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I am submitting herewith a thesis written by Michelle Ann Long entitled "An Investigation of the Relationship Between Body Fat and Secondary Amenorrhea in Collegiate Athletes." I have examined the final copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Physical Education.

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AN INVESTIGATION OF THE RELATIONSHIP BETWEEN BODY FAT
AND SECONDARY AMENORRHEA IN COLLEGIATE ATHLETES

A Thesis

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Master of Science

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DEDICATED TO

Paul, my husband,
for all his love, support and encouragement

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ABSTRACT

The primary purpose of this study was to investigate the relationship between percentage of body fat and secondary amenorrhea in collegiate athletes. One hundred and five female athletes from five East Tennessee colleges and universities served as subjects for this investigation.

The subjects completed a questionnaire eliciting information on age, menstrual history, characteristics of the menstrual cycle, contraception and training schedule. Height, weight, and three skinfold measurements (triceps, suprailiac, and subscapular) were taken on each subject. Body density was estimated from the triceps and suprailiac skinfolds using the equation developed by Sloan et al. (1962). The percentage of body fat was then estimated from body density using the equation developed by Brozek et al. (1963).

No significant differences were found among the categories of menstrual functioning for either percentage of body fat or body weight ($p > .05$). There were significant differences among categories of menstrual functioning for the work index variable (indicating the subject's total work), when percentage of body fat was controlled ($p < .05$).

This investigation does not support the theory that secondary amenorrhea in collegiate athletes is caused by their low levels of body fat. However, the results point out a need for further research into the relationship between the work index variable and menstrual dysfunction in collegiate athletes.

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CHAPTER I

INTRODUCTION AND REVIEW OF RELATED LITERATURE

Over the past decade the number of women participating in athletics and athletic competition has increased significantly. These women are training and competing at levels which are much more strenuous than in the past (Dale et al., 1979b; Erdelyi, 1976). It has been shown that those athletes participating in sports which require strenuous physical effort and endurance quite frequently experience secondary amenorrhea and oligomenorrhea (Erdelyi, 1962; Erdelyi, 1976).

Secondary amenorrhea is defined as the absence of menses in a previously menstruating woman for more than six months (Wentz et al., 1979). Other researchers (de Prose and Keettel, 1977; Frisch et al., 1980; Pettersson et al., 1973; Yaginuma, 1979) define secondary amenorrhea as a lack of menstrual periods for three months or more in a previously menstruating woman. For the purpose of this study, the definition provided by Wentz et al. (1979) will be used. Oligomenorrhea is defined as menstrual irregularity with menses experienced every two to five months (Wentz et al., 1979).

Although secondary amenorrhea is known to have multiple causes, this study will only be concerned with secondary amenorrhea associated with collegiate athletic training. Specifically, the relationship between percentage of body fat in collegiate athletes and secondary amenorrhea will be investigated.

The following review of literature is divided into three main topics: etiological factors of secondary amenorrhea, body composition and the determination of body fat.

I. ETIOLOGICAL FACTORS

The etiological factors in the disruption of the menstrual cycle are separated into six subject areas: organic dysfunction, psychogenic stress, anorexia nervosa, simple weight loss, drugs, and athletic training.

Organic Dysfunction

Secondary amenorrhea is a symptom which may have multiple causes and is often accompanied by extreme anxiety in the sufferer (Steele, 1978). The most common causes of secondary amenorrhea are pregnancy and hypothalamic-pituitary-ovarian dysfunction. The latter cause may be related strictly to hormonal factors or have a stress component involved. The following problems are found within the category of hypothalamic-pituitary-ovarian dysfunction: hypothalamic amenorrhea, physiologic anovulation, oligoovulation, and amenorrhea following cessation of oral contraceptives (de Prosse and Keettel, 1977; Melnick, 1978). Melnick (1978) also adds adrenal pathology and hyper-hypothyroid conditions to the list of causes of secondary amenorrhea. McDonough (1978), however, categorizes the causes of secondary amenorrhea into a hypogonadotropic group and an androgen excess group.

Psychogenic Stress

Various emotional upsets including the loss of a loved one, career changes, residence changes, and numerous additional psychological and environmental factors (Lein, 1979; Steele, 1978) can halt the menstrual cycle. Secondary amenorrhea which results from emotional stress has been termed psychogenic amenorrhea (Groll, 1978; McDonough, 1978). Groll (1978) believes that gonadotropic function is altered by emotional stress through the action of central nervous system catecholamines.

Lein (1978) offers an explanation of the role that catecholamines play in the hypothalamic endocrine function. He says that at present there is no clear understanding of the mechanisms involved in the relationship between the higher brain centers which control mood and emotion and the hypothalamus. Lein proposes that the hypothalamus may require catecholamines for its proper functioning. The catecholamines could represent an important link between the higher brain centers and the hypothalamus. If the catecholamine input to the hypothalamus were inadequate, then the resulting deficiency of the luteinizing-releasing factor to the anterior pituitary would result in an anovulatory cycle, low ovarian hormone production, and cessation of menses.

Lein (1979) is in agreement with McDonough (1978) that the precise biochemical mechanisms involved in psychic stress and the production of gonadotropins are unknown. McDonough says that within the hypothalamus and limbic system, the same anatomical areas are involved with emotional expression and contain steroid receptors and a few of the enzymes necessary for steroid metabolism.

Acute or chronic emotional stress may produce psychogenic amenorrhea. A disturbance in gonadotropin and prolactin production of either a temporary or prolonged nature may result from a disruption of neuroendocrine function caused by stress (McDonough, 1978).

Yaginuma (1979) classifies secondary amenorrhea associated with stressful stimuli as stress amenorrhea. He proposes that the severity of the amenorrhea has no relationship to the types of stressful stimuli experienced by the individual. Yaginuma believes that the reason for this may be the various mediating factors such as perception which come into play.

Sommer (1978) notes that social and environmental stressors have an effect on the menstrual cycle. She says that catastrophic events such as war and nutritional deprivation frequently result in anovulatory cycles and a halt in the menstrual cycle. Secondary amenorrhea can result from psychological and social factors of a chronic nature including "personality problems, disturbed interpersonal relationships, chronic deprivation, etc." (p. 43).

Anorexia Nervosa

Secondary amenorrhea is a characteristic of people with anorexia nervosa (Beumont et al., 1976; Boyar et al., 1974; McDonough, 1978; Sherman et al., 1975). Anorexia nervosa is usually psychogenic in origin and occurs most often in young women before 25 years of age (McDonough, 1978). In addition to amenorrhea, these anorexic women are characterized by significant weight loss and hyperactivity (Boyar et al., 1974). These young women "have lost at least 25% of their original body weight and exhibit a distorted attitude toward eating

and weight gain that over-rides all hunger. They take pleasure in refusing food and losing weight" (McDonough, 1978, p. 10). These women have a distorted perception of body image in which they visualize themselves as being fat and subsequently subject themselves to totally inadequate food consumption (Steele, 1978).

Most researchers agree that amenorrhea associated with anorexia nervosa results from a limited and reversible disruption of endocrine functioning. Body weight has been shown to be an important determinant in the proper functioning of the hypothalamic pituitary gonadal axis (Beumont et al., 1976; Boyar et al., 1974). The return of an anorexic person's body weight to normal is necessary for the resumption of menses (Beumont, et al., 1976; Boyar et al., 1974). Beumont (1976) believes, however, that other factors, which are at present unidentified, are also involved in the resumption of menses.

Lein (1979) believes that the emotional upset experienced by women with anorexia nervosa is the cause of both the loss of appetite and also the dysfunction of the hypothalamus which leads to a halt in the menstrual cycle. This underlying emotional disturbance in the anorexic person is believed to cause changes in the synthesis of catecholamines which result in a dysfunction of the hypothalamus. If the hypothalamus is not working properly, the menstrual cycle is disrupted.

Frankel and Jenkins (1975) report that controversy still exists as to whether the clinical and biochemical disturbances of anorexia nervosa result from a primary hypothalamic disorder or from changes associated with longstanding malnutrition. They are of the opinion, however, that there is little evidence to suggest a primary hypothalamic

disorder. Through refeeding of their subjects, Frankel and Jenkins have shown that endocrine disturbances are secondary to malnutrition. Warren and Vande Wiele (1973) and Frankel and Jenkins (1975) agree that weight loss in anorexia nervosa precedes physiological disturbances.

Simple Weight Loss

Although secondary amenorrhea has long been associated with anorexia nervosa, only recently has weight loss resulting from voluntary dieting been suggested as a possible cause for cessation of the menstrual cycle (Graham et al., 1979; Lev-Ran, 1974; Vigersky et al., 1977; Wentz, 1980). These individuals with simple weight loss have similar endocrine patterns to women with anorexia nervosa, but they do not have the psychiatric abnormalities associated with anorexia nervosa (Graham et al., 1979).

Individuals with secondary amenorrhea associated with simple weight loss have "direct and indirect hypothalamic dysfunction while pituitary and end-organ function is normal" (Vigersky et al., 1977, p. 1145). This view is in agreement with Warren and co-workers (1975) who believe that the primary defect in amenorrheic women with simple weight loss is probably found in the hypothalamus. However, they also state that the "basal pituitary gonadotropic function is undoubtedly affected" (p. 608).

On the other hand, Fries (1974) has a different idea about the etiology of secondary amenorrhea. He concludes that neither psychological factors nor weight loss are sufficient to explain the cause of amenorrhea; it is suggested that some other factor is intervening. Fries describes this factor as a "predisposing

diencephalohypothalamic vulnerability, rendering some women more susceptible to non-specific stimuli such as emotional stress and/or weight loss" (p. 39). He believes that such a hypothetical factor could be reflected in frequent menstrual irregularities and possibly, in the high incidence of EEG abnormalities seen in these women.

Drugs

Secondary amenorrhea can also be induced by certain drugs (Lein, 1979; McDonough, 1978). "Phenothiazine derivatives, reserpine, and ganglion-blocking agents affect the hypothalamus and produce amenorrhea which is sometimes associated with galactorrhea" (McDonough, 1978, p. 9). Galactorrhea is defined as the "persistent secretion of milk irrespective of nursing" (Dorland's Illustrated Medical Dictionary, 1974, p. 626). The effects of these drugs are usually reversible once medication has stopped. "Other drugs such as alcohol, digitalis preparations, cytotoxic drugs, and certain antibiotics may produce amenorrhea through their anorectic effect" (McDonough, 1978, p. 9).

Another category of drug-related amenorrhea includes the oversuppression syndrome which results from using oral or parenteral synthetic steroids. However, "post-pill amenorrhea" occurs in less than 1% of women who discontinue oral contraceptives (McDonough, 1978; Steele, 1978).

Athletic Amenorrhea

A number of investigations have been conducted which examine the effect of training on the menstrual cycle. Erdelyi (1962, 1976) believes that athletic training and competition can disturb the menstrual cycle. In a review of his previous investigations with

Hungarian female athletes (1962, 1976), Erdelyi reports that amenorrhea and oligomenorrhea occur more frequently in athletes who participate in those sports that require strenuous physical effort and endurance, including tennis, rowing and skiing. Further, he reports that the menstrual irregularity experienced by rowers during the rowing season disappeared during off-season. Sports participation has been found to have both positive and negative effects on the menstrual cycle. Erdelyi (1976) noted that unfavorable changes in the menstrual cycle related to sports participation occur in not more than 10% to 12% of women. Unfavorable changes were experienced by 9.3% of the athletes, favorable changes in 5.6%, and 85.1% had no change. Erdelyi states that excessive sports activity could result in "any type of menstrual disorder - polymenorrhea, menorrhagia, scanty menstrual bleeding, oligomenorrhea, amenorrhea, completely irregular periods, dysmenorrhea, or a combination of these" (p. 80). The only favorable change noted by Erdelyi was the positive effect on dysmenorrhea. Erdelyi reports that an investigation by Stammer showed unfavorable changes in the menstrual cycle in 8.1% of the athletes, favorable changes in 21.4%, and no change in 70.5%. An additional investigation of Finnish sportswomen conducted by Ingman and reported by Erdelyi found that 16.8% of the women experienced unfavorable changes, 14% experienced positive changes, and 69.2% had no change. Erdelyi also reports that Rougier and Linquette found no consistent effect of exercise on the menstrual cycle.

Erdelyi (1962, 1976) observed that the greatest number of menstrual disorders which were associated with an excess of physical

activity were found in the athletes between 15 and 17 years of age. Unfavorable changes in the menstrual cycle were noted by 18% of this group while only 7.4% of the adult group, 18 years and older, showed unfavorable changes.

Dale and co-workers (1979a) studied 48 women ranging in age from 16 to 43 years. The women were categorized into four groups:

1) marathoners - included women who within the previous 12 months had completed a marathon in less than four hours and one minute, 2) distance runners - included subjects who appeared capable of finishing a marathon as evidenced by their five to 30 km training, but who had not done so at the time of this study, 3) athlete controls - included women who participated in activities other than distance running; some of them ran up to 20 miles a week as part of their training, and were also active in college athletics, yoga, or other physical activities and, 4) sedentary controls - included women who were randomly selected from a population that was similar in age, height, education, and occupation to the previous groups described, differing only by their nonparticipation in formal physical activity.

Each of the women completed a questionnaire designed by Dale and co-workers to obtain personal data, menstrual and reproductive history, contraceptive use, and training schedules. Various tests which included determination of cardiac performance, blood chemistry analyses, measurement of the serum levels of pituitary and ovarian hormones, and determination of the percentage of body fat were administered.

Although the four groups were similar in age and height, these researchers found a significant difference ($p < .05$) in percentage

of body fat and weight between the runners and the sedentary controls. The researchers believe that the differences in weight resulted from endurance training. Significant differences ($p < .05$) were also seen between the runners and sedentary controls in menstrual patterns. The women who participated in endurance training had a significantly lower number of menstrual periods per year as compared to the athlete controls and sedentary controls. These findings are similar to another study done by Dale et al. (1979b). No marked differences in contraceptive use existed among the four groups. It was also found that the endurance training groups and the athlete controls visited physicians for menstrual problems significantly ($p < .05$) more often than the sedentary controls. The conclusions from this study were consistent with the ones from the larger study conducted by Dale and co-workers (1979b).

Dale et al. (1979b) were involved in another study examining menstrual dysfunction. They studied 168 women between the ages of 18 and 45. These women were divided into three groups which consisted of: runners (those who run in excess of 30 miles per week, combining slow distance with speed work), joggers (those who jog between 5-30 miles per week at a slow pace), and a control group. Each participant in the study completed a questionnaire to obtain personal data, training data, body weight changes, menstrual and contraceptive histories. In addition, subsets within the study were evaluated for serum levels of gonadotropins and ovarian hormones, and percentage of body fat.

Significant differences were found among the groups. Although the running and control groups were almost identical in average

height, significant differences existed in body weight and percentage of body fat. Examination of menstrual cycle data revealed that the athletes who had the most intensive training schedules and those who had been training for the longest time period appeared to have the longest cycle between periods. In addition, an inverse relationship existed between prior ~~gravity~~ and the incidence of exercise-induced oligo/amenorrhea. Twenty-one percent of runners with previous pregnancies developed oligo/amenorrhea, whereas 51% of the nulliparous runners were oligo/amenorrheic. Only 4% of the control group had patterns of oligo/amenorrhea and none of these women had been pregnant. Contraceptive use was similar for all three groups, so post-pill amenorrhea most likely did not account for the increased amenorrhea among the runners.

The authors state that it would be too naive to say that the stress resulting from exercise and competition causes the differences in menstrual patterns among the three groups. However, stress is caused by exercise and competition and the response to this physical and psychological stress may be reflected in numerous ways. The response can be seen in body weight changes, percentage of body fat changes, slight fluctuations in body-core temperature, hormone secretion changes, and emotional state changes which can all have an effect on the hypothalamic function, resulting in disruptions of the menstrual pattern.

Dale and co-workers concluded from their study that long-distance runners experience menstrual dysfunction. Although the evidence is not fully substantiated, it appears that the degree and incidence of menstrual dysfunction is directly proportional to the severity of

physical exercise, measured by miles run per week. They believe that each woman probably has her own oligo/amenorrheic threshold which is correlated to the amount and intensity of competitive events, training, weight loss, percentage of body fat, and other unknown factors. These authors state as a tentative conclusion that this menstrual dysfunction is reversible and responsive to therapeutic measures indicated by the pituitary gonadotropin levels falling in the low-normal range and minimal ovarian hormone production. The therapeutic measures can include cessation of training, weight gain, or medication. Several oligomenorrheic runners had reported to the authors that their menses had resumed when injury or other reasons had forced a reduction in training. These observations are consistent with those of Erdelyi (1962, 1976) who noticed that rowers' menses returned in off-season. Dale et al. (1979b) state that it is unknown whether the increase in body fat or the decrease in training is responsible for the return of menses.

Feicht et al. (1978) also studied secondary amenorrhea in athletes. Secondary amenorrhea was defined by these researchers as the occurrence of three or fewer menstrual periods in one year. These researchers investigated the relationship of training intensity to frequency of amenorrhea by sending questionnaires to 400 women on 15 teams; 128 responses were used for analyses.

A positive correlation between the frequency of amenorrhea and the mileage per week was noted. The frequency of amenorrhea ranged from 6% in the women with the least mileage to 43% in the women who ran the most. Feicht and co-workers also found that the performance on middle distance events (800-5000m) was significantly better

($p < .05$) in the amenorrheic women as compared with regular menstruating women. In addition, the researchers found that the amenorrheic athletes had a significantly later age of menarche than the athletes with regular cycles ($p < .05$). The only other significant difference noted between the two groups was in the number of months that the athletes trained intensely ($p < .05$). The amenorrheic athletes trained intensely for an additional month each year.

These researchers concluded that the low body weight of these athletes was not associated with secondary amenorrhea because there was no significant difference between the two groups for height and weight. Stress, resulting from intensive training and competition, was offered as a possible explanation for the cause of amenorrhea. They support their hypothesis from the reports of amenorrheic athletes who felt that they participated in training for a greater percentage of the year than the athletes with regular cycles.

The researchers state that amenorrhea could be caused by the additional stress of the more intensive training which could also lead to better performance. They proposed that the better endurance performance in the amenorrheic athletes could possibly result from a higher hematocrit from the prolonged amenorrhea.

McArthur et al. (1980) studied three amenorrheic, middle distance runners of normal body weight to determine common characteristics and to hypothesize as to the cause of the secondary amenorrhea. Organic disease was ruled out in these athletes. Regularly menstruating women who occasionally participated in

physical activity, but not in formal training, served as controls.

The researchers compared the runners using three estimations of body composition. One of the body composition estimations used Sargent's (1963) standard of weight for height. The second estimation used height and weight to predict total body water and lean body weight. The third estimation used four skinfold measures to predict body density from which percentage of body fat was then estimated. A gonadotropin releasing hormone (GnRH) test and a plasma estradiol concentration test were administered and, in addition, serial measurements of serum luteinizing hormone (LH) and follicle stimulating hormone (FSH) concentrations were taken.

The researchers found that the runners did not differ from the controls in terms of the physical characteristics of estimated body fat or relative weight for height. For the GnRH test, the researchers found that the athletes had a variable LH response. However, their FSH response was more consistent. The gonadotropic hormones were shown to be biologically active because of the increase of estradiol concentrations over baseline values after the GnRH test. As a result of the serial measurement tests, it was found that the athletes had a reduced LH concentration as compared to the controls, but the FSH concentration was not significantly different. In other words, there was an impairment of LH release into the circulation.

The authors suggest that other factors besides body weight or relative fat are responsible for secondary amenorrhea because the athletes were of normal body composition. McArthur et al.

found neither an extensive depletion of fat stores, nor any indication that any of the athletes were below the minimum level of weight and relative fat which has been proposed by Frisch and McArthur (1974) as necessary for the restoration and maintenance of the menstrual cycle. McArthur et al. observed that the athletes did not differ significantly from the controls on body composition measurements. They state, however, that their observation should be viewed with caution since the equations they used are known to be population specific.

These researchers concluded that body composition did not affect the "athletic amenorrhea" seen in their study, but rather was the result of an impairment in the hypothalamic control of the release of the gonadotropins. They state that the way in which the stress and energy expenditure of running alter the hypothalamic control of LH release is unknown.

Wilmore (1977) stated that amenorrhea reported by female athletes who train with long-distance running may be related to their extremely low body weight and also low levels of body fat. He noted that it is common for these athletes to run 70 to 100 miles per week and, consequently, their percentage of body fat is reduced to 10% or less. When the training intensity is reduced, these athletes usually experience a resumption of menses.

Bloomberg (1977) reported an informal study by Foreman which found that menstrual disturbances in athletes occurred only in long-distance runners and cross-country skiers. Foreman believed that the intensive training of these athletes was somehow related

to their menstrual dysfunction. In light of these findings, Foreman conducted a formal study at the National AAU women's cross-country championships in 1971 and 1973. A questionnaire concerning their menstrual periods was completed by most of the top runners. Foreman found that of the 47 runners surveyed, 27 (57%) were "regulars," 9 (19%) were "irregulars," and 11 (23%) were "very irregulars." The "very irregular" group had no more than two periods per year. The "irregulars" were found to have a much higher average weekly mileage than the "regulars". Foreman also found that regular menstrual cycles returned after a reduction in training time.

Ryan (1975) reported that Prokop, Ingmann, Iwato and Nemoto, and Bausenwein all showed a higher percentage of menstrual disturbances in women who began intensive athletic training before menarche than those who began their training after menarche.

Zhanell (1971) investigated women fencers by means of a questionnaire. Of the investigated fencers, 13% reported moderate menstrual disturbances, where 87% reported no change.

Frisch et al. (1980) distributed questionnaires to 89 ballet dancers to investigate the high incidence of menstrual dysfunction within this group. Each girl was measured for height and weight in order to estimate relative fatness. Total body water, expressed as a percent of body weight, was used as the indicator of relative fatness and was estimated from height and weight measurements. Frisch et al. note that in general, as the amount of body water increases, the amount of body fat decreases.

Secondary amenorrhea was reported in 15% of the dancers, irregular cycles in 30%, and regular cycles in 33%. The researchers also state that the age of menarche was significantly later for the dancers than for the general population. In addition, the ballet dancers with secondary amenorrhea and irregular cycles had a significantly higher lean to fat ratio than the dancers with regular cycles. The dancers with amenorrhea or irregular cycles were "below the critical weight for height necessary for menarche or the maintenance of regular cycles in well-nourished women with average activity" as indicated by "their average total body water as percent of body weight" (p. 18). These dancers' weight for height were also below the value for "underweight" established by Sargent (1963) for young women. All but one of the dancers with regular cycles were above the threshold of minimum weight for height, even though they "were in the very low range of weight for height and relative fatness for their age" (Frisch et al., 1980, p. 18). These researchers also noted that two of the dancers had a normal degree of fatness to maintain the menstrual cycle, yet these dancers had irregular cycles. They believe that this phenomenon indicates that weight is critical, but that by itself, is not sufficient for menses to occur; the effect of weight can be overpowered by emotional or physical stress.

Frisch et al. concluded that their findings suggest that the "hard training and low intake" of the dancers contribute strongly to the occurrence of irregular cycles and secondary amenorrhea.

The occurrence of menarche after an injury preventing dancing supports the hypothesis that a change in fat/lean ratio and the accompanying changes in metabolic and hormonal levels characteristic of hard physical exercise may be involved in the delay of menarche and menstrual disturbances in these ballet dancers. (p. 18)

Zaharieva (1965) surveyed 66 sportswomen from 10 different countries at the Tokyo Olympics. The athletes were participating in track and field, gymnastics, swimming, and volleyball. The average age for these athletes was 25; the range was from 16 to 33 years. Swimmers constituted the majority of athletes under 20. These athletes, as a group, had active sports careers averaging from six to eight years. Ninety-two percent of the athletes had regular menstrual cycles. Four girls under 16 had irregular cycles and one 19 year-old girl had no menstrual cycle.

X Hendrix and Lohman (1981) conducted a study to determine the incidence of menstrual disorders in women participating in intercollegiate athletics and to relate this incidence to percentage of body fat in the athletes. The subjects for the study were 62 athletes who were active on a university's gymnastics, swimming, diving, basketball, track and field, cross-country, golf, and tennis teams. Measurements of height, weight, and seven skinfolds were taken from each subject before training began and also at the peak of the season. A regression equation was derived from a subset of 34 athletes to enable the experimenters to estimate body fat from two skinfolds. As a group, the mean percentage of body fat was 22.7% prior to training, ranging from 15.9 to 32.2%; the mean weight was 59.6kg prior to training. At peak season, the mean percentage body

fat was 20.4%, ranging from 15.2 to 31.2%, and the mean weight was 59.9kg. Eighty-four percent of the athletes reported normal menstrual cycles, whereas secondary amenorrhea or menstrual irregularity was reported by 14.5% or nine athletes.

The researchers noted that the athletes who reported menstrual irregularity did not have a significant weight loss over the season, nor were they dissimilar from the normal cycle athletes in terms of the reduction in the percentage of body fat or the level of body fat. Hendrix and Lohman concluded, therefore, that the findings of their study were not supportive of the proposed relationship between menstrual disorders and body fat for a population of athletes whose percentage of body fat is greater than 15%.

Snyder et al. (1981) also looked at body fat in relation to amenorrhea. They studied 88 intercollegiate athletes at Purdue in order to determine if these athletes were amenorrheic when their percentage of body fat fell below 22% body fat, the critical value which has been traditionally accepted in the sedentary population. Each of the athletes completed a questionnaire regarding menstrual history and the athletes were then classified into three groups: 1) amenorrheic with training, 2) infrequent menstrual periods with training, or 3) menstrual cycles 22-40 days long. The researchers then estimated the percentage of body fat for the athletes by two methods: 1) the skinfold method proposed by Sloan et al. (1962) and 2) the regression equation of Mellits and Cheek (1970), which was used to establish the 22% critical level by means of height and weight measurements.

The researchers found that the estimation of body fat through the use of skinfolds was less than that determined through height and weight measurements. In addition, they found that there was no difference among the three groups in the percentage of body fat when the height and weight method was used. Snyder et al. noted that when the skinfold method was used, the amenorrheic with training group had significantly less ($p < .05$) fat than the other two groups.

The researchers concluded that in the college athletes that they studied, the traditionally accepted criterion of 22% body fat was not associated with amenorrhea. They further noted that the role body fat plays in menstrual rhythmicity is still undefined.

Carlberg et al. (1981) examined the relationship of low body weight to athletic oligo/amenorrhea. They reported that in a sample of 252 athletes, 12% were oligo/amenorrheic, whereas only 3% of a control group of 426 non-athletes were oligo/amenorrheic. Through the use of the questionnaire, the researchers found that low body weight was common to the majority of athletes reporting oligo/amenorrhea, but not to nonathletic women reporting oligo/amenorrhea. A significant difference ($p < .005$) was noted between the weights of the oligo/amenorrhea athletes and regularly menstruating athletes. However, there was no significant difference between the weights of oligo/amenorrheic nonathletes and regularly menstruating nonathletes. The researchers noticed an increased vulnerability to exercise-related menstrual dysfunction in underweight women as compared with overweight women. Oligo/amenorrhea was reported

by 27% of underweight athletes as compared to 2% of underweight control women. In addition, 11% of normal weight athletes were oligo/amenorrheic, contrasted with 2% of normal weight women in the control group. Both of the previous two findings were significant ($p \leq .0001$). In overweight women, oligo/amenorrhea was present in 5% of the athletes and the controls.

Carlberg et al. found that a more severe form of menstrual dysfunction was noted in athletes with a lower body weight when compared with heavier athletes, although no definition was given for menstrual dysfunction. All of the athletes weighing over 55 kilograms and reporting oligo/amenorrhea had menstruated a few times each year, or had experienced amenorrhea only during their competitive season. On the other hand, most of the athletes who weighed less than 55 kilograms and were oligo/amenorrheic had not had a menstrual period in one to six years. The researchers also found that in the distance runners which were examined, body weight and mileage per week were correlated with menstrual functioning. All the runners who reported oligo/amenorrhea were below 100% of their ideal body weight. In addition, all women who ran more than 55 miles per week and who weighed below 100% of their ideal body weight reported amenorrhea. Carlberg et al. concluded that athletes with a low body weight have an increased susceptibility to menstrual dysfunction.

Warren (1980) studied 15 ballet dancers between the ages of 12 and 15 with a high activity level. Body water was estimated for each of the dancers through height and weight measurements using the

equation of Mellits and Cheek (1970). Body fat was then estimated from body water.

The ballet dancers had a significantly ($p < .001$) later age of menarche than both the age-matched control group and the mean menarcheal age for American girls. In addition, the dancers had a slightly lower ($p < .05$) body weight and estimated body fat than the controls.

A correlation was found in 10 of the 15 dancers between a decrease in exercise and/or forced rest of at least two months resulting from injury and the onset of menarche and pubertal progression. Weight gain was minimal or nonexistent during the rest period and no significant change in body composition was noted.

During the time period that Warren studied the ballet dancers, 13 of the subjects reached menarche, and subsequently, 11 of the subjects developed amenorrhea. Menarche had occurred in these dancers during a period of rest and when exercise was resumed, menses ceased. Warren noted no change in either body weight or percentage of body fat during this time period. Warren also found that activity increased the incidence of amenorrhea, with the effect being the most noticeable in the dancers with the lower estimated percentages of body fat.

Warren concluded that "an energy drain may have an important modulatory effect on the hypothalamic pituitary set point at puberty and, in combination with low body fat, may prolong the prepubertal state and induce amenorrhea" (p. 1156).

Fishman (1980) commented on the relationship of body weight and composition to secondary amenorrhea and delayed puberty. Fishman

offered an explanation for Warren's (1980) findings that when amenorrheic ballet dancers cease training due to illness or injury for at least two months, menses returned although no observable changes were detected in body weight or composition. He stated that unmeasurable somatic changes could have occurred which might result in a return of menses, but a more probable explanation is that the primary and secondary amenorrhea noted in these ballet dancers is caused by a combination of energy output and body changes. Fishman noted that although controversy still exists as to the function of body weight and composition in the initiation of puberty and the maintenance of menses, strong support for their importance has been added with the findings of the ballet dancers.

Frisch and McArthur (1974) have hypothesized that the onset and maintenance of normal menstrual cycles are dependent on the maintenance of a body weight for a particular height, which apparently represents a critical fat storage. The minimum body weight for a particular height necessary for normal menstrual functioning corresponds to about 22% fat of body weight. This theory suggests that a particular body composition may be essential for reproductive ability in women.

Frisch (1980) has also pointed out that a "loss of body weight in the range of 10 to 15% of normal weight for height, which represents a loss of about one-third of body fat, results in amenorrhea" (p. 2395). She also states that amenorrhea can result from an excess of body fat. It appears, then, that reproductive functioning can be impaired by too little or too much fat.

Frisch and McArthur (1974) state that the onset and maintenance of menses are affected by other factors including emotional stress. So, a halt to a woman's menstrual cycle can occur without weight loss, and resumption of menses may not occur even though a woman has attained the necessary minimum weight.

Menarcheal age and menstrual periodicity were examined in relation to the age of onset of training in a sample of 21 college swimmers and 17 runners by Frisch et al. (1981). These researchers found that the mean menarcheal age was later for the 18 premenarche-trained athletes than for the 20 postmenarche-trained athletes. The mean menarcheal age for the postmenarche-trained athletes was similar to that of the college age control group. In addition, these researchers found that 61% of the premenarche-trained athletes reported irregular menstrual cycles, 22% reported amenorrhea, and 17% reported regular cycles. In contrast, 60% of the postmenarche-trained athletes reported regular cycles, 40% reported irregular cycles, and no athlete reported amenorrhea. Frisch and co-workers found that the incidence of oligomenorrhea and amenorrhea was increased by training in both the premenarche- and postmenarche-trained athletes.

These researchers suggest that the menstrual dysfunction of the athletes may be explained by an increased lean/fat ratio. These athletes may have had too little fat in proportion to their lean body mass. This theory of a critical fat storage was discussed previously (Frisch and McArthur, 1974). Hormonal and metabolic changes which affect the menstrual cycle occur as the result of the increased

lean/fat ratio. They conclude that athletic training is a possible cause of menstrual disturbances, especially if the training was begun prior to menarche.

Summary

Multiple causes exist for secondary amenorrhea. The etiological factors associated with the disruption of the menstrual cycle are classified into six areas: organic dysfunction, psychogenic stress, anorexia nervosa, simple weight loss, drugs, and athletic training.

Organic dysfunction includes such problems as hypothalamic dysfunction (de Prosse and Keettel, 1977; Melnick, 1978), adrenal pathology, hyper-hypothyroid conditions (Melnick, 1978), hypogonadotropic state, and an excess of androgens (McDonough, 1978).

The menstrual cycle can be halted by various emotional upsets including the death of a loved one, career and residence changes, and numerous additional psychological and environmental factors (Lein, 1979; Steele, 1978). Groll (1978) hypothesizes that gonadotropic function is altered by emotional stress through the action of central nervous system catecholamines. Psychogenic amenorrhea may result from either acute or chronic emotional stress (McDonough, 1978).

Anorexia nervosa is a condition which is usually psychogenic in origin and occurs most often in young women before 25 years of age (McDonough, 1978). These women "have lost at least 25% of their original body weight and exhibit a distorted attitude toward eating and weight gain that over-rides all hunger" (McDonough, 1978, p. 10). Most researchers agree that amenorrhea associated with anorexia nervosa

results from a limited and reversible disruption of endocrine functioning. Body weight has been shown to be an important determinant in the proper functioning of the hypothalamic pituitary gonadal axis (Beumont et al., 1976; Boyar et al., 1974).

The endocrine patterns of women with simple weight loss are similar to those of women with anorexia nervosa, but these women do not have the psychiatric abnormalities associated with anorexia nervosa (Graham et al., 1979). There appears to be agreement that the primary defect in these amenorrheic women with simple weight loss is found in the hypothalamus (Vigersky et al., 1977; Warren et al., 1975).

Certain drugs can induce amenorrhea (Lein, 1979; McDonough, 1978). Such drugs include phenothiazine derivatives, reserpine, ganglion-blocking agents, alcohol, digitalis preparations, cytotoxic drugs, certain antibiotics, and oral or parenteral synthetic steroids (McDonough, 1978).

There are numerous views among researchers as to the causes of secondary amenorrhea in athletes. One cause frequently encountered in the literature is percentage of body fat. Controversy exists in the literature as to the role of body fat in secondary amenorrhea in athletes. In the literature reviewed, the majority of the research studies indicate that a relationship exists between body fat and menstrual disorders (Frisch, 1980; Frisch and McArthur, 1974; Frisch et al., 1980; Wilmore, 1977). Controversy also exists as to whether body weight in athletes is associated with secondary amenorrhea (Carlberg et al., 1981; Feicht et al., 1978).

Several researchers (Carlberg et al., 1981; Dale et al., 1979b; Feicht et al., 1978) noted that the incidence of amenorrhea was positively correlated with mileage per week. One group of researchers (Feicht et al., 1978) believes that the stress resulting from intensive training and competition is the cause of amenorrhea. Other researchers (Dale et al., 1979b), however, state that a combination of factors causes secondary amenorrhea including amount and intensity of competitive events, training, weight loss, percentage of body fat, and other unknown factors. Another opinion (Frisch et al., 1981; Ryan, 1975) held is that whether a woman started training prior to menarche or not has an impact on menstrual functioning. These researchers found a greater percentage of menstrual disturbances reported in women who began training prior to menarche. Another view (McArthur et al., 1980) of the cause of amenorrhea in athletes is that an impairment exists in the hypothalamic control of the release of the gonadotropins.

II. BODY COMPOSITION

The body has been divided into the basic components of fat, water, protein and mineral; these components can be grouped more generally into fat, muscle, and bone (Malina, 1969b). It would seem obvious that women athletes, as well as nonathletic women, would vary in the relative proportions of these three components.

Parizkova (1977) stated that, "Body composition, i.e., the relative and absolute amount of lean body mass (LBM) and depot fat is one of the most variable morphological characteristics of the organism" (p. 240). The changes in body composition primarily result from physical activity and nutrition. Exercise has been shown to have a modifying influence on the ratio of lean body mass to fat (Wells et al., 1962 a, b, c; Wells et al., 1963). The nature, intensity, and amount of the physical activity engaged in by individuals with adequate nutrition has an influence on body composition (Jokl, 1962). The greater proportion of lean body mass to fat which results from physical activity has been shown to be a nonpermanent characteristic through longitudinal studies of athletes. A dynamic relationship has been shown between body composition and training intensity and efficiency (Thompson et al., 1956; Thompson, 1959).

During training it has been shown that body composition changes occur without significant changes in body weight. The amount of lean body mass increases while the amount of fat decreases. On the other hand, when training ceases, an increase in body weight is noted

which results from increased fat deposition. Body density falls which is indicative that lean body mass decreases and fat content increases (Parizkova and Poupa, 1963). As would seem obvious, researchers have shown that women engaged in sports have different relative proportions of muscle and fat than women not active in sports (Malina et al., 1971; Sinning and Linberg, 1972).

Various estimates of the percentage of body fat for college age females have been provided in the literature: 21.5% (Katch and Michael, 1968), 23.4% (Malina et al., 1971), 25.2% (Conger and Macnab, 1967), 25.7% (Wilmore and Behnke, 1970), 22-26% (Wilmore, 1977), 26.4% (Weltman and Katch, 1975), and 28.7% (Young et al., 1962).

Estimations of the percentage of body fat vary among athletes participating in different sports. Conger and Macnab (1967) found that gymnasts averaged 23.3% relative fat which was lower than the percentages noted for the other three sports teams (swimming, basketball, and volleyball) which were investigated. An even lower percentage of body fat for gymnasts (15.5%) was reported by Sinning and Linberg (1972). The lowest percentage of body fat reported in the literature for female gymnasts was 11.8% (using the Siri equation) noted by Parizkova and Poupa (1963).

Sinning (1973) found an average of 20.8% relative fat in his sample of female basketball players, whereas Conger and Macnab reported a mean of 26.9%. Wilmore (1977) reported that he found, in an unpublished study, swimmers to average 29.6% relative fat. Conger and Macnab (1967) reported an average of 26.3% relative fat for swimmers. Parizkova (1968) stated that Grimm has proposed that

swimmers have a greater percentage of subcutaneous fat as a result of an adaptation response to extended periods of time in cold water. Katch et al. (1973) found that the mean percentage of body fat for a group of unidentified varisty athletes was 20.6%. Conger and Macnab (1967) found an average of 25.3% relative fat for volleyball players. All of the previous studies cited used college age females as subjects in their studies.

Women involved in track and field competition have varying percentages of body fat depending upon the event of specialization. Malina et al. (1971) have reported findings of 19.1%, 19.4%, and 20.7% for distance runners, sprinters, and jumpers, respectively.

Wilmore and Brown (1974) found a mean value of 15.2% relative body fat in a sample of highly trained long distance runners. This value is almost identical to the average value reported college age men. Three of the subjects in their sample had percentages of body fat which fell within the range of average values reported for male distance runners. The three percentages were 5.9%, 6.1%, and 9.0%.

Wilmore (1977) reported that values for percentage of body fat are highly variable for track and field athletes as a group. However, female distance runners have lower percentages of body fat than women competing in field events. Twelve women out of 68 which were evaluated had values under 10% and 32 had values below 15%. Two of the athletes had relative body fat values of approximately 6%. Wilmore stated that although the low percentages of body fat in these runners may be largely accounted for by their genetic inheritance, the high-intensity

endurance training of the athletes also plays a significant role.

A comparison of the percentages of body fat among women participating in different sports is difficult because different techniques and equations were used to estimate percentage of body fat. Various equations for estimating lean body weight, percentage of body fat, or body density for college age women have been reported (Behnke, 1963; Katch and McArdle, 1973; Katch and Michael, 1968; Sloan et al., 1962; Weltman and Katch, 1975; Wilmore and Behnke, 1970; and Young et al., 1962).

Maximum predictive accuracy for percentage of body fat depends upon the use of equations only on samples which are similar to the original sample which was used to derive the equations (Katch and McArdle, 1973; Wilmore and Behnke, 1970).

III. THE DETERMINATION OF BODY FAT

Various methods have been employed to estimate the percentage of body fat and lean body weight. A precise estimation of body fat and lean body weight can be accomplished through the laboratory methods of hydrostatic weighing, helium dilution, radiography, total body potassium, and total body water. Hydrostatic weighing is probably the most frequently used method.

These laboratory methods, however, require elaborate equipment and complicated laboratory procedures, as well as time and expense. Body fat and lean body weight have also been estimated from anthropometric body measurements including skinfolds, circumferences, and diameters (Behnke and Wilmore, 1974; Wilmore and Behnke, 1970). The measurement of skinfolds is the second best index for estimating

the percentage of body fat, falling below the determination of body density through underwater weighing (Brozek and Keyes, 1951).

Special calipers designed to exert a constant pressure throughout their range of motion are used to assess the subcutaneous body fat. These calipers are measuring the subcutaneous tissue, as well as the thickness of a double layer of skin. Only a slight difference is noted in skin thickness among individuals; therefore, the difference in measurements is an indirect estimate of the amount of subcutaneous fat (Behnke and Wilmore, 1974).

Determining the precise location of the skinfold site is a necessity, as well as maintaining a constant distance between the pinched skinfold (using the thumb and index finger) and the caliper (Behnke and Wilmore, 1974). The use of skinfold calipers is generally regarded as a valid and reasonably precise means to estimate the percentage of body fat since a large percentage of an individual's body fat is located within the subcutaneous tissue (Malina, 1969a).

CHAPTER II

METHODS

I. SELECTION OF SUBJECTS

The subjects for this investigation were 105 female athletes enrolled in the following East Tennessee colleges and universities: the University of Tennessee of Knoxville, Carson-Newman College, Walters State Community College, East Tennessee State University, and Maryville College. The coaches and/or athletic trainers from the colleges and universities listed above were contacted to explain this study and to elicit help in the scheduling of athletes for testing. Each subject's participation in this study was voluntary. The subjects ranged in age from 18 to 23 and participated in one of the following sports events: basketball, cross-country, gymnastics, softball, swimming, tennis, track and field, and volleyball. (See Tables 1 through 5 for physical characteristics of the subjects.)

II. PROCEDURES AND TECHNIQUES OF MEASUREMENT

Questionnaire

All study participants completed a questionnaire designed to obtain information on age, menstrual history, characteristics of the menstrual cycle, contraception, and training schedule (see Appendix A). The questionnaires were distributed to each group at the time of testing and were collected at the end of the testing session. The questionnaire was developed by the experimenter following a review of similar research using questionnaires to gather information (Dale et al., 1979a; Dale et al., 1979b).

TABLE 1. PHYSICAL CHARACTERISTICS--ALL SUBJECTS

	<u>HT</u>	<u>WT</u>	<u>WT/HT</u> <u>RATIO</u>	<u>% FAT</u>	<u>AGE</u>	<u>AGE AT MENARCHE</u>	<u>WORK INDEX</u> ^a
$\bar{X}$	66.34"	138.26 lbs.	2.08	17.87	19.6 years	13.3 years	12.53
S.D.	(+3.21)	(+19.74)	(+.25)	(+2.24)	(+1.12)	(+1.37)	(+1.95)
Range	(57.5-76)	(89.25-184)	(1.55-2.64)	(13.7-23.5)	(18-23)	(11-18)	(7-16)
	N=105	N=105	N=105	N=105	N=105	N=102	N=103

^a Work Index is the sum of the number of days in training per week + hours per day spent in training + intensity of workout

TABLE 2. PHYSICAL CHARACTERISTICS--FOUR CATEGORIES OF MENSTRUAL FUNCTIONING

CATEGORY	HT	WT	WT/HT RATIO	% FAT	AGE	AGE AT MENARCHE
1 - Regular						
$\bar{X}$	66.32"	140.16 lbs.	2.11	18.10	19.6 yrs.	13.2 yrs.
S.D.	(+3.38)	(+20.27)	(+.25)	(+2.31)	(+1.07)	(+1.16)
Range	(57.5-73.5)	(89.25-181.0)	(1.55-2.64)	(13.7-23.5)	(18-22)	(11-16)
	N=79	N=79	N=79	N=79	N=79	N=76
2 - Irregular						
$\bar{X}$	66.15"	133.31 lbs.	2.01	17.36	19.8 yrs.	13.2 yrs.
S.D.	(+1.85)	(+13.88)	(+.19)	(+2.00)	(+1.30)	(+1.52)
Range	(63-69.75)	(106.0-164.75)	(1.67-2.45)	(15.3-21.5)	(18-23)	(11-16)
	N=13	N=13	N=13	N=13	N=13	N=13
3 - Highly Irregular						
$\bar{X}$	65.68"	130.75 lbs.	-----	16.86	19.2 yrs.	14.3 yrs.
S.D.	(+1.96)	(+12.03)	-----	(+1.64)	(+1.32)	(+1.95)
Range	(63.25-69.25)	(103.5-144.25)	-----	(14.1-19.4)	(18-22)	(12-18)
	N=10	N=10	-----	N=10	N=3	N=10
4 - Amenorrheic						
$\bar{X}$	69.83"	134.67 lbs.	-----	17.2	19.0 yrs.	15.0 yrs.
S.D.	(+5.48)	(+42.83)	-----	(+2.86)	(+1.0)	(+1.73)
Range	(65.5-76.0)	(107.0-184.0)	-----	(14.5-20.2)	(18-20)	(14-17)
	N=3	N=3	-----	N=3	N=3	N=3

SPORT AND NUMBER OF SUBJECTS

Category 1 - Basketball 23; Volleyball 14; Cross-Country 4; Track and Field 9; Gymnastics 8; Swimming 5; Tennis 11; Softball 5

Category 2 - Basketball 2; Volleyball 2; Cross-Country 3; Track and Field 1; Gymnastics 0; Swimming 4; Tennis 1; Softball 0

Category 3 - Basketball 0; Volleyball 1; Cross-Country 2; Track and Field 0; Gymnastics 0; Swimming 5; Tennis 2; Softball 0

Category 4 - Basketball 1; Volleyball 0; Cross-Country 2; Track and Field 0; Gymnastics 0; Swimming 0; Tennis 0; Softball 0

TABLE 3. PHYSICAL CHARACTERISTICS--THREE CATEGORIES OF MENSTRUAL FUNCTIONING

	<u>HT</u>	<u>WT</u>	<u>WT/HT</u> <u>RATIO</u>	<u>% FAT</u>	<u>AGE</u>	<u>AGE AT MENARCHE</u>	<u>WORK INDEX</u> ^a
1 - Regular							
$\bar{X}$	66.32"	140.16 lbs.	2.11	18.10	19.6 yrs.	13.2 yrs.	12.08
S.D.	(+3.38)	(+20.27)	(+.25)	(+2.31)	(+1.07)	(+1.16)	(+1.80)
Range	(57.5-73.5)	(89.25-181.0)	(1.55-2.64)	(13.7-23.5)	(18-22)	(11-16)	(7-16)
	N=79	N=79	N=79	N=79	N=79	N=76	N=77
2 - Irregular							
$\bar{X}$	66.15"	133.31 lbs.	2.01	17.36	19.8 yrs.	13.2 yrs.	13.50
S.D.	(+1.85)	(+13.88)	(+.19)	(+2.00)	(+1.30)	(+1.52)	(+1.80)
Range	(63-69.75)	(106.0-164.75)	(1.67-2.45)	(15.3-21.5)	(18-23)	(11-16)	(9-15)
	N=13	N=13	N=13	N=13	N=13	N=13	N=13
3 - Highly Irregular							
$\bar{X}$	66.63"	131.65 lbs.	1.97	16.94	19.2 yrs.	14.5 yrs.	14.23
S.D.	(+3.35)	(+20.43)	(+.24)	(+1.85)	(+1.21)	(+1.86)	(+1.74)
Range	(63.25-76)	(103.5-184)	(1.59-2.42)	(14.1-20.2)	(18-22)	(12-18)	(10-16)
	N=13	N=13	N=13	N=13	N=13	N=13	N=13

SPORT AND NUMBER OF SUBJECTS

Category 1 - Basketball 23; Volleyball 14; Cross-Country 4; Track and Field 9; Gymnastics 8; Swimming 5; Tennis 11; Softball 5

Category 2 - Basketball 2; Volleyball 2; Cross-Country 3; Track and Field 1; Gymnastics 0; Swimming 4; Tennis 1; Softball 0

Category 3 - Basketball 1; Volleyball 1; Cross-Country 4; Track and Field 0; Gymnastics 0; Swimming 5; Tennis 2; Softball 0

^a Work Index is the sum of the number of days in training per week + hours per day spent in training + intensity of workout

TABLE 4. PHYSICAL CHARACTERISTICS—BY EVENT

EVENT	HT	WT	WT/HT RATIO	% FAT	AGE	AGE AT MENARCHE	WORK INDEX ^a
Basketball							
$\bar{X}$	68.67	148.62	2.16	17.38	19.6	13.19	12.29
S.D.	(+1.20)	(+19.09)	(+0.22)	(+1.76)	(+0.8)	(+0.98)	(+1.59)
Range	(N=26)	(N=26)	(N=26)	(N=26)	(N=26)	(N=26)	(N=26)
Volleyball							
$\bar{X}$	66.90	144.03	2.15	19.19	19.53	12.41	11.16
S.D.	(+2.85)	(+13.47)	(+0.16)	(+1.38)	(+0.87)	(+1.06)	(+1.96)
Range	(N=17)	(N=17)	(N=17)	(N=17)	(N=17)	(N=17)	(N=16)
Cross-Country							
$\bar{X}$	65.41	113.64	1.74	15.34	20.09	14.27	13.55
S.D.	(+1.55)	(+8.49)	(+0.11)	(+1.08)	(+1.22)	(+2.05)	(+1.19)
Range	(N=11)	(N=11)	(N=11)	(N=11)	(N=11)	(N=11)	(N=11)
Track & Field							
$\bar{X}$	66.03	137.75	2.08	17.39	19.60	13.37	12.83
S.D.	(+2.46)	(+24.89)	(+0.34)	(+3.51)	(+1.17)	(+1.51)	(+1.58)
Range	(N=10)	(N=10)	(N=10)	(N=10)	(N=10)	(N=8)	(N=9)
Gymnastics							
$\bar{X}$	61.72	117.91	1.91	18.48	19.0	14.0	11.81
S.D.	(+1.64)	(+11.49)	(+0.16)	(+2.57)	(+1.07)	(+1.31)	(+1.00)
Range	(N=8)	(N=8)	(N=8)	(N=8)	(N=8)	(N=8)	(N=8)
Swimming							
$\bar{X}$	66.64	137.55	2.06	17.14	19.21	13.84	15.14
S.D.	(+1.55)	(+11.15)	(+0.15)	(+1.44)	(+1.31)	(+1.41)	(+0.53)
Range	(N=14)	(N=14)	(N=14)	(N=14)	(N=14)	(N=13)	(N=14)
Tennis							
$\bar{X}$	65.70	142.96	2.18	19.29	19.43	13.36	12.14
S.D.	(+2.12)	(+7.98)	(+0.11)	(+1.90)	(+0.94)	(+1.01)	(+1.39)
Range	(N=14)	(N=14)	(N=14)	(N=14)	(N=14)	(N=14)	(N=14)
Softball							
$\bar{X}$	63.35	141.30	2.22	19.48	20.20	12.80	10.40
S.D.	(+5.43)	(+35.87)	(+0.47)	(+2.05)	(+1.30)	(+1.30)	(+2.61)
Range	(N=5)	(N=5)	(N=5)	(N=5)	(N=5)	(N=5)	(N=5)

^a Work Index is the sum of the number of days in training per week + hours per day spent in training + intensity of workout

TABLE 5. PHYSICAL CHARACTERISTICS--REGULAR AND NON-REGULAR GROUPS

GROUP	HT	WT	WT/HT RATIO	% FAT	AGE	AGE AT MENARCHE	WORK INDEX ^a
Regular							
$\bar{X}$	66.32"	140.16 lbs.	2.11	18.10	19.6	13.2	12.08
S.D.	(+3.38)	(+20.27)	(+.25)	(+2.31)	(+1.07)	(+1.16)	(+1.80)
Range	(57.5-73.5)	(89.25-181.00)	(1.55-2.64)	(13.7-23.5)	(18-22)	(11-16)	(7-16)
	N=79	N=79	N=79	N=79	(N=79)	N=76	N=77
Non-Regular							
$\bar{X}$	66.39"	132.48 lbs.	1.99	17.15	19.5	13.8	13.87
S.D.	(+2.66)	(+17.13)	(+.21)	(+1.90)	(+1.27)	(+1.79)	(+1.78)
Range	(63.0-76.0)	(103.5-184.0)	(1.59-2.45)	(14.1-21.5)	(18-23)	(11-18)	(9-16)
	N=26	N=26	N=26	N=26	N=26	N=26	N=26

^a Work Index is the sum of the number of days in training per week + hours per day spent in training + intensity of workout

Height, Weight, and Skinfold Measurements

The height of each subject was measured through the use of a Healthometer Physician's scale (Continental Scale Corporation, Bridgeview, Illinois). Measurements were taken with shoes and socks removed. The subject stood facing away from the measuring device with her feet flat and together on the center of the scale, and her arms relaxed at her sides. The top of her head was level and the eyes were fixed forward. Measurements were recorded to the nearest quarter inch.

Each subject's weight was measured on the same Physician's scale with the subject dressed in a tee-shirt and gym shorts. Each subject stood with her feet on the center of the scale with her arms at her sides. Weight was recorded to the nearest quarter pound. The same scale was used for all measurements and was calibrated prior to the beginning of each testing session.

The three sites of skinfold measurements were triceps, suprailiac, and subscapular. The triceps and iliac crest sites are considered to be the most accurate in the prediction of body density for young women (Sloan et al., 1962). Sloan et al. found that these two measurements and body density had a multiple correlation of $-.74$. The skinfold measurements were taken with the Lange Skinfold Calipers which are designed to exert a constant pressure of approximately 10 gm. per sq. mm. throughout the range of motion. Each subject was dressed in a tee-shirt and gym shorts and stood with her feet slightly apart with her arms at her sides. The calipers were held in the experimenter's right hand and the

skinfold was pinched on the right side of the body between the thumb and forefinger with the experimenter's left hand. The skinfold is made up of a double layer of skin and subcutaneous fat. The calipers were applied to the skinfold approximately 1 cm. below the finger and the measurement was recorded to the nearest one-half millimeter. Measurements were taken at each skinfold site until three were within 1 mm. of each other. The average of the three measurements was used to estimate body density. All measurements were taken by the experimenter to eliminate inter-individual variation (Moneoye, 1970; Fardy and Hellerstein, n.d.).

Following the procedures of Montoye (1970) and Fardy and Hellerstein (n.d.), the site of the triceps skinfold was halfway between the tip of the acromion and the olecranon process and was determined with the elbow flexed creating a 90° angle. This skinfold was taken in the vertical plane on the back of the right upper arm, with the arm relaxed and extended. The suprailiac skinfold was located just above the crest of the ilium on the midaxillary line. This skinfold was taken in the natural diagonal line going dorsally upward. The site of the subscapular skinfold was immediately below the tip of the scapula. This skinfold was lifted on a diagonal plane about 45° from the horizontal level going laterally downward.

The measurements obtained from the triceps and suprailiac skinfolds were used in the following equation to estimate body density (Sloan et al., 1962):

$$X_1 = 1.0764 - 0.0081X_2 - 0.00088X_3$$

where:

X_1 = density (g/ml)

X_2 = suprailiac skinfold (mm.)

X_3 = triceps skinfold (mm.)

Sloan et al. reported that this equation has a standard error of estimation of ± 0.00082 g/ml.

The percentage of body fat was then estimated from body density through the use of the following equation (Brozek et al., 1963):

$$F = 100(4.570/D - 4.142)$$

where:

F = body fat (percentage of body weight)

D = density (g/ml).

Work Index

A work index value was calculated for each subject from training information obtained by the questionnaire. The work index variable is composed of objective measures of frequency and duration of exercise and a subjective measure of the intensity of exercise. These three components of work index were summed to give a value for work index which gave an indication of the subject's total work. Frequency was determined from the number of days that the subject trained per week. Duration was obtained from the hours per day spent in training. The subject was scored one if she trained zero to one hour and scored two, three, or four if she trained one to two, two to three or more hours, respectively. Intensity was determined from

a subjective rating by the subject of the intensity of her typical workout. The intensity scale ranged from one (light) to five (exhaustive) (See questionnaire, Appendix A).

Statistics

The Kruskal-Wallis one-way analysis of variance of ranks, a nonparametric test, was used to test the significance of percentage of body fat in menstrual functioning. A one-way analysis of variance was used to determine the significance of both body weight and the work index variable in menstrual functioning. Scheffe's Test was used to determine where differences existed. An analysis of covariance was used to test the significance of the work index variable in menstrual functioning while percentage of body fat was controlled. The Least Squares Means Test was used to determine where significant differences were found. Pearson product-moment correlation coefficients, a parametric technique, were calculated for continuous variables. Spearman's rho correlation coefficients, a nonparametric technique, were calculated for discrete variables. Partial correlation coefficients, which controlled for body fat, were calculated for category of menstrual functioning and training variables. Chi-square analyses were used to compare a high and low fat group for menstrual cycle pain and regular and non-regular athletes for menstrual cycle pain were performed.

CHAPTER III

RESULTS

On the 114 subjects initially agreeing to participate in this investigation, two were excluded because of organic causes of amenorrhea and seven were excluded because of oral contraceptive use.

To answer the question as to whether a relationship exists between percentage of body fat and secondary amenorrhea, the sample was grouped into four categories: regular, irregular, highly irregular, and amenorrheic, according to each subject's response on the questionnaire (Appendix A). Each subject indicated her menstrual cycle pattern on the questionnaire according to criteria stated on the questionnaire.

The Kruskal-Wallis one-way analysis of variance (ANOVA) of ranks, a nonparametric test, was used for the analysis of the relationship between percentage of body fat and category because there was neither homogeneity of variance among the categories, nor was there a normal distribution for percentage of body fat. The results of this test indicated that there were no significant differences among the four categories for the percentage of body fat (Table C-1, Appendix C).

The original four categories were then condensed into three categories to increase the number of subjects in each category. Categories three and four were combined to make a new "highly irregular" group. Although there was now homogeneity of variance,

the distribution for percentage of body fat was not normal, so the Kruskal-Wallis ANOVA of ranks was used again to compare the categories. Again, there were no significant differences found among the three categories for percentage of body fat (Table C-2, Appendix C).

Correlation coefficients were determined for percentage of body fat and selected variables. Significant positive Pearson product-moment correlations were found between percentage of body fat (using the two skinfold measurements, triceps and suprailiac) and the sum of three skinfold measurements (triceps, suprailiac, and subscapular) ($r=+.96$) and between percentage of body fat and weight/height ratio ($r=+.67$). A significant negative correlation was noted between percentage of body fat and work index ($r=-.34$) (Table C-8, Appendix C). Significant negative Spearman's rho correlations were found for percentage of body fat and miles jogged/run per day ($r=-.39$), percentage of body fat and number of days in training per week ($r=-.40$) and percentage of body fat and intensity of workout ($r=-.23$) (Table C-9, Appendix C).

Statistical analysis was done to test the significance of body weight among categories. A one-way analysis of variance (ANOVA) revealed no significant differences among the three categories for body weight (Table C-3, Appendix C). However, significant negative Spearman's rho correlations were found for body weight and category ($r=-.21$) (Table C-9, Appendix C).

A significant difference was found among the three categories for the work index variable (Table C-4, Appendix C). Scheffe's Test,

a conservative post-hoc test, was used to determine which categories were significantly different from each other. It was found that categories one (regular) and three (highly irregular) were significantly different from each other. Category three (highly irregular) had the largest mean for the work index variable and category one (regular) had the smallest mean (Table C-5, Appendix C).

An analysis of covariance comparing the three categories for work index while controlling for percentage of body fat was calculated. Significant differences were still observed among the three categories (Table C-6, Appendix C). The Least Squares Means Test was then performed in order to determine where significant differences were found. An examination of the work index means adjusted for percentage of body fat (Table C-7, Appendix C) revealed that category three (highly irregular) had the highest mean and category one (regular) had the lowest mean. Significant differences existed between categories one (regular) and two (irregular) and between categories one (regular) and three (highly irregular). There was no significant difference noted between category two (irregular) and category three (highly irregular).

Various significant positive Spearman's rho correlations were noted including category and work index ($r=+.43$), category and miles jogged/run per day ($r=+.23$), category and number of days in training per week ($r=+.38$), category and times per day spent in training ($r=+.42$), category and hours per day spent in training ($r=+.28$), and category and intensity of workout ($r=+.28$). Significant negative correlations were found for menstrual cycle pain and miles

jogged/run per day ($\underline{r}=-.30$), and menstrual cycle pain and number of days in training per week ($\underline{r}=.23$) (Table C-9, Appendix C).

Partial correlations were done controlling for percentage of body fat. Positive, significant correlations were indicated for category and work index ($\underline{r}=+.37$), category and miles jogged/run per day ($\underline{r}=+.19$), category and number of days in training per week ($\underline{r}=+.32$), category and times per day spent in training ($\underline{r}=+.45$), category and intensity of workout ($\underline{r}=+.22$), and category and hours per day spent in training ($\underline{r}=+.27$) (Table C-10, Appendix C).

The data concerning category and menstrual cycle pain was arranged into a 3 x 2 chi-square format with category by pain in order to determine trends. The probabilities obtained through the use of a chi-square analysis would not be valid because over 20% of the cells have expected counts of less than five. The pain scale on the questionnaire ranged from zero to five (zero represented no pain and five represented extreme pain. For analysis of trends, the scale was condensed to include two groups (zero to two, three to five) in order to increase the cell size (Table C-11, Appendix C). With the data arranged into a chi-square format, it was observed that within each category the greatest percentage of athletes had light pain.

Two fat groups were compared for significant differences on menstrual cycle pain. Fat groups one and two were composed of athletes with the smallest and largest percentages of body fat, respectively. The median (17.8%) of the percentages of body fat was chosen as the cut off point for the two groups.

The athletes with less than or equal to 17.8% body fat were placed in fat group one while those athletes with greater than 17.8% body fat were placed in fat group two. As stated above, the six classifications for pain were condensed into two groups (zero to two; three to five). A 2 x 2 chi-square analysis with fat groups by pain was performed to determine if there was a significant difference between the two fat groups on the pain associated with the menstrual cycle. The results of the analysis indicated that there was no significant difference for the two fat groups on the pain associated with the menstrual cycle (Table C-12, Appendix C).

A 2 x 2 chi-square analysis was done to compare the regular and non-regular athletes on their menstrual cycle pain. As before, the six classifications for pain associated with the menstrual cycle were condensed into two classifications (zero to two; three to five) in order to increase the expected frequencies in the cells and thus alleviate the violations of the chi-square test. The chi-square analysis indicated that there was no significant difference for the two groups on the pain associated with the menstrual cycle (Table C-13, Appendix C).

An examination of trends was done to compare categories by athletic event because of violations of the requirements for the chi-square test (Table C-14, Appendix C). It can be noted that in category one (regular, n=79), the largest percentage of athletes were basketball players (29.11%); the smallest percentage of athletes were cross-country runners (5.06%). In category two (irregular, n=13), the largest percentage of athletes were

swimmers (30.77%); there were no gymnasts or softball players in this category. The largest percentage of athletes in category three (highly irregular, n=13) was again swimmers (38.46%), followed closely by cross-country runners (30.77%). Category three had no athletes in track and field, gymnastics, or softball.

The irregular and highly irregular categories were combined to form a non-regular group. The regular and the new non-regular groups were compared by athletic event. The results of the comparison are presented in Table C-15, Appendix C.

A comparison of categories for menstrual flow was completed by observing trends with the data arranged into a chi-square format. This format was used because of violations of the requirements of the chi-square test. It was found that within each category the largest percentage of athletes reported a two on a scale of one to three for menstrual flow (with one being heavy flow and three being light flow). Overall, the athletes' flow was from medium to light with only 10 athletes reporting a heavy flow. These 10 athletes had regular menstrual cycles (Table C-16, Appendix C).

The data was also arranged into a chi-square format in order to compare it with the criterion established by Frisch and McArthur (1974) of a minimal weight necessary for a particular height in order for regular menstrual cycles to occur in non-athletic women (Frisch et al., 1981). This minimal weight for a particular height is according to Frisch et al. 56.1, total water/body weight percent. The data from the present investigation indicated that 88.5% of the non-regular athletes were below 56.1% set by Frisch

and McArthur. In addition, 100% of the regular athletes were below 56.1%. In both categories, only three athletes (2.9%) were above 56.1% and these athletes did not have regular menstrual cycles (Table C-17, Appendix C).

CHAPTER IV

DISCUSSION

The primary purpose of this investigation was to determine whether a relationship existed between percentage of body fat and secondary amenorrhea in collegiate athletes. Since there was disagreement in the literature as to the role of body fat in menstrual functioning, it was hoped that this investigation could provide further clarification.

The results of the present investigation indicate that there are no significant differences in percentages of body fat for athletes with regular cycles and those with oligo/amenorrhea. This finding is in contrast to the majority of research studies reviewed by this investigator which indicate that secondary amenorrhea in athletes may be related to their low levels of body fat (Bloomberg, 1977; Frisch, 1980; Frisch and McArthur, 1974; Frisch et al., 1980; Wilmore, 1977). Other researchers, however, concur that there is no relationship between percentage of body fat and secondary amenorrhea (Hendrix and Lohman, 1981; McArthur et al., 1980).

It is interesting to note, however, that the percentage of body fat was found to decrease from the regular to the highly irregular category (Table 3). This may indicate that percentage of body fat is related in some way to menstrual irregularity, in spite of the lack of a statistically significant relationship between percentage of body fat and category. Since percentage of body fat varies according to category of menstrual functioning,

but not significantly, some other factor or factors may be affecting the category.

One such factor which could possibly explain the fluctuation of percentage of body fat with category is the work index variable which gives an indication of the subject's total work. A significant negative correlation ($r = -.34$) exists between percentage of body fat and work index which indicates that the more total work a person does the lower the level of percentage of body fat will be. Therefore, the change in percentage of body fat is more than likely a function of the total work as measured by the work index variable.

The work index variable was found to be significantly related to menstrual functioning. When percentage of body fat was controlled, the work index variable was again found to be significantly related to menstrual functioning. This indicates that something within this variable, irrespective of body fat, is affecting menstrual functioning. Not much difference was found in the correlations among the following individual components of work index: number of days in training per week ($r = +.32$), hours per day spent in training ($r = +.27$), and intensity of workout ($r = +.22$) and category of menstrual functioning. This suggests that the importance of this variable may be in the combination of factors, rather than in any given factor. This researcher is not aware of the identification of this relationship in any previous studies.

The work index variable, composed of frequency, intensity, and duration, offers the researcher a unique method of grouping factors previously associated with secondary amenorrhea in collegiate

athletes and provides a single and more comprehensive measure of total work and physical stress. The relationship found in this study between work index and menstrual dysfunction supports Dale et al.'s (1979a; 1979b) previous findings that intensity and duration are related to menstrual dysfunction. In addition, the work index variable, as a measure of total work, supports earlier research on the relationship between energy expenditure/physical stress and menstrual dysfunction in athletes (Feicht et al., 1978; McArthur et al., 1980; Warren, 1980). The finding that menstrual functioning is correlated with miles jogged/run per day and number of days in training per week is consistent with the findings of other researchers (Carlberg et al., 1981; Dale et al., 1979b; Feicht et al., 1978).

Various methods have been used for the estimation of percentage of body fat. This investigation used the estimation obtained through the skinfold method (Sloan et al., 1962; Brozek et al., 1963). This estimation of the percentage of body fat using the skinfold method was compared with the estimation obtained by the method which uses height and weight in the regression equation of Mellits and Cheek (1970). It was found that the estimation derived from the skinfold method was lower than the one using the height and weight method. The mean estimation of percentage of body fat for the present investigation was 17.87% using the skinfold method and 30.55% using the height and weight method. The large difference between these two estimations of percentage of body fat is probably a function of the population (athletic). The height and weight estimation of body fat is based upon the

normal population. For a given body weight, the athletic population is expected to have a larger percentage of lean body mass to fat than the normal population. The height and weight method was used by Frisch and McArthur (1974) and Frisch (1980) in determining the 22% body fat criterion necessary for maintaining and restoring regular menstrual cycles in nonathletic women 16 years and older.

A secondary issue examined in this study was the relationship of body weight to menstrual dysfunction. Other research studies (Feicht et al., 1978; McArthur et al., 1980) support the present finding that body weight does not have a significant effect on menstrual functioning. McArthur et al. believe that factors other than body weight or body fat are responsible for secondary amenorrhea in athletes. Carlberg et al. (1981), however, found significant differences between the weights of oligo/amenorrheic athletes and athletes with regular cycles. The conclusion was that the athletes with low body weight are more susceptible to menstrual dysfunction than other athletes. Frisch and McArthur (1974) also believe that body weight is critical to menstrual functioning. They contend that a minimal weight is necessary for a particular height in order for regular menstrual cycles to occur in nonathletic women. In comparing the athletes from the present investigation to the criterion set by Frisch and McArthur, it was found that only three athletes (2.9%) were above the criterion which suggests that this criterion is not applicable to the athletic population.

Two interesting correlations were noted in the present investigation for the pain associated with the menstrual cycle and training variables. A significant negative correlation was found between menstrual cycle pain and miles jogged/run per day ($\underline{r} = -.30$) and between menstrual cycle pain and number of days in training per week ($\underline{r} = -.23$). It appears that as an athlete increases her training, she also decreases the pain associated with her menstrual cycle. These findings are consistent with those of Erdelyi (1976) who noted that sports participation had a positive effect on dysmenorrhea.

In conclusion, the results of this investigation indicate that neither percentage of body fat nor body weight play a significant role in the incidence and prevalence of oligomenorrhea or secondary amenorrhea in collegiate athletes. However, the work index variable (indicating total work) was significantly related to menstrual functioning, even when percentage of body fat was controlled. Further research is needed in order to clarify the role of the components comprising the work index variable in menstrual dysfunction among collegiate athletes.

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APPENDICES

APPENDIX A

The following questionnaire is part of a study conducted at the University of Tennessee, Knoxville, to determine the relationship between body composition and secondary amenorrhea in athletes. In addition to the questionnaire, the study will also include an estimation of the percentage of body fat.

By completing this questionnaire, it is agreed that you consent to participate in this investigation. All responses to this questionnaire will remain confidential through the use of a coding procedure.

QUESTIONNAIRE

Name _____ Address _____

Age _____ Year _____ Month _____ Phone _____

1. At what age did your menstrual periods begin? _____ Yr. _____ Mo.
2. Are you using oral contraceptives at the present time? YES NO
3. Have you used any type of contraceptive device in the past? YES NO
If so, how long has it been since you stopped using it? _____
4. Do you have regular menstrual periods (variation of +/- 7 days)? YES NO
5. Do you have irregular menstrual periods (varying from one to four weeks late - never consistently the same)? YES NO
6. Do you have highly irregular menstrual periods (with menstrual periods occurring every two to five months - never consistently the same)? YES NO
7. Have you had an absence of menstrual periods for longer than six months? YES NO
If so, how long has it been since you had a menstrual period? _____
8. Please describe the pattern of your last three menstrual cycles as precisely as possible. Indicate the number of days between each period as well as the number of days of flow (if necessary, use the back of the page).

9. How would you characterize your flow during menstrual period?
- a) heavy b) medium c) light
10. Is there pain associated with your menstrual periods? YES NO
If so, how would you characterize the pain?
- | | | | | |
|-------|---|----------|---|---------|
| Light | | Moderate | | Extreme |
| 1 | 2 | 3 | 4 | 5 |
11. In which athletic event do you compete? _____
12. Is running/jogging a part of your training? YES NO
If so, how many miles per day do you run?
- | | | | |
|-----|------|-------|-----|
| 0-5 | 6-10 | 11-20 | 21- |
|-----|------|-------|-----|
13. How many days per week do you workout?
- | | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
14. How many times per day do you workout?
- | | | | |
|---|---|---|---|
| 1 | 2 | 3 | - |
|---|---|---|---|
15. How would you characterize the intensity of your typical workout?
- | | | | | |
|-------|---|----------|---|------------|
| Light | | Moderate | | Exhaustive |
| 1 | 2 | 3 | 4 | 5 |
16. How many hours per day do you typically spend in training?
- | | | | |
|-----|-----|-----|----|
| 0-1 | 1-2 | 2-3 | 3- |
|-----|-----|-----|----|

If you have any questions or comments about the questionnaire, please use the space below and, if necessary, the back of the page.

APPENDIX B

INFORMED CONSENT

The purpose of this study is to investigate the relationship between body composition and the menstrual cycle in athletes. The primary objective of the study is to determine if a relationship exists between the percentage of body fat and secondary amenorrhea. Secondary amenorrhea is the lack of menstrual periods in a previously menstruating woman for greater than six months.

Three procedures are necessary for participation in the study: 1) completion of a questionnaire regarding menstrual history and athletic workouts, 2) height and weight measurements and, 3) three skinfold measurements. All measurements will be taken by the investigator.

I have read the statement above and understand my role in the experiments and the risks involved. I have had the procedures explained and demonstrated to me. In addition, I am aware that:

1. I am entitled to have any further inquiries answered regarding the procedures.
2. I may withdraw my consent and discontinue participation at any time without penalty or prejudice toward me.
3. In the event of physical injury resulting from the research procedure, financial compensation is not available and medical treatment is not provided free of charge.
4. In the event of presentation of publication the data will be described in a manner to protect my rights.

Signature

Date

APPENDIX C

TABLE C-1

KRUSKAL-WALLIS ANOVA OF RANKS SUMMARY TABLE FOR THE COMPARISON OF THE FOUR CATEGORIES
OF MENSTRUAL FUNCTIONING FOR PERCENTAGE OF BODY FAT

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F	P $\angle$
Model (Categories)	3	3305.63	1101.88	1.20	.31
Error	101	92775.37	918.57		
Total	104	96081.00			

TABLE C-2

KRUSKAL-WALLIS ANOVA OF RANKS SUMMARY TABLE FOR THE COMPARISON OF THE THREE CATEGORIES
OF MENSTRUAL FUNCTIONING FOR PERCENTAGE OF BODY FAT

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F	P $\angle$
Model (Categories)	2	3201.00	1600.50	1.76	.18
Error	102	92879.80	910.59		
Total	104	96081.00			

TABLE C-3
ANOVA SUMMARY TABLE FOR THE COMPARISON OF THE THREE CATEGORIES
OF MENSTRUAL FUNCTIONING FOR BODY WEIGHT

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F	P $\angle$
Model (Categories)	2	1170.82	584.41	1.52	.22
Error	102	39356.36	385.85		
Total	104	40527.18			

TABLE C-4
ANOVA SUMMARY TABLE FOR THE COMPARISON OF THE THREE CATEGORIES
OF MENSTRUAL FUNCTIONING FOR WORK INDEX^a

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F	p $\angle$
Model (Categories)	2	65.12	32.56	10.11	.0001
Error	100	322.01	3.22		
Total	102	387.13			

^a Work Index is the sum of the number of days in training per week + hours per day spent in training + intensity of workout

TABLE C-5
SUMMARY TABLE FOR SCHEFFE'S TEST OF THE MEANS OF THE THREE CATEGORIES
OF MENSTRUAL FUNCTIONING FOR WORK INDEX

	CATEGORY 1 12.08	CATEGORY 2 13.50	CATEGORY 3 14.23
Means			
1 - 12.08			b
2 - 13.50			
3 - 14.23			

^b Significant at the .05 level

TABLE C-6
ANALYSIS OF COVARIANCE SUMMARY TABLE FOR THE COMPARISON OF THE THREE CATEGORIES
OF MENSTRUAL FUNCTIONING FOR WORK INDEX^a

<u>SOURCE</u>	<u>DF</u>	<u>MEAN SQUARE</u>	<u>F</u>	<u>P L</u>
Category/Fat	2	23.88	8.02	.0006
Error	99	2.98		

* Percentage of body fat is the covariate factor

^a Work Index is the sum of the number of days in training per week + hours per day spent in training + intensity of workout

TABLE C-7
SUMMARY TABLE FOR THE LEAST SQUARES MEANS OF THE THREE CATEGORIES OF MENSTRUAL
FUNCTIONING FOR WORK INDEX^a

	<u>CATEGORY</u> 1	<u>CATEGORY</u> 2	<u>CATEGORY</u> 3
	12.14	13.38	14.01
Means			
1 - 12.14		b	b
2 - 13.38			
3 - 14.01			

^b Significant at the .05 level

TABLE C-8
CORRELATIONS OF BODY FAT WITH
SUM OF SKINFOLD MEASUREMENTS, WEIGHT/HEIGHT, RATIO, AND WORK INDEX

<u>VARIABLE</u>	<u>BODY FAT</u>
Sum of Skinfold Measurements ^a	.96 ***
Weight/Height Ratio	.67 ***
Work Index ^b	-.34 ***

*** Significant at the .0005 level

^a Triceps, suprailiac, and subscapular

^b Work Index is the sum of the number of days in training per week + hours per day spent in training + intensity of workout

TABLE C-9
CORRELATIONS OF BODY FAT, BODY WEIGHT, CATEGORY AND PAIN WITH TRAINING VARIABLES

Category	<u>BODY FAT</u>	<u>BODY WEIGHT</u>	<u>CATEGORY</u>	<u>PAIN^a</u>
Work Index ^b		-.21 *	.43 *	
Mi/Day ^c	-.39 *		.23 *	-.30 *
Da/Wk ^d	-.40 *		.38 *	-.23 *
Ti/Day ^e			.42 *	
Hr/Day ^f			.28 *	
Intensity	-.23 *		.28 *	

* Significant at the .05 level

^a Pain associated with the menstrual cycle

^b Work Index is the sum of the number of days in training per week + hours per day spent in training + intensity of workout

^c Miles jogged/run per day

^d Number of days in training per week

^e Times per day spent in training

^f Hours per day spent in training

TABLE C-10
PARTIAL CORRELATIONS (CONTROLLING FOR BODY FAT)
BETWEEN CATEGORY AND TRAINING VARIABLES

	<u>WORK INDEX</u> ^a	<u>MI/DAY</u> ^b	<u>DA/WK</u> ^c	<u>TI/DAY</u> ^d	<u>INTENSITY</u>	<u>HR/DAY</u> ^e
Category	.37 *	.19 *	.32 *	.45 *	.22 *	.27 *

* Significant at .05 level

^a Work Index is the sum of the number of days in training per week + hours per day spent in training + intensity of workout

^b Miles jogged/run per day

^c Number of days in training per week

^d Times per day spent in training

^e Hours per day spent in training

TABLE C-11

COMPARISON OF CATEGORY OF MENSTRUAL FUNCTIONING BY PAIN ^a

CATEGORY	<u>PAIN</u>				
	0 - 2	3 - 5	1	2	3
1 - Regular					
Frequency	46	33			79
Percent	44.66	32.04			76.70
Row Pct.	58.23	41.77			
Col Pct.	73.02	82.50			
2 - Irregular					
Frequency	7	5			12
Percent	6.80	4.85			11.65
Row Pct.	58.33	41.67			
Col Pct.	11.11	12.50			
3 - Highly Irregular					
Frequency	10	2			12
Percent	9.71	1.94			11.65
Row Pct.	83.33	16.67			
Col Pct.	15.87	5.00			
Total	63	40			103
	61.17	38.83			100.00

^a Pain associated with the menstrual cycle:

0	1	2	3	4	5
no pain					extreme pain

TABLE C-13
COMPARISON OF REGULAR AND NON-REGULAR GROUPS BY PAIN ^a

GROUPS	<u>PAIN</u>				
	0 - 2	3 - 5	TOTAL		
1 - Regular					
Frequency	46	33			79
Percent	44.66	32.04			76.70
Row Pct.	58.23	41.77			
Col Pct.	73.02	82.50			
2 - Non-Regular					
Frequency	17	7			24
Percent	16.50	6.80			23.30
Row Pct.	70.83	29.17			
Col Pct.	26.98	17.50			
Total	63	40			103
	61.17	38.83			100.00

$$\chi^2 = 1.24, p > .20$$

^a Pain associated with the menstrual cycle:

0 no pain 1 2 3 4 5
extreme pain

TABLE C-14
COMPARISON OF CATEGORY OF MENSTRUAL FUNCTIONING BY EVENT ^a

CATEGORY	EVENT								Total
	1	2	3	4	5	6	7	8	
1 - Regular									
Frequency	23	14	4	9	8	5	11	5	79
Percent	21.90	13.33	3.81	8.57	7.62	4.76	10.48	4.76	75.24
Row Pct.	29.11	17.72	5.06	11.39	10.13	6.33	13.92	6.33	
Col Pct.	88.46	82.35	36.36	90.00	100.00	35.71	78.57	100.00	
2 - Irregular									
Frequency	2	2	3	1	0	4	1	0	13
Percent	1.90	1.90	2.86	0.95	0.00	3.81	0.95	0.00	12.38
Row Pct.	15.38	15.38	23.08	7.69	0.00	30.77	7.69	0.00	
Col Pct.	7.69	11.76	27.27	10.00	0.00	28.57	7.14	0.00	
3 - Highly Irregular									
Frequency	1	1	4	0	0	5	2	0	13
Percent	0.95	0.95	3.81	0.00	0.00	4.76	1.90	0.00	12.38
Row Pct.	7.69	7.69	30.77	0.00	0.00	38.46	15.38	0.00	
Col Pct.	3.85	5.88	36.36	0.00	0.00	35.71	14.29	0.00	
TOTAL	26	17	11	10	8	14	14	5	105
	24.76	16.19	10.48	9.52	7.62	13.33	13.33	4.76	100.00

^a

1 - Basketball	5 - Gymnastics
2 - Volleyball	6 - Swimming
3 - Cross-Country	7 - Tennis
4 - Track and Field	8 - Softball

TABLE C-15

COMPARISON OF REGULAR AND NON-REGULAR GROUPS BY EVENT ^a

GROUPS	EVENT							
	1	2	3	4	5	6	7	8
0 - Non-Regular								
Frequency	3	3	7	1	0	9	3	0
Percent	2.86	2.86	6.67	0.95	0.00	8.57	2.86	0.00
Row Pct.	11.54	11.54	26.92	3.85	0.00	34.62	11.54	0.00
Col Pct.	11.54	17.65	63.64	10.00	0.00	64.29	21.43	0.00
1 - Regular								
Frequency	23	14	4	9	8	5	11	5
Percent	21.90	13.33	3.81	8.57	7.62	4.76	10.48	4.76
Row Pct.	29.11	17.72	5.06	11.39	10.13	6.33	13.92	6.33
Col Pct.	88.46	82.35	36.36	90.00	100.00	35.71	78.57	100.00
Total	26	17	11	10	8	14	14	5
	24.76	16.19	10.48	9.52	7.62	13.33	13.33	4.76
								105
								100.00

^a

1 - Basketball	5 - Gymnastics
2 - Volleyball	6 - Swimming
3 - Cross-Country	7 - Tennis
4 - Track and Field	8 - Softball

TABLE C-16
COMPARISON OF CATEGORY OF MENSTRUAL FUNCTIONING BY FLOW ^a

CATEGORY	FLOW			TOTAL
	1	2	3	
1 - Regular				
Frequency	10	52	17	79
Percent	9.71	50.49	16.50	76.70
Row Pct.	12.66	65.82	21.52	
Col Pct.	100.00	78.79	62.96	
2 - Irregular				
Frequency	0	7	5	12
Percent	0.00	6.80	4.85	11.65
Row Pct.	0.00	58.33	41.67	
Col Pct.	0.00	10.61	18.52	
3 - Highly Irregular				
Frequency	0	7	5	12
Percent	0.00	6.80	4.85	11.65
Row Pct.	0.00	58.33	41.67	
Col Pct.	0.00	10.61	18.52	
Total	10	66	27	103
	9.71	64.08	26.21	100.00

^a
1 - Heavy Flow
2 - Medium Flow
3 - Light Flow

TABLE C-17
COMPARISON OF REGULAR AND NON-REGULAR GROUPS FOR CRITERION SET BY FRISCH AND McARTHUR

GROUPS	NON-REGULAR	REGULAR	TOTAL
1 -			
Frequency	23	79	102
Percent	21.90	75.24	97.14
Row Pct.	22.55	77.45	
Col Pct.	88.46	100.00	
2 -			
Frequency	3	0	3
Percent	2.86	0.00	2.86
Row Pct.	100.00	0.00	
Col Pct.	11.54	0.00	
Total	26	79	105
	24.76	75.24	100.00

Group 1 - > 0 and $< 56.1\%$ (Total water/body weight percent)

Group 2 - $\geq 56.1\%$ (Total water/body weight percent) .

VITA

Michelle Poston Long was born in Rockwood, Tennessee on September 2, 1956. She attended public schools in Whitwell, Tennessee and was graduated from Whitwell High School in June 1974. In September of 1974 she entered the University of Tennessee, Knoxville, and received from there the Bachelor of Arts degree with a major in Psychology in 1978.

In September of 1980 she began graduate studies at the University of Tennessee, Knoxville. While there, she completed the requirements for the Master of Science degree in Physical Education with an emphasis in the area of exercise physiology.