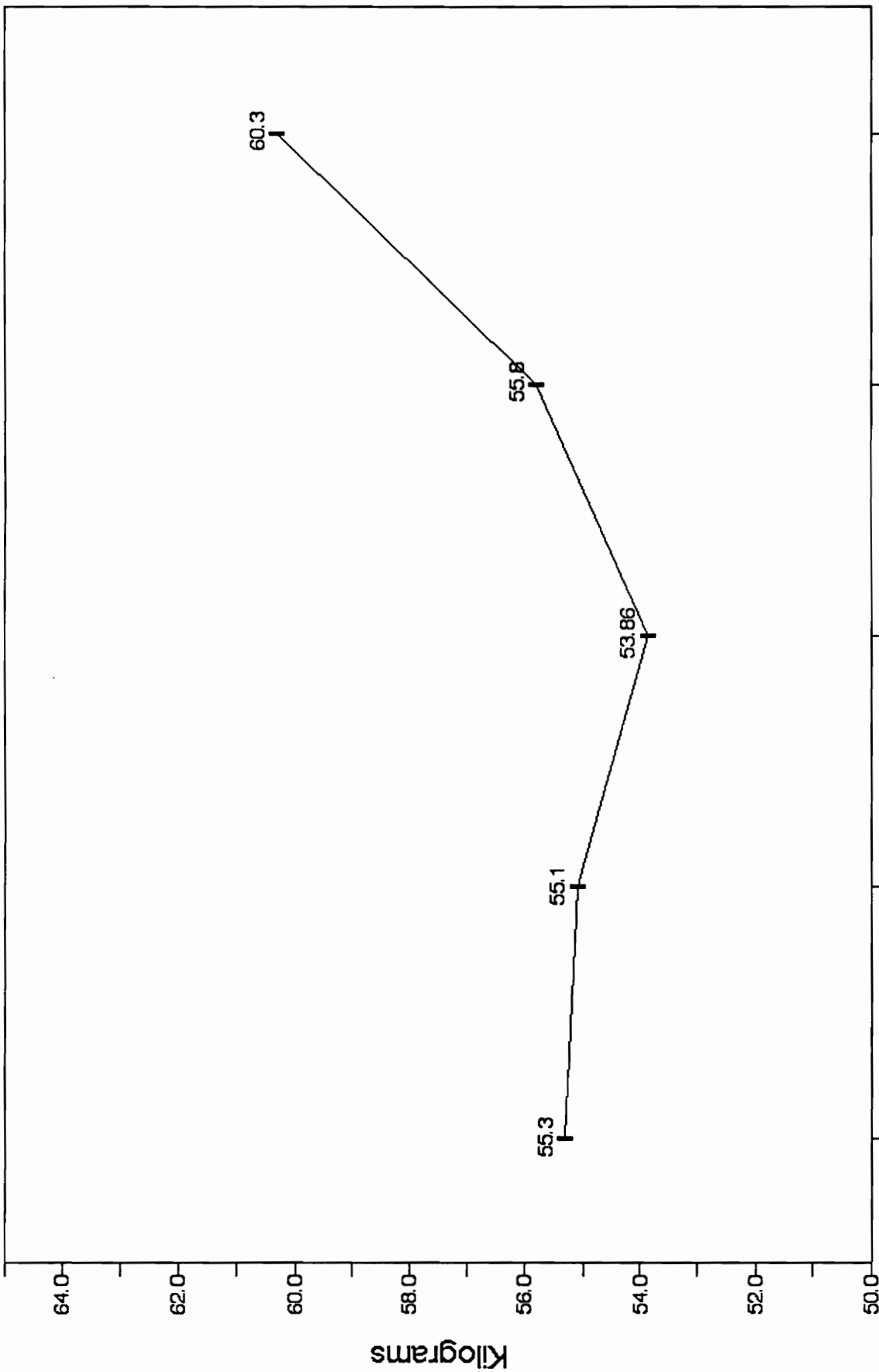


Figure 6f: Body Weight Changes for Subject #6

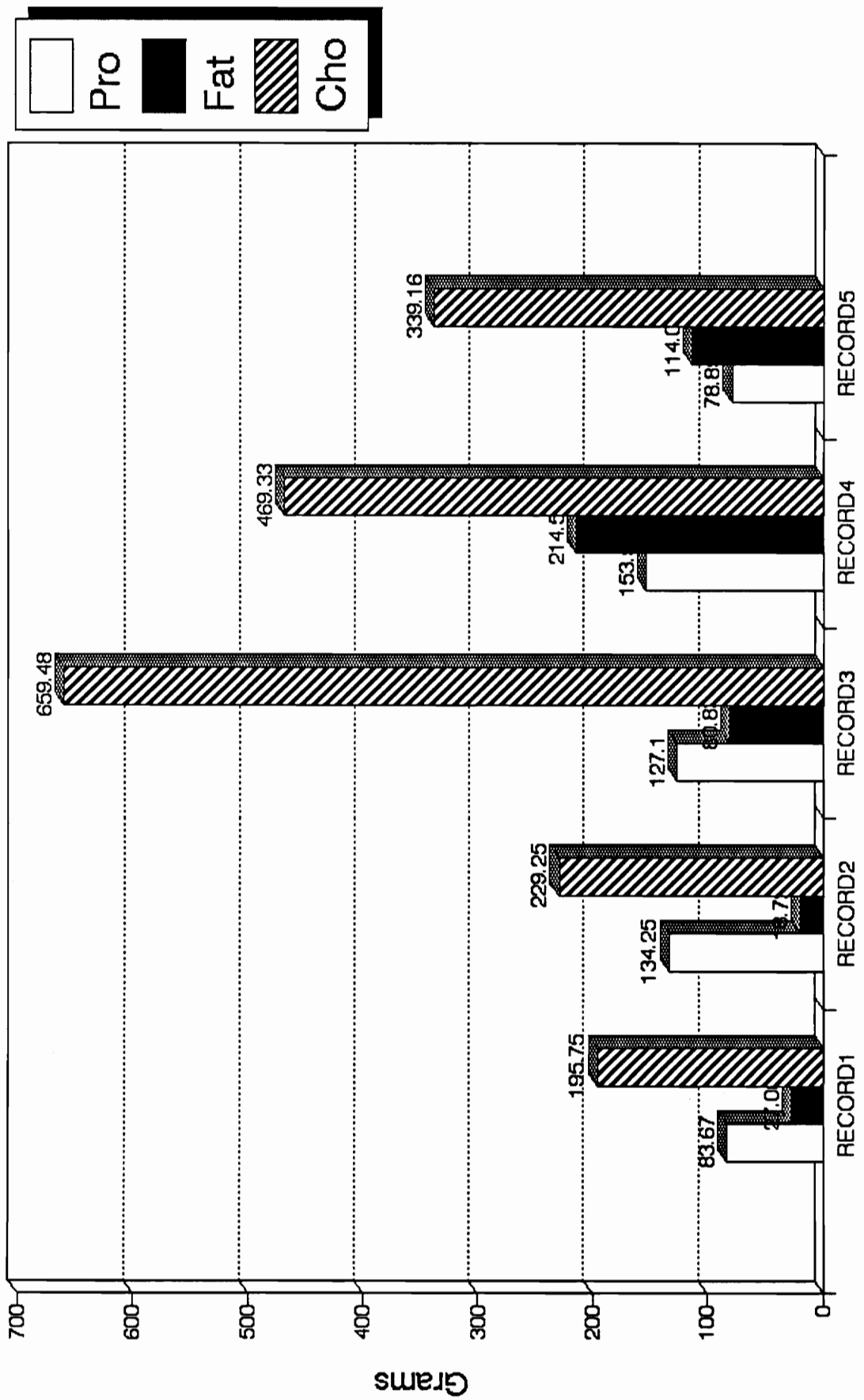


Figure 7a: Composition of Diet for Subject #1

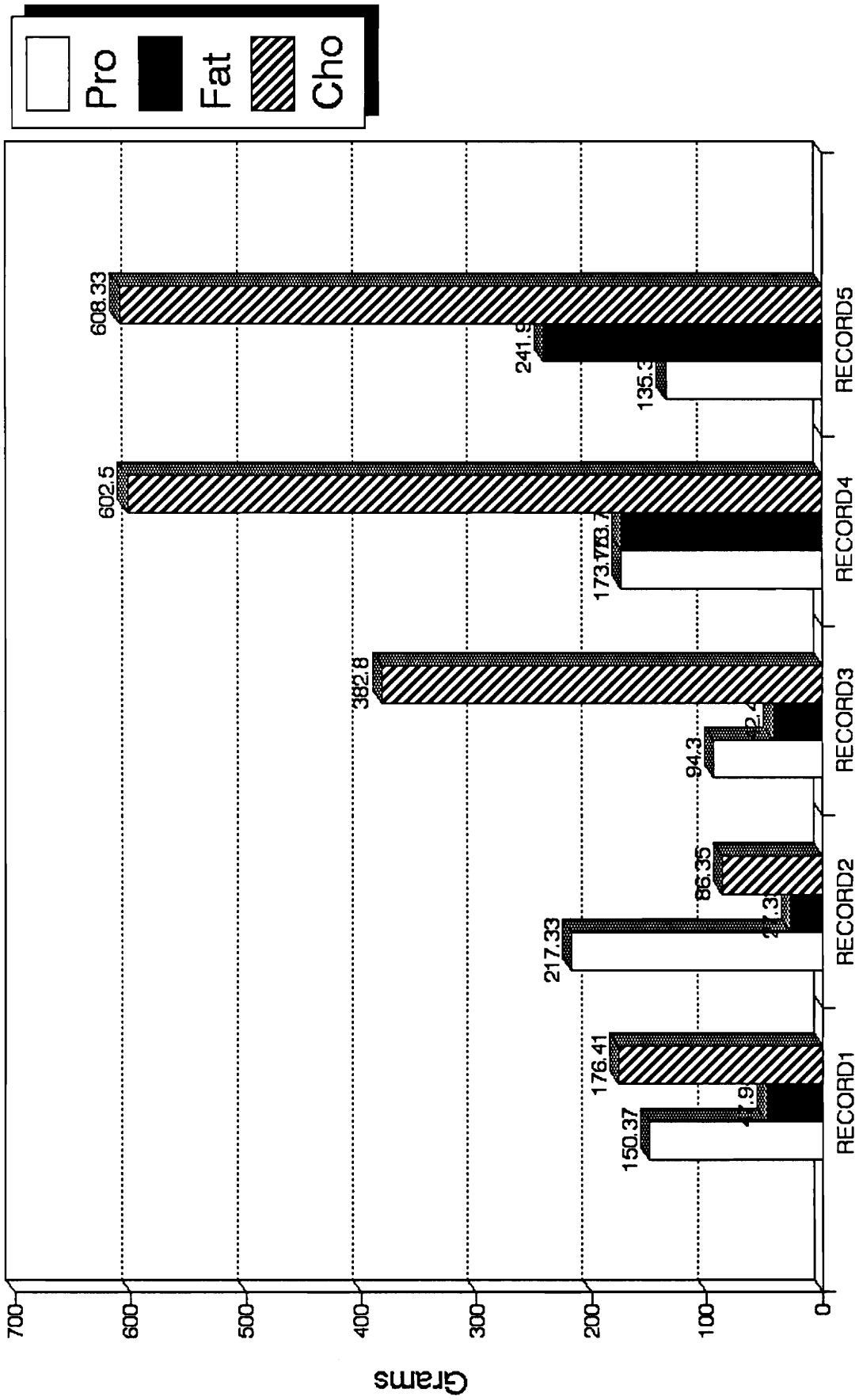


Figure 7b: Composition of Diet for Subject #2

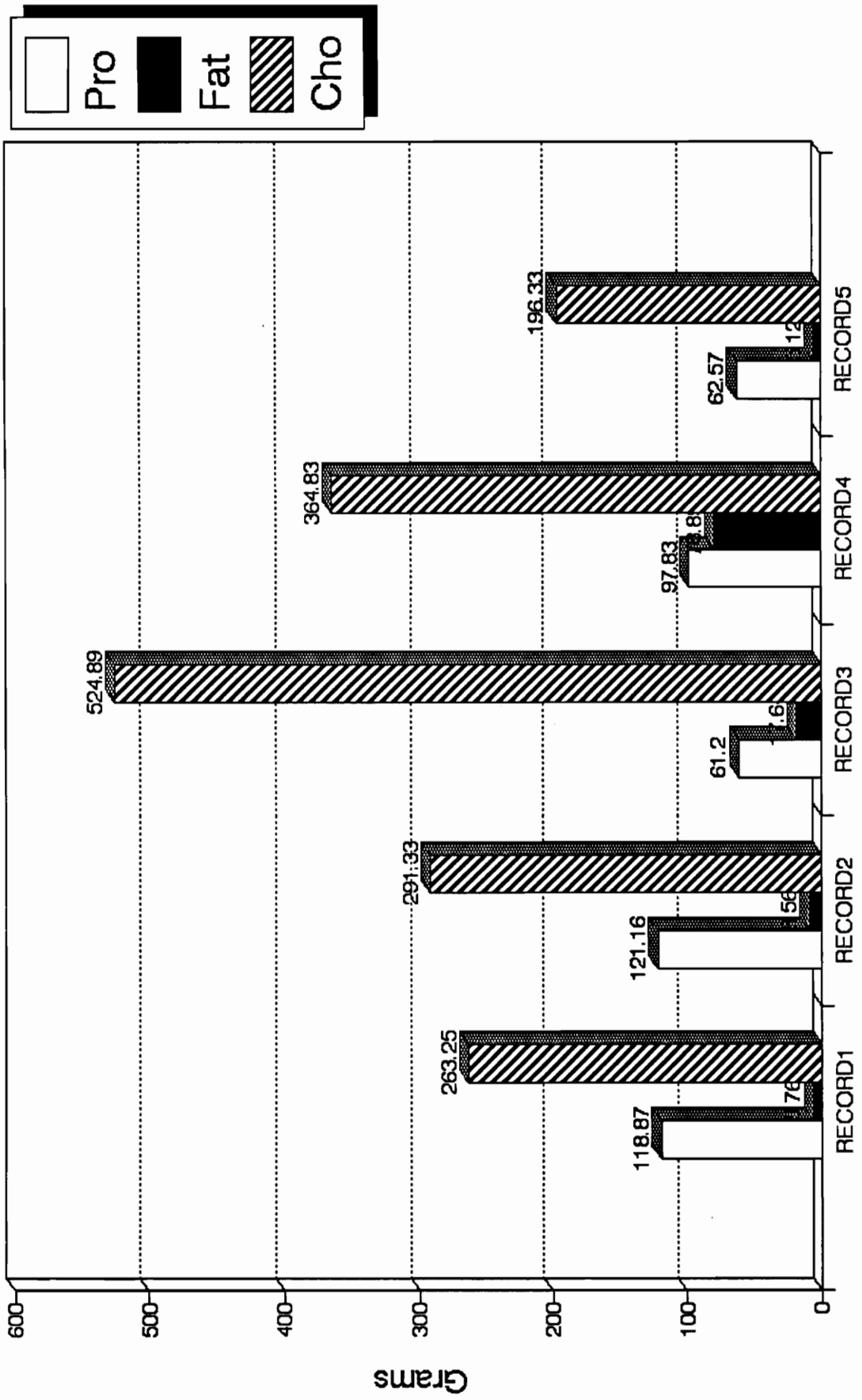


Figure 7c: Composition of Diet for Subject #3

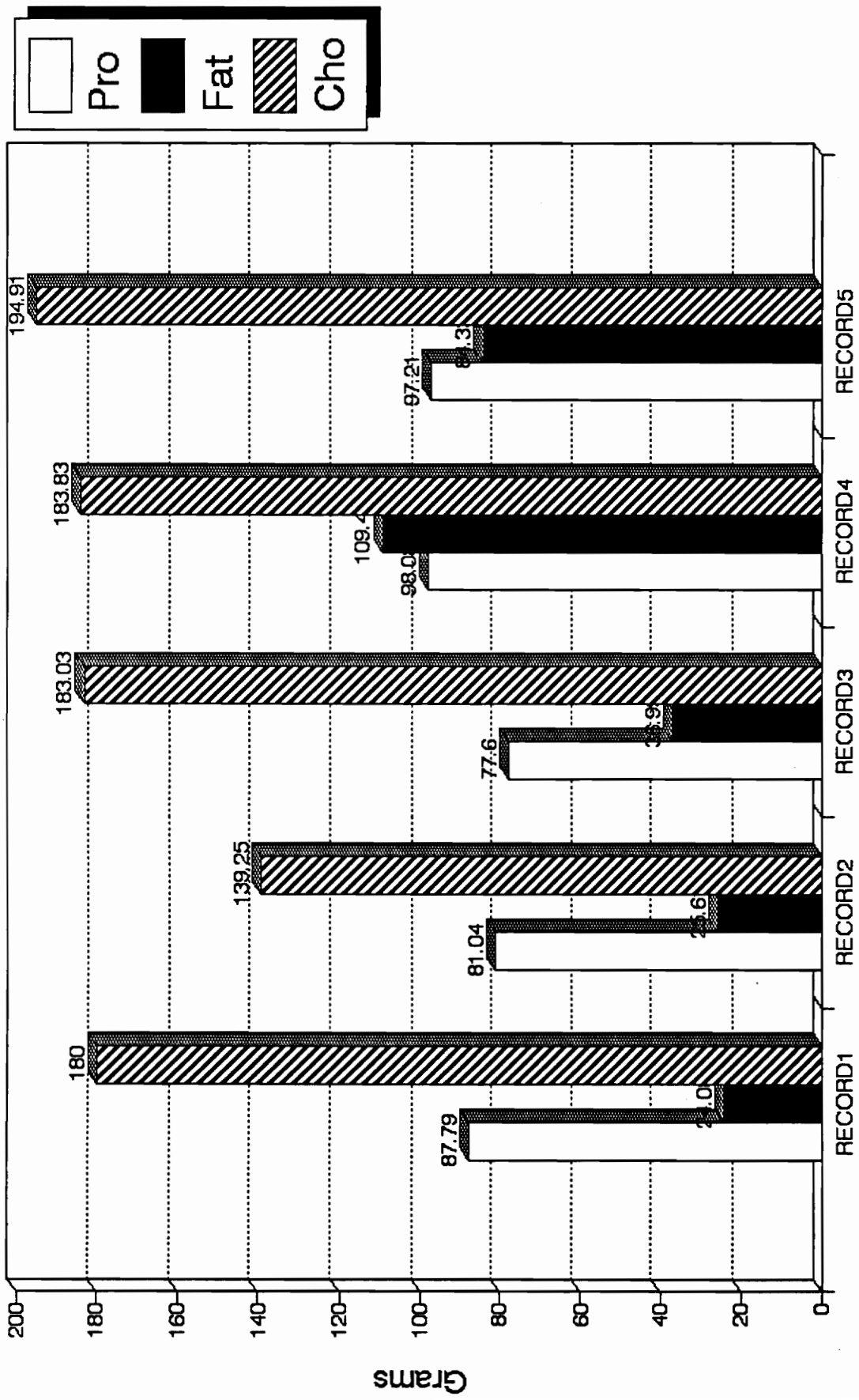


Figure 7d: Composition of Diet for Subject #4

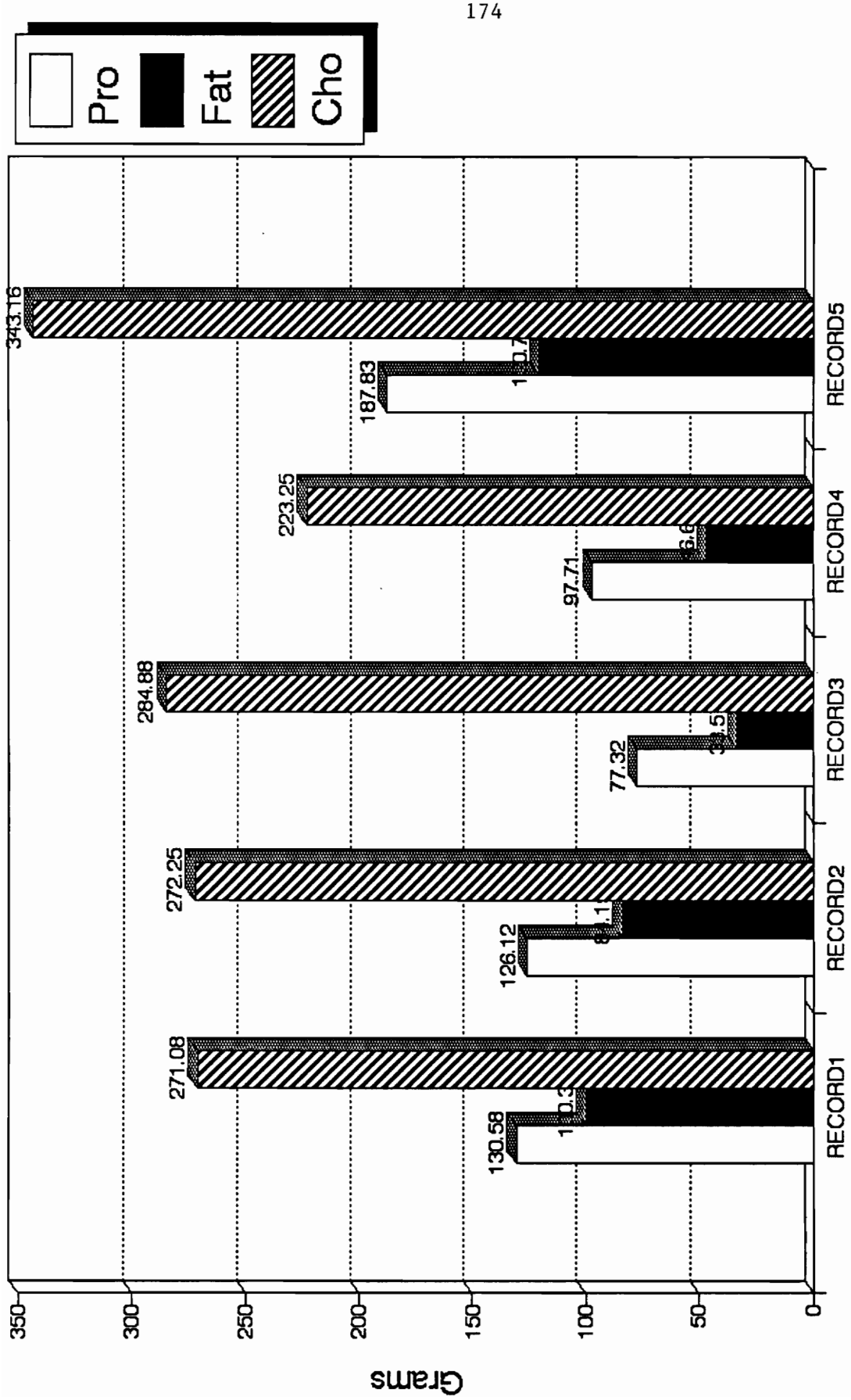


Figure 7e: Composition of Diet for Subject #5

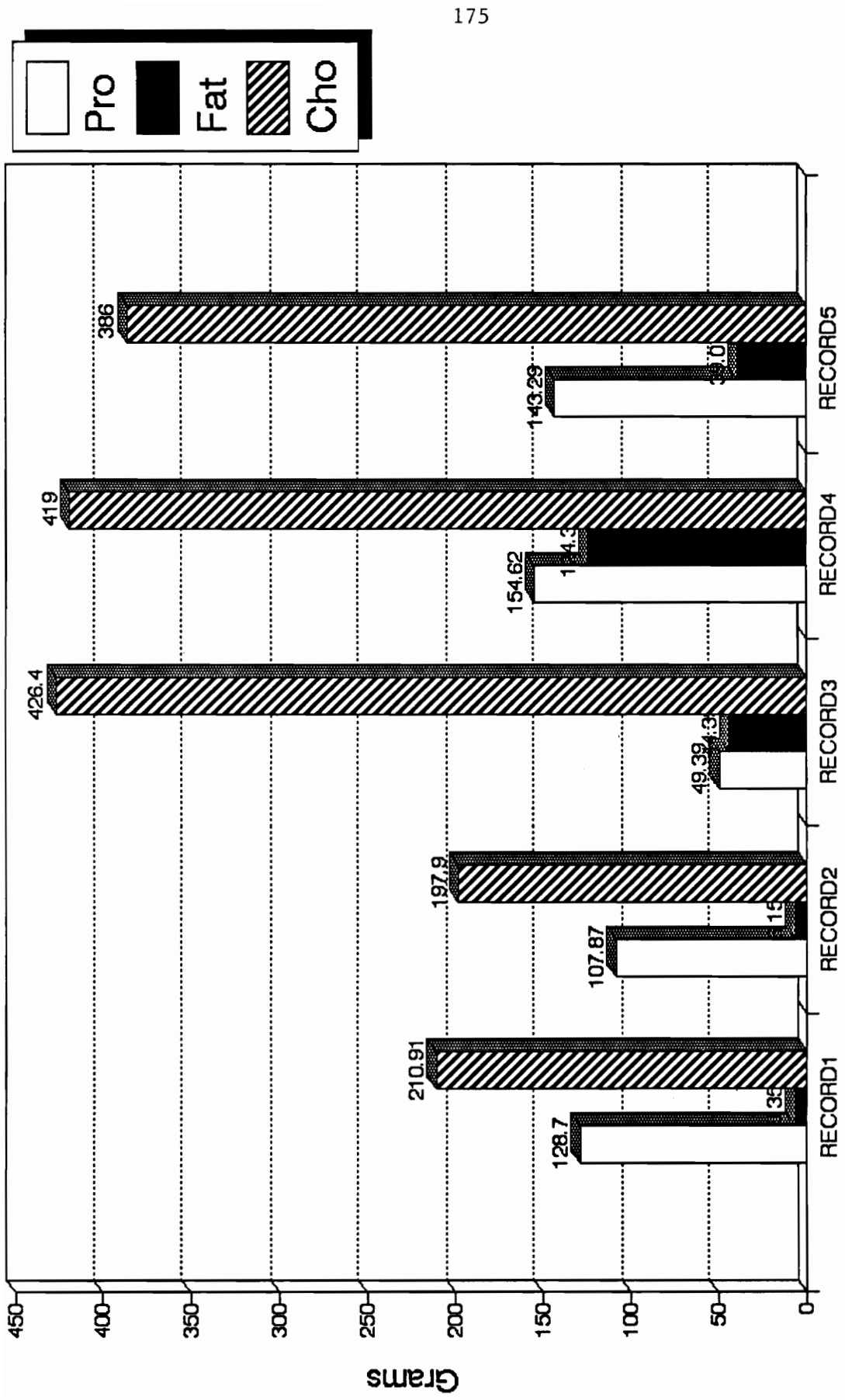


Figure 7f: Composition of Diet for Subject #6

TABLE 23: URINE SAMPLE DATA

SUBJECT #2

SAMPLE #	(P4)(ng)	(E2)(pg)	SAMPLE #	(P4)(ng)	(E2)(pg)
1.	.51	535.04	34.	.74	326.96
2.	.47	675.30	35.	1.03	175.72
3.	.66	789.20	36.	.81	206.76
4.	.72	664.40	37.	1.28	573.28
5.	.64	424.60	38.	1.86	720.46
6.	.73	893.70	39.	1.88	626.76
7.	.87	1024.60	40.	1.83	942.56
8.	.55	1111.06	41.	1.21	862.51
9.	.59	1668.10	42.	1.06	380.25
10.	.67	1746.12	43.	.90	719.65
11.	.57	1310.49	44.	1.01	427.17
12.	.60	2518.08	45.	.36	155.10
13.	.58	3197.52	46.	.41	380.99
14.	.74	3850.22	47.	.82	933.01
15.	.81	5215.99	48.	.62	680.10
16.	1.26	2981.16	49.	.83	995.12
17.	1.09	936.16	50.	1.36	1476.73
18.	1.77	1172.19	51.	.64	1053.30
19.	4.49	2363.99	52.	1.08	1529.77
20.	2.93	2041.00	53.	.43	801.00
21.	1.81	1685.99	54.	.45	1635.74
22.	1.08	852.05	55.	.79	2583.89
23.	1.16	955.78	56.	.66	1882.64
24.	.90	553.81	57.	1.01	2555.90
25.	.76	317.13	58.	2.12	1626.42
26.	.89	352.98	59.	2.02	772.24
27.	.85	361.46	60.	2.67	1953.51
28.	.67	272.12	61.	1.51	1032.31
29.	.57	356.38	62.	1.09	370.14
30.	.53	293.66	63.	4.00	2204.72
31.	.60	276.10	64.	1.89	1966.49
32.	.40	416.82	65.	2.15	1430.79
33.	.71	227.49	66.	1.35	1118.26

TABLE 23: (continued)

SUBJECT #5

SAMPLE #	(P4)(ng)	(E2)(pg)	SAMPLE #	(P4)(ng)	(E2)(pg)
1.	1.87	1728.24	31.	2.02	2463.08
2.	.76	851.27	32.	1.14	1314.52
3.	1.36	1599.19	33.	1.21	1762.47
4.	1.07	1529.84	34.	1.6	2297.72
5.	1.17	1913.56	35.	.27	1161.58
6.	.96	1822.11	36.	3.90	1188.22
7.	.84	1681.90	37.	4.37	1261.73
8.	.92	2906.87	38.	7.67	2308.14
9.	1.18	2898.84	39.	6.51	1459.67
10.	.91	3939.08	40.	10.16	2389.90
11.	1.22	3716.57	41.	6.99	1850.07
12.	.83	3836.81	42.	3.35	2541.63
13.	.67	1113.32	43.	3.12	2688.00
14.	2.66	2402.79	44.	4.18	2491.28
15.	1.21	922.59	45.	1.16	965.37
16.	2.96	1139.63	46.	1.16	938.12
17.	2.90	1135.17	47.	1.33	1301.87
18.	3.77	1575.46	48.	1.73	1296.59
19.	4.23	1641.48	49.	1.72	1444.70
20.	4.92	1282.09	50.	1.98	2524.91
21.	6.71	2802.56	51.	2.27	2198.30
22.	5.77	3409.12	52.	2.32	2471.24
23.	1.53	1188.27	53.	1.24	7377.48
24.	5.31	3036.07	54.	2.02	3930.28
25.	2.18	1915.82	55.	2.15	3932.55
26.	1.59	1477.95	56.	2.33	7882.69
27.	1.66	1672.45	57.	2.08	6744.63
28.	1.87	1665.77	58.	2.39	7235.88
29.	1.26	1326.52	59.	.79	1947.00
30.	2.45	2264.42			

QUESTIONNAIRE INFORMATION

THE FOLLOWING QUESTIONNAIRE WILL ASK YOU TO PROVIDE INFORMATION ABOUT YOUR MENSTRUAL HISTORY, TRAINING HISTORY AND DIET HISTORY. ALL OR YOUR RESPONSES WILL BE KEPT CONFIDENTIAL AND WILL BE USED FOR RESEARCH PURPOSES ONLY. YOUR RESPONSES ARE INVALUABLE FOR THE SPORT OF FEMALE BODY BUILDING, SO PLEASE ANSWER ALL QUESTIONS AS ACCURATELY AS POSSIBLE. YOUR TIME AND ASSISTANCE WITH THIS STUDY IS GREATLY APPRECIATED.

THANK YOU,

CYNTHIA ECKSTEIN

I.D. NUMBER:_____

QUESTIONNAIRE

Menstrual History:

1. How old were you when you had your first menstrual period?
   a. younger than age 12
   b. age 12 to 13
   c. age 14 to 15
   d. age 16 to 17
   e. age 17 to 18
   f. older than 18

2. Do your periods usually occur at consistent intervals?
   a. yes b. no

3. If yes, what is the average length of your menstrual cycle? From the first day of your period to the first day of your next period?
   _____.

4. In the past three months, how many periods have you had?
   a. 4 - 3
   b. 2 - 1
   c. 0

5. Have you missed a period within the last year?
   a. yes b. no

6. If yes, this was probably best explained by:
   a. pregnancy
   b. dieting
   c. change in exercise
   d. illness
   e. none of the above
   f. do not know

7. How long has it been since you last took birth control pills?
   a. not applicable or more than three months ago.
   b. less than three months ago or are presently taking them.

8. Do you have any children?
   a. yes b. no

9. Did you begin athletic/sport participation prior to your first period?
   a. yes
   b. no
   c. do not remember

10. When you increase the amount of exercise you are doing, does your menstrual cycle length:
    a. increase in the number of days between periods
    b. decrease in the number of days between periods
    c. no change
    d. not applicable

11. When you decrease calories to lose weight, does your menstrual cycle length:
    a. increase in the number of days between periods
    b. decrease in the number of days between periods
    c. no change
    d. not applicable

12. Do you notice spotting / bleeding between your menstrual periods?
    a. yes b. no

13. Do you notice that the spotting / bleeding between periods is related to an increase in the amount of exercise you are doing?
    a. yes
    b. no
    c. not applicable

14. Do you notice that the spotting / bleeding between periods is related to a decrease in your caloric consumption?
    a. yes
    b. no
    c. not applicable

15. During my menstrual period, spotting occurs instead of an average menstrual flow.
    a. yes
    b. no
    c. not applicable

16. The more I exercise, the more irregular my periods become.
    a. yes
    b. no
    c. not applicable

17. During a break from training, my menstrual cycle occurs at regular intervals.
    a. yes
    b. no
    c. not applicable

Training History:

1. How old were you when you became involved in sports?
_____

For questions 2 through 7, indicate the months per year, times per week, and minutes per session that you participate in each of the aerobic activities listed write the word none beside that activity.

	months/year	times/week	min/session
2. running			
3. cycling			
4. swimming			
5. aerobic dance			
6. rowing			
7. cross country skiing			

8. How long have you been lifting weights?
_____.

9. How many times per week do you weight train?
_____.

10. Have you ever competed in a body building competition?
a. yes b. no

11. How many times have you competed? _____.

12. When was the last time that you competed?
_____.

13. Do you plan to compete within the next six months?
a. yes b. no

14. If yes, when are you going to compete?_____.

15. How often do you compete in a body building competition?
a. 1 time per year.
b. 2 times per year.
c. 3 times per year.
d. 4 times per year.
e. more than 4
f. not applicable

16. During the off-season, what is the most that you have weighed?_____.

17. During the competitive season, what is the least that you have weighed?_____.

18. If you compete more than one time per year, are the competitions:
    a. less than 1 month apart.
    b. 1 month apart.
    c. 1 - 2 months apart.
    d. 3 - 4 months apart.
    e. 5 - 6 months apart.
    f. other_____.

19. What is the most weight that you have lost for a competition?
    a. never been in a competition.
    b. less than 5 lbs.
    c. 5 - 10 lbs.
    d. 10 - 15 lbs.
    e. more than 15 lbs.
    f. other_____

20. How fast do you lose weight before a competition?
    a. 1 - 2 lbs. per week
    b. 3 - 4 lbs. per week
    c. 5 - 6 lbs. per week
    d. 7 - 8 lbs. per week
    e. 9 - 10 lbs. per week
    f. not applicable

21. If you compete in more than one body building competition per year, does your weight:
    a. increase after each competition
    b. stay the same until the next competition
    c. not applicable

22. If your weight fluctuates between competitions, how much weight do you gain?_____.

23. If your weight fluctuates between competitions, how fast is this weight gain?
    a. 1 - 2 lbs. per week
    b. 3 - 4 lbs. per week
    c. 5 - 6 lbs. per week
    d. 7 - 8 lbs per week
    e. 9 - 10 lbs per week
    f. other_____

24. If your weight fluctuates during competitive months, do you notice a change in your menstrual cycle?
    a. yes, explain_____
    _____.
    b. no
    c. not applicable

25. How many months per year do you train intensely?
    a. more than 9 months
    b. 7 - 8 months
    c. 5 - 6 months
    d. 3 - 4 months
    e. less than 3
    f. not applicable

Diet History:

1. Does your average dietary intake consist of:
    a. red meat at least once per week
    b. no red meat, only chicken or fish
    c. no meats, only animal products such as milk, cheese or eggs
    d. no animal products
    e. other_____.

2. Do you take any vitamin/mineral supplements?
    a. yes b. no

3. Do you take any other supplements?
    a. amino acids
    b. protein
    c. potassium
    d. other,_____.
    e. all of the above

4. Do you get uncontrollable urges to eat and eat until you feel physically ill?
    a. yes b. no

5. Are there times when you are afraid that you cannot voluntarily stop eating?
    a. yes b. no

6. Have you ever had an episode of eating an enormous amount of food within a short period of time (an eating binge)?
    a. yes b. no

7. If you have ever binged, did you feel miserable and annoyed at yourself afterwards?
    a. yes b. no

For questions 8 - 11. In order to control your weight, how often do you use...

a. never
b. less than once every four weeks
c. 1 to 3 times every four weeks
d. once every week
e. 2 to 6 times every week
f. once every day
g. more than once every day

_____ 8. Diet Pills
_____ 9. Laxatives
_____10. Diuretics or Water Pills
_____11. Vomiting

12. Do you consider yourself to be or to have been bulimic?
a. yes, now
b. yes, used to be
c. no

13. Do you consider yourself to be or to have been anoretic?
a. yes, now
b. yes, used to be
c. no

For questions 14 - 17. Have you had any of the following symptoms?

14. Over-activity/exercise without enjoyment.
a. yes b. no

15. Feeling terrified of fat.
a. yes b. no

16. Feeling fat despite others saying you are too thin.
a. yes b. no

17. Being obsessed or totally preoccupied with thoughts of food.
a. yes b. no

I.D. NUMBER:_____

SUBJECT INFORMATION SHEET

Name:_____ Birthdate:_____

Address:_____ Height:_____

_____ Weight:_____

Phone #:_____

When was the first day of your last menstrual period?

_____

NAME:_____ I.D. #:_____
DATE:_____

SKINFOLD MEASUREMENT DATA SHEET

	Triceps	Suprailium	Thigh
Trial 1			
Trial 2			
Trial 3			
Trial 4			
Trial 5			
AVG.			

Sum of the averages of triceps, suprailium and thigh = _____

$BD = 1.0994921 - 0.0009929(X3) + 0.0000023(X3)^2 - 0.0001392(Age) =$ _____

$BD = 1.0994921 - 0.0009929(\_\_\_\_\_) + 0.0000023(\_\_\_\_\_)^2 - 0.0001392(\_\_\_\_\_) =$ _____

$$\%BF = \frac{4.570}{BD} - 4.143 - \_\_\_\_\_ \times 100 = \_\_\_\_\_$$

* X3 = Sum of triceps, suprailium and thigh.

3-DAY DIET RECORD

To complete your 3-day diet record, please write down all the food and drink that you consume on each of the three days. Two (2) weekdays and one (1) weekend day will be included such as Thursday, Friday and Saturday or Sunday, Monday and Tuesday. Please indicate the type of food eaten as well as the quantity, brandname, and how the food was prepared. When you indicate the type of food, please include important adjectives such as skim milk or lowfat cottage cheese. For the quantity of food eaten, include important units of volume such as 8 ounces of orange juice or 2 cups of green beans. Examples of brandnames may include Wendy's Single or Lite-n-Lively Yogurt. Also, please include how foods were prepared such as fried, baked, broiled.

Please include:

I. TYPE: skim milk, white bread

II. QUANTITY:

A. Number of items eaten, such as 1 orange, 5 cookies or 1 large order of fries.
B. Volume units such as one-half cup, 8 ounces, 2 cups. Use measuring cup whenever possible to help you estimate the volume of foods eaten. A measuring cup will be provided if you do not have one.
C. Serving Size is sometimes difficult to estimate especially for meats, breads or pies and cakes. If serving size is not indicated on the food package, please try to use the diagrammed models to help you determine serving sizes or estimate ounces of servings.

III. BRAND NAMES: If you know the brand name of food eaten, please indicate them also. Examples of these may include Smuckers Grape Jelly, Philadelphia Cream Cheese, Mrs. Filbert's. Fast Food Chains should also be listed such as Wendy's, Hardee's or McDonald's.

IV. PREPARATION: Please indicate how food was prepared such as fried, baked, broiled, sauteed, etc. Also, indicate if the skin or peel was removed from meats, vegetables or fruits such as chicken without the skin, peeled apples or peeled potatoes.

An Example Entry May Look Like This:

Breakfast:	Thomas' English Muffins	1 Whole
	with margarine	1 ounce
Lunch:	Chicken Breast	1/2 baked
	French Fries	1 large order

3-DAY DIET RECORD
DAY_____

DATE:__________________ I.D. #:______________

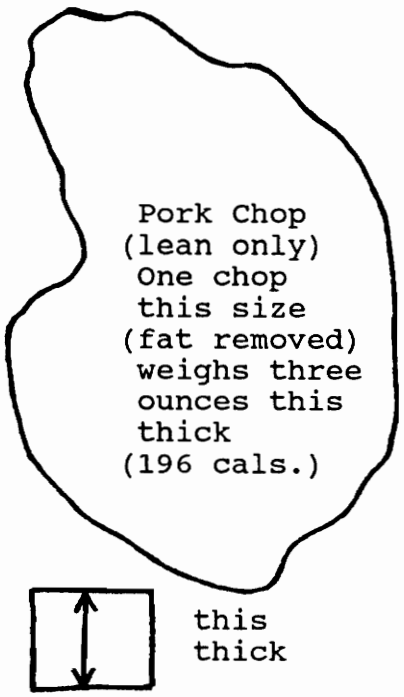
TYPE	QUANTITY		BRAND NAME	PREPARED
	Number	Volume		

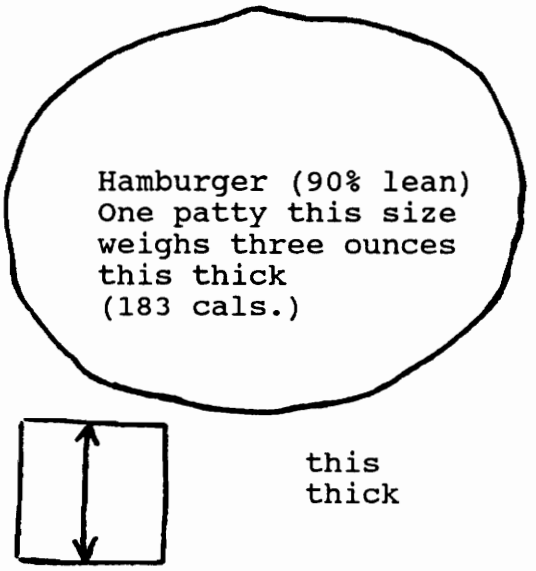
ESTIMATING 3 OUNCE PORTIONS OF COOKED MEAT

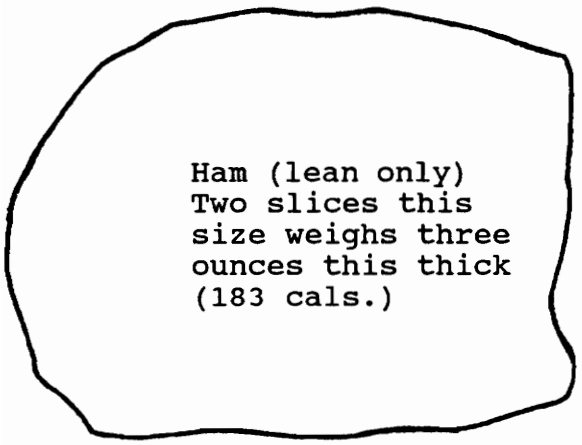
Most of us have a hard time looking at a serving of meat and knowing how many ounces it weighs. To the untrained eye, a three-ounce hamburger patty looks about the same as a four-ounce patty.

The diagrams below will give you a realistic idea of how large a three-ounce serving of several different kinds of meat would be. As you examine the diagrams, remember that you need only one hamburger patty, pork chop or veal cutlet of the sample size to get the three ounces. If you have roast beef, ham, lamb chops or roast turkey, you need two lean, cooked slices or chops to have three ounces. With round steak, you will need four slices of the sample size. Practice estimating the sizes of your typical servings.

Note: The weight here refers to cooked meat. Fresh, raw meat shrinks on cooking as moisture and fat are lost.

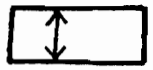


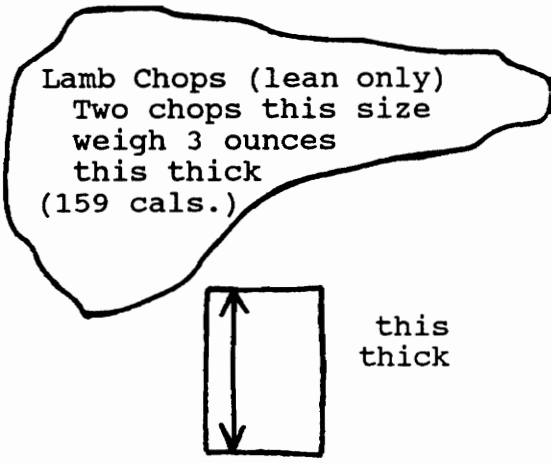




Ham (lean only)
Two slices this size weighs three ounces this thick (183 cals.)

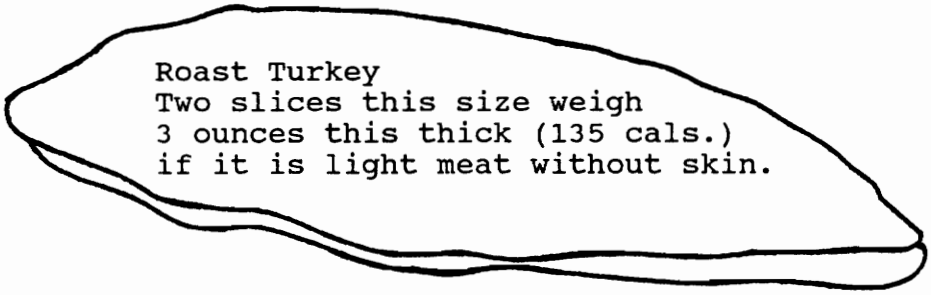
this thick





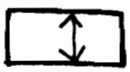
Lamb Chops (lean only)
Two chops this size weigh 3 ounces this thick (159 cals.)

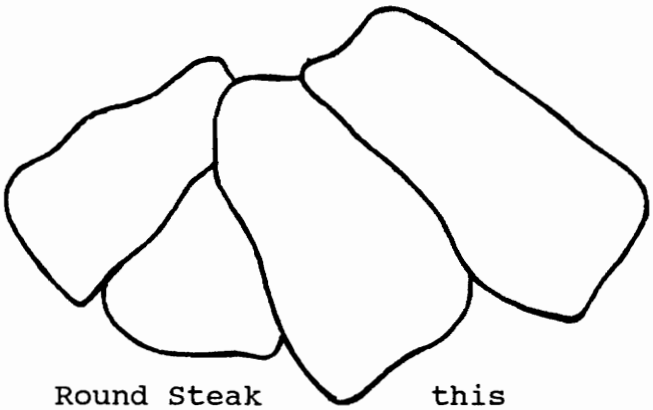
this thick



Roast Turkey
Two slices this size weigh 3 ounces this thick (135 cals.) if it is light meat without skin.

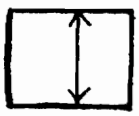
this thick

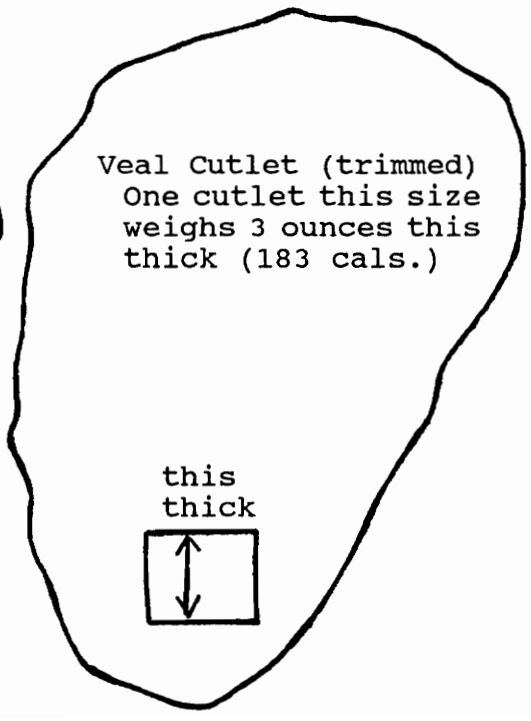




Round Steak
(lean only)
4 slices this size weighs 3 ounces this thick (159 cals.)

this thick





Veal Cutlet (trimmed)
One cutlet this size weighs 3 ounces this thick (183 cals.)

this thick

EXERCISE AND BODY WEIGHT RECORD

Exercise Record: To complete your exercise record, please write all exercises that you do including weight training, aerobic exercises, and any recreational activities. You will need to indicate the type of exercise and the total time that you participate in the exercise.

Please Include:

I. TYPE or MODE OF EXERCISE:

Examples include: running, aerobic dance, cycling, racquetball, etc.

II. TOTAL TIME or DURATION OF EXERCISE:

The total time involved for each exercise should be indicated as well as the mileage of running or cycling. Do not include time spent socializing, resting, etc.

AN EXAMPLE EXERCISE RECORD MAY INCLUDE:

MODE	DURATION/TOTAL TIME	AMOUNT
Aerobic Dance	60 minutes	
Cycling	90 minutes	20 miles
Weight Lifting	45 minutes	

Body Weight Record: On the same day that diet and exercise is recorded, please record your body weight also. Since body weight tends to fluctuate throughout a given day and every scale differs slightly, please remember to:

1. weigh yourself at the same time each day, and
2. use the same scale each day.

Your body weight should be recorded in the space provided on your exercise record.

EXERCISE AND BODY WEIGHT RECORD

DATES:_____ I.D. #:_____

DAY I	Body Weight:_____ Time:	
Type of Exercise	Total Time	Amount
DAY II	Body Weight:_____ Time:	
Type of Exercise	Total Time	Amount
Day III	Body Weight:_____Time:	
Type of Exercise	Total Time	Amount

INSTRUCTIONS
FOR
URINE SAMPLE COLLECTION

Daily urine samples should be taken prior to the body building competition and after the competition. Begin urine sample collection on day one of your next menstrual cycle. If you have inconsistent menstrual cycle lengths, urine samples should be taken for one month or 30 days prior to the competition and then continue for one month or 30 days after the competition. You will be supplied with a sample collection schedule and urine samples tubes, one for each day. On each tube, the day of your menstrual cycle or sample day and the date will be marked. Take the urine sample from the first morning void. Urine samples need to be kept frozen until they are analyzed; therefore, they should be kept in your freezer. The urine samples will be collected from you on a weekly basis.

Remember:

* begin urine sample collection on day one of your next menstrual cycle -or- 30 days before your competition.
* take daily urine samples for one menstrual cycle or one month prior to the competition.
* take urine samples from the first morning void.
* store urine samples in the freezer.
* urine samples will be collected from you each week.
* follow the same procedures after your competition for one month or one menstrual cycle.

If you have any questions, please feel free to ask. You may contact us at the following numbers:

Cynthia Eckstein 703-989-3985

Janet Walberg, Ph.D. 703-961-6355

EXAMPLE DATA COLLECTION SCHEDULE

SUN	MON	TUES	WED	THURS	FRI	SAT
				@ Urine Sample 1		
Begin Record1		End Record1				
						Asses %BF
				Begin Record2		End Record2
				Begin Record3		** End Record3
Begin Record4		End Record4				
				Begin Record5		End Record5
	@ End Urine					

** = Competition Day; @ = 30 days before competition and 30 days after competition for subjects collecting daily urine samples. Specific calendar dates were indicated in the small boxes provided for each subject's sheet.

APPENDIX C

INFORMED CONSENT

HUMAN PERFORMANCE LABORATORY

Division of Health, Physical Education and Recreation
Virginia Polytechnic Institute and State University

INFORMED CONSENT

I, _____, do hereby voluntarily agree and consent to participate in a testing program conducted by the personnel of the Human Performance Laboratory of the Division of Health, Physical Education and Recreation of Virginia Polytechnic Institute and State University.

Title of Study:

DIET AND MENSTRUAL STATUS OF COMPETITIVE FEMALE BODY BUILDERS

The purposes of this experiment include:

To investigate the occurrence of oligo-/amenorrhea in body builders and to identify dietary factors associated with its development.

I voluntarily agree to participate in this testing program. It is my understanding that my participation will include:

A. completing a 60-item questionnaire relevant to menstrual history, training history and diet.
B. having skinfold measurements taken to determine body composition.
C. completing two 3-day diet records prior to a body building competition and two 3-day diet records after a competition which will include two weekdays and one weekend day.
D. completing an exercise record on the same days that the 3-day diet records are completed.
E. collecting daily urine samples from the morning void for one month or one complete menstrual cycle prior to competition and after a competition.

I understand that participation in this experiment may produce certain discomforts and risks. These discomforts and risks include:

- possible discomfort of skin-pinching from the skinfold calipers during the percent body fat assessment.

Certain personal benefits may be expected from participation in this experiment. These include:

A. an estimation of percent body fat and the comparison with age-group norms for the individual.
B. a nutritional analysis which will determine dietary deficiencies for the individual.
C. a comparison of the individual's menstrual status with reports from literature across various sports.
D. an analysis of hormonal patterns and comparison with norms for progesterone and estradiol levels.

Appropriate alternative procedures that might be advantageous to you include:

I understand that any data of a personal nature will be held confidential and will be used for research purposes only. I also understand that these data may only be used when not identifiable with me.

I understand that I may abstain from participation in any part of the experiment or withdraw from the experiment should I feel the activities might be injurious to my health. The experimenter may also terminate my participation should he feel the activities might be injurious to my health.

I understand that it is my personal responsibility to advise the researchers of any preexisting medical problem that may affect my participation or of any medical problems that might arise in the course of this experiment and that no medical

treatment or compensation is available if injury is suffered as a result of this research. A telephone is available which would be used to call the local hospital for emergency service.

I have read the above statements and have had the opportunity to ask questions. I understand that the researchers will, at any time, answer my inquiries concerning the procedures used in this experiment.

Scientific inquiry is indispensable to the advancement of knowledge. Your participation in this experiment provides the investigator the opportunity to conduct meaningful scientific observations designed to make significant educational contribution.

If you would like to receive the results of this investigation, please indicate this choice by marking in the appropriate space provided below. A copy will then be distributed to you as soon as the results are made available by the investigator. Thank you for making this important contribution.

_____ I request a copy of the results of this study.

Date_____ Time_____a.m./p.m.

Participant Signature _____

Witness_____
HPL Personnel

Project Director Dr. Janet L. Walberg Telephone 961-6355

HPER Human Subjects Chairman Dr. Charles Baffi Telephone 961-6561

Dr. Charles Waring, Chairman Institutional Review Board for Research Involving Human Subjects. Telephone 961-5283.

VITA

Cynthia Adair Eckstein was born March 8, 1963 in Roanoke, Virginia. She graduated from Cave Spring High School in Roanoke, Virginia in 1981. She attended Roanoke College for her freshmen year. During this year, she attained All-American status in swimming and was named to the Roanoke College Athletic Hall of Fame. In the fall of 1982, she entered Virginia Polytechnic Institute and State University. She graduated in 1986 with a degree in Exercise Science. As an undergraduate, she worked as an intern for Downtown West Athletic Club in Roanoke as well as the Radford Wellness and Fitness Center. She returned to VPI & SU to pursue a Master's Degree in Exercise Physiology. As a graduate assistant, she taught advanced lifesaving, swimming, physical fitness and aerobic dance classes for the Health and Physical Education Department. The Master's curriculum included work as an exercise leader and ECG technologist for the Cardiac Therapy and Intervention Center and as a Phase II Cardiac Therapy assistant for Radford Memorial Hospital. In the spring of 1989, she was hired by the Roanoke Athletic Club as the Director of Exercise Development.

Cynthia Eckstein Edmunds

Cynthia Eckstein Edmunds