AGE OF MENARCHE AND TRAINING HISTORIES OF FORMER HIGH SCHOOL AND UNIVERSITY LEVEL RUNNERS

by

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DEDICATION

This thesis is dedicated to my parents, Mr. and Mrs. Lyle K. Loader, who have given me their love and support in all my endeavors, and to David, my husband, for his continual encouragement and confidence which enabled me to complete this work.

CHAPTER 1

INTRODUCTION

The participation of women in athletics has become accepted in today's society. Now, females can experience the enjoyment that participation and competition in sport can provide. Sparked by the passage of Title IX of the Education Amendment of 1972, the number of females involved in sport has increased over the past decade. A "1982 Sports Participation Survey" conducted by the National Federation of State High School Association (1982), representing 89 percent of the nation's public and private high schools, reported that the number of girls participating in junior and senior high school sports during the 1970's began at 294,000 during the 1970-71 school year, grew to 1.3 million during the 1974-75 year and reached a high of 2.1 million in the 1977-78 year. The number of participants levelled off to approximately 1.8 million in 1981-82. At the university level, the National Collegiate Athlete Association (1981, 1983) reported an estimated 64,375 women participating in 19 sports in the 1976-77 term and 74,248 women competing in 23 sports during the 1981-82 year. Recent figures from the National Association of Intercollegiate Athletics (1982) estimate participation at the varsity level to be more than 14,360 women. Based on these reports, close to 2 million females are now participating in high school and university level athletics.

Accompanying this increased sport participation has been increased training. Intense training produces improved performances by athletes,

and in this regard, women respond to training much like men (ACSM, 1980). Endurance training, for example, produces increases in maximal oxygen uptake and decreases in percent body fat (Drinkwater, 1973; Pollock, 1973; Wilmore and Brown, 1974). Women also respond well to strength training programs (Wilmore, 1974). One consideration related to women and training is the effect of training on the age of menarche.

Menarche, or the first menstrual flow, is commonly viewed as a maturity indicator in females and occurs as a result of a maturation of the hypothalamus. At menarche, increased amounts of gonadotropin hormones and estrogens are produced, essential for ovulation and the monthly rhythmical cycles for reproduction in the female (Kulin, 1974).

In the United States, the average age of menarche cited is approximately 12.8 years (Frisch, Gotz-Welbergen, McArthur, Albright, Witschi, Bullen, Birnholz, Reed, and Hermann, 1981; Malina, Bouchard, Shoup, Demirjian, and Lariviere, 1970; Wyshak and Frisch, 1982). Young female athletes, as well as ballet dancers, involved in strenuous training, have reported ages of menarche from 13 to 15 years, with some attaining menarche as late as 18 and 19 years of age (Frisch et al, 1981; Malina, Harper, Avent, and Campbell, 1973; Malina, Spirduso, Tate, and Baylor, 1978; Warren, 1980). The delayed menarche is especially prevalent in Olympic and national level competitors (Malina et al, 1978). Athletes of other nations besides the United States also report ages of menarche later than their non-athlete counterparts (Malina et al, 1978). The age of menarche tends to vary according to sport; with gymnasts, runners and dancers reporting the latest ages. Swimmers, on the average, seem to be an exception to the reports of late menarche in that they attain menarche close to the general population

of females but are earlier than national and international athletes in other sports (Malina et al, 1979).

In order to explain the later age of menarche reported by athletes, Malina et al (1978) offers the following two-part hypothesis: 1) body-types (long-legged, narrow-hipped) of late maturing girls are more conducive to successful sports participation than those of early maturers and 2) the early maturer is socialized away from sport participation while late maturers, not having experienced early social pressures, experience success early in the adolescent years and continue to compete thereafter.

Recently, Frisch et al (1981) and Sidhu and Grewal (1980) have proposed that intense physical training prior to menarche is responsible for the delay in menarche, based on the observation that females who train before the onset of menarche attain menarche at a later age than those who begin training after menarche. Frisch et al (1981) hypothesizes that a critical lean/fat ratio is necessary for the attainment and maintenance of menstrual cycles and that early training prevents athletes from reaching this critical value. Warren (1980) reported a significant delay of menarche in young ballet dancers. In support of Frisch's hypothesis, Warren states that "In conclusion, an energy drain /in the form of exercize/ 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). Warren also notes, in agreement with Malina et al (1978), that ballet may attract girls with specific physique characteristics.

While training may have an effect on the onset of menarche, it may also be true that the young female athlete may have a predisposition to

mature late, with a body-type conducive to sport, encouraging early participation and training. Thus the two factors of early onset of training and late maturity may co-exist in the athlete without being the result of a cause-effect relationship. One way to better understand the relationship of training and age of menarche is to closely examine the onset and quantity of training of athletes prior to the age of menarche. Few studies have attempted to do so. The studies by Frisch et al (1981) and Sidhu and Grewal (1980) reported the number of years trained by the athletes but failed to discuss the quantity of training experienced or exactly what the term "intensive training" prior to menarche meant. Warren (1980) does report the number of hours trained by young ballet dancers from age 8 to 17. A recent study by Wakat, Sweeny, and Rogol (1982) reported no difference in age of onset of training, 14 years, among 41 college cross country runners who trained for 10 months per year, on the average. Wakat et al (1982) did find that athletes who had regular cycles began training 2-3 years after menarche, while those with irregular cycles began training 0-1 year prior to menarche.

Need for the Study

Past studies have sought to explain the incidence of late onset of menarche in young female athletes. It is possible that early training may affect the age of menarche but an athlete may also have an inherited predisposition to mature late. Late maturers tend to have body-types that can perform well in sports, encouraging participation and early training. Early onset of training and late maturity may co-exist in the athlete without a causal relationship existing between the two variables. Fur-

thermore, the research on training prior to menarche in athletes is limited. There is a need to examine the onset and quantity of training before menarche in female athletes.

Statement of the Problem

The purpose of the present study is to determine if the age of onset of training and quantity of training are related to a delayed menarche. More specifically, the study will examine the age of menarche, age of onset of athletic training and quantity of training of former high school and current university level female runners.

Limitations

Factors affecting the validity of the study include:

1. Ability of subjects to correctly interpret the meaning of survey questions requesting age of onset of menarche, age of onset of training and previous training.

2. Ability of subjects to accurately recall age of menarche, age of onset of training and previous training history.

3. Because subjects were voluntary, those individuals having past menstrual disorders may or may not have been influenced to participate in the study. This factor would more likely affect the participation of subjects from the non-athlete and former high school groups since nearly all of the females from the university teams participated in the study.

4. The extent of past training of the subjects may have been due to the school size and availability of various sports at schools attended by the subjects.

Delimitations

The boundaries of the study are extended to the following:

1. Female volunteers enrolled at Kansas State University, Manhattan Christian College, the University of Nebraska, and Wichita State University. Kansas State University and Manhattan Christian College are located in Manhattan, Kansas, population 35,000. The University of Nebraska is located in Lincoln, Nebraska, population 166,000 and Wichita State University is located in Wichita, Kansas, population 269,100. Kansas State University, the University of Nebraska, and Wichita State University are members of the National Collegiate Athletic Association; Wichita State University is a member of the Missouri Valley Conference, and Kansas State and the University of Nebraska are members of the Big Eight Conference.

2. Females who: 1) never participated in formal sports training; 2) participated in running events in track and/or cross country at least two years during junior and/or senior high school but not at the university level; or 3) were currently competing in running events in track and/or cross country during the 1982-83 school year at the university level.

3. Athletes who were involved in other sports in addition to track and/or cross country below the university level.

Definitions

Menarche--The onset of the first menstrual flow.

Age of Menarche--The age in which the first menstrual flow occurred, reported to the nearest year and month. If the exact month could not be recalled, the age of menarche was referred to as the age in years on the previous birthday.

Training--Regular or formalized training in a club or school sport. Examples include Amateur Athletic Union (AAU) or school swimming, track, cross country, volleyball, gymnastics, and basketball sports. Recreational and intramural activities or physical education classes were not considered as training.

Age of Onset of Training--The age in which training began, reported to the nearest year and month. If the exact month could not be recalled, the age of onset of training was referred to as the age in years on the previous birthday.

CHAPTER 2

REVIEW OF THE LITERATURE

This chapter will review the literature related to the following areas: menarche, age of menarche, age of menarche in athletes, and menarche and training.

Menarche

Physiological Basis

Menarche, or the onset of the first menstrual flow, is commonly viewed as an indicator of sexual maturity in females. At this point, the body prepares itself for reproduction. The attainment of menarche is not always indicative of a fully functioning reproductive system, and as described by Greulich, Day, Lachman, Wolfe, and Shuttleworth (1938), "It is the reflection of a physiological state which may occur, at different times during the puberal period in different individuals and which usually precedes by a considerable interval the attainment of the capacity to reproduce" (p. 54).

The menstrual flow is the result of monthly bleeding of the endometrium of the uterus, and is caused by a sudden reduction of progesterone and estrogen hormones at the end of the menstrual cycle (Guyton, 1981, chap. 81). The occurrence of the menstrual cycle is a result of a maturation of the hypothalamus. At this time, via a positive feedback system, gonadal hormones stimulate the hypothalamic-pituitary axis to secrete

increased amounts of gonadotropin hormones and estrogen essential for ovulation and monthly rhythmical cycles (Kulin, 1974).

Small amounts of these hormones exist before sexual maturation and interact in a negative feedback system. Menarche results from a change in the negative feedback system and appearance of the positive feedback relationship between the gonad and neural centers (Kulin, 1974). Guyton (1981) describes the events leading up to the onset of menarche:

> In the female, as in the male, the infantile pituitary gland and ovaries are capable of full function if appropriately stimulated. However, the hypothalamus is extremely sensitive to the inhibitory effects of estrogen, which keeps its stimulation of the pituitary almost completely suppressed throughout childhood. Then, at puberty, for reasons not understood, the hypothalamus matures; its excessive sensitivity to the negative feedback inhibition becomes greatly diminished, which allows enhanced production of gonadotropins and the onset of adult female sexual life (pp. 1015-1016).

The increased levels of estrogen produced at menarche cause an increase in the size of the female fallopian tubes, uterus and vagina. Estrogen produced at menarche is responsible for marked fat deposition in the hip, thigh, and buttocks area, causing the broadening of hips observed in the maturing female. Fat also increases in the genitalia, subcutaneous tissues and breasts. While causing increased bone growth, estrogen causes uniting of the epiphyses with the shafts of the long bones (Guyton, 1981, chap. 81). Thus, at menarche, the female undergoes physiological changes in her body.

Other Developmental Changes Related to Menarche

Studies have examined the age of menarche as related to the timing of other physical changes occurring during the adolescent years (Faust,

1977; Marshall and Tanner, 1969; Simmons and Greulich, 1943). These changes include increases in height, weight and skeletal age as well as development of secondary sex characteristics. In a longitudinal study of 200 girls, ages 7 to 17 years and of above-average socioeconomic status, in the Brush Foundation Regular Series, Simmons and Greulich (1943) examined relationships between menarcheal age, standing height and weight; skeletal age (assessed by hand, foot, elbow, knee, hip, and shoulder X-rays); annual increments; and weight-height indices. Skeletal age was found to correlate the best with menarcheal age. For 187 girls, the mean age of menarche was 151.52 months (12.63 years); the mean interpolated skeletal age was 156.99 months (13.08 years), with 50 percent of the skeletal ages occurring $\pm$3 months of the mean. Chronological age at menarche was found to be twice as variable as skeletal age.

Weight relationships with menarcheal and skeletal age remained positive until a later age than did height relationships. Early maturers were associated with a greater weight for height. For all girls, maximum increments in weight were spread over a two-year period, with values negatively related to the age of menarche. Maximum increments in standing height always preceded menarche. The average girl experienced maximal height growth during the year preceding menarche; some experienced it two years before; and late maturers seemed to have little or no spurt in height growth. The authors concluded that it was natural for some girls to grow at a fast rate and others to grow more slowly. In this study, the rate of growth had no reliable relationship to terminal size.

Marshall and Tanner (1969) studied the variation in patterns of physical changes of girls during puberty in 192 white British girls in

the Harpenden Growth Study. The study found that girls progress through five stages of pubic hair and breast development at different rates. The first signs of breast or pubic hair development appeared between the ages of 8.5 and 13.0 years in 95 percent of the girls. In general, most girls were into the mid- to late stages of development when menarche was attained. Again, peak height velocity was found to occur before menarche in all cases. The authors noted that the relation between different events of puberty was a better index than the chronological age at which they occurred, in that a girl of 17 years of age, who is growing rapidly and is at mid-stages of breast and pubic hair development, would be expected to menstruate in the near future. She would be considered a late maturer. On the other hand, if menarche had not occurred in a female who had stopped growing in height and had mature secondary sex characteristics, other explanations would have to be sought for the absence of menarche.

A longitudinal study by Faust (1977) analyzed developmental sequences and interrelationships among somatic changes of 94 girls, ages 6 through 18 years of age. Growth characteristics measured were weight; standing and sitting height; shoulder and hip width; subcutaneous tissue and strength. Secondary sex characteristic ratings were noted for axillary hair, pubic hair and breast development. The hand and knee were X-rayed for skeletal age. The time of greatest acceleration of growth for each of these measures was studied in relation to the girls' peak height velocity. Age of menarche was recorded as well.

The mean age of menarche was 12.79 years, varying from 10.5 to 15.8 years. Again, the girls were more similar to each other in skeletal age than chronological age at menarche. Skeletal age was significantly

correlated with chronological age throughout the adolescent growth period for height growth, meaning that, when matched at developmental points, girls who were older had achieved greater skeletal ages than those who were younger. The skeletal ages of early maturers, however, were more advanced than girls of that same chronological age while late maturers had skeletal ages less than those girls of the same chronological age.

The onset of menarche occurred after the midpoint of puberal growth period for height acceleration. Menstrual onset was a reliable indicator that the rate of height growth would slow down, although some girls did gain in height considerably after menarche. The most common pattern for increases in skeletal growth was for increases in leg growth to occur early in the growth years while hip width increased after menarche. Leg length growth was followed by increases in shoulder width, height and stem length (standing minus sitting height). The growth trend for shoulder to hip width ratio was to decrease in size, with hip width growth occurring at a faster rate than shoulder width through the puberal years.

Weight gain was associated with a gain of subcutaneous tissue and skeletal growth. The greatest increases in weight were more likely to occur after the peak height velocity than before it. Weight increases were found to follow increases in stem length and leg length; with increases in weight gain following the greatest increases in linear dimensions. Weight gains paralleled growth in subcutaneous tissue. These gains occurred relatively late in the adolescent growth period. The correlation between age of menarche and weight at menarche was zero. Faust noted that while Frisch and Revelle (1969, 1970, 1971) suggested

a critical weight hypothesis for the attainment of menarche, her data variation was too large to predict menarche from weight alone. Faust stated, "From the present analyses it seems more reasonable to conclude that the observed pattern of change in weight during the puberal period for height growth is a concomitant and not an instigator of menarche and associated puberal events" (p. 54).

Based on grip strength tests, the study showed that girls, in general, increase in strength during the puberal years. Strength was found to be positively correlated with chronological and menarcheal age early in puberty, but was found to be moderately or negatively correlated at the end of the puberal period. The author noted that because of the wide fluctuation in strength results of the girls and the variation in timing at peak height velocity, increases in strength may not be a very good indicator of maturity.

Girls late in reaching menarche tended to be taller, longer in stem length and leg length at menarche than girls who were young at menarche. This correlation did not predict ultimate height. Early maturing girls progressed through successive stages of breast, pubic and axillary hair development at younger ages than late maturing girls. Faust concluded that while differences are most apparent between early and late maturers during early adolescence, these differences are less apparent by the age of 18.

Other authors have found endomorphy, or fatness, related to early maturation and linearity in physiques associated with late maturation (Bruch, 1971; Hammar, M. Campbell, V. Campbell, Moores, Sareen, Gareis, and Lucas, 1972; Malina, 1978a; Roberts, Rozner, and Swan, 1971). Girls

who reached menarche early were heavier for their height than girls who attained menarche later.

Growth studies on females indicate that while a great deal of individiual variation exists, young girls pass through similar stages of development to reach maturity. The first signs of maturation are the appearance of pubic hair and breast development, followed by increases in height and weight. Increases in height and weight are largely the result of gains in skeletal growth and subcutaneous tissue. Peak height velocity generally precedes menarche and by the time menarche occurs, the development of secondary sex characteristics are well-established. Females continue to develop during the years following menarche. Menarche is but one event of many occurring in a series of changes during the adolescent growth years.

Age of Menarche

The age of menarche varies among population samples around the world, from about 12 years to 18 years of age. The majority of samples, including those from the United States, report an average age of menarche of approximately 13 years of age. There is also individual variation, as most of the samples have standard deviations of $\pm$ 2 years (Malina, 1978b; Johnston, 1974).

Secular Trend

The secular trend, or trend toward earlier maturation, as discussed by Johnston (1974), Malina (1978b) and Wyshak and Frisch (1982), is reflected in earlier ages of menarche reported by females in progressive,

industrialized nations of Europe, Australia, Japan, and the United States. This occurred from the mid- 1800's to the mid- 1900's. Today's female matures earlier than the female of a century ago. The age of menarche has decreased, for example, in Europe, from 17 to 13 in the years from 1830 to 1960 (cited by Johnston, 1974). No such trend, however, was observed in the underdeveloped nations of Africa, Asia and Latin America, while a reversal has been observed in parts of Africa and India (Malina, 1978b).

The reasons for the secular trend occurring are not fully understood. Malina (1978b) suggests that the secular trend was due to the elimination of growth-inhibiting factors; improved nutrition and health conditions, reduced child labor; reduction in family size; less famine and wars; and natural selection. Because heredity also plays a role in determining the age of menarche, Johnston (1974) proposes that an interaction between heredity and environmental determinants may best determine menarcheal ages.

Psychological Impact and Timing of Menarche

In the United States, the average age of menarche is approximately 12.8 years (cited in Frisch et al, 1981; Johnston, 1974; Malina et al, 1979; Wyshak and Frisch, 1982) and most females can recall age of menarche within two to three months (Bergsten-Brucefors, 1976; Damon and Bajema, 1974; A. Damon, S. Damon, Reed, and Valadian, 1969). In a review of studies on the psychological impact of menarche on early adolescent females, Greif and Ulman (1982) found menarche to be a significant event in the lives of females. The onset of menarche could be either a positive

(integrating, happy, excited) or negative (upset, scared) experience, depending on the girl's age at the time, her knowledge and expectations, family support and her own personality. Girls who began to menstruate early (10 or 11) have had less chance to be prepared for the event. Lack of preparation for menarche correlated with negative experiences. Thus early maturers were at a disadvantage. Timing of menarche was important, depending on whether the event helped the individual "fit in" with her peers. If a girl's friends were beginning to menstruate about the same time she was, she would be "in phase" with her peers. Being early or late could result in being different from the peer group.

A study by Ruble and Brooks-Gunn (1982) examined the reactions of girls, in the fifth through twelfth grade, to the onset of menarche. In general, the girls' reactions reflected mixed emotional reactions that were neither entirely positive (happy, excited, proud) or negative (embarrassed, angry, scared, upset). However, girls who were unprepared or reached menarche early were more likely to have negative initial reactions, more symptoms and for some (seventh graders), more negative self-images. When the subjects were asked what age they would choose to begin menstruating, 51 percent chose an average age, 12-13 years, because of an expressed desire to be like their peers. The rest preferred older ages because they would tend to be more prepared and the later menstruation would not limit their activities as an earlier onset of menarche would. For the most part, the girls did not feel their behavior or activity restricted because of menarche, but many noted that swimming and other athletics, and for some, school work and chores, were limited during their periods. The authors concluded that initially, menarche may create inconvenience, ambivalence,

and confusion, particularly for early-maturing and unprepared girls, but may not be as traumatic an experience as was previously believed.

Age of Menarche in Athletes

An early study of female Hungarian athletes (Erdelyi, 1962) found the age of menarche of the athletes, 13.6 years, to be close to the equivalent of the Hungarian average age of menarche. More recent studies have reported late ages of menarche in athletes, with the exception of swimmers, compared to the non-athlete population. While the average age of menarche in the United States is approximately 12.8 years of age, menarcheal ages from 13 to 15 years, with some as late as 18 and 19 years of age, have been reported in young female athletes, including ballet dancers (Frisch et al, 1981; Malina et al, 1973; Malina et al, 1978; Warren, 1980). The delayed menarche is common in athletes of national and international calibre. The age of menarche tends to vary according to sport; with gymnasts, runners, and dancers reporting the latest ages.

Three studies by Malina indicate the later age of menarche in athletes at high competitive levels. The first (Malina et al, 1973), found a later age of menarche in 66 college track and field athletes as compared to 30 non-athlete females of college age. The mean age of menarche for the athletes was 13.58 years while that of the non-athletes was 12.23 years.

In a second study, Malina et al (1978) reported the age of menarche in athletes at different competitive levels in different sports. He compared the age of menarche of 110 non-athletes, 59 former high school athletes, 53 college athletes of various sports, and 18 Olympic volleyball

candidates. Results showed that the non-athletes attained menarche significantly earlier, 12.29 years, than the former high school athletes (13.02 years), college athletes (13.05 years), and Olympic volleyball athletes (14.18 years). The age of menarche of the Olympic athletes was later than the high school and college athletes. High school and college athletes did not differ significantly in age of menarche. The Olympic athletes attained later ages of menarche compared to sport-specific college athletes, except that of the gymnastic-track group (13.21 years) and the tennis athletes (13.73 years).

In a third study, Malina et al (1979) reported the age of menarche, family size, and birth order in athletes at the 1976 Montreal Olympic Games. He found that on the average, athletes reached menarche later than the general population in their respective countries. The mean age of menarche for 139 athletes was 13.66 years. Gymnasts, runners, and rowers had later menarches (14.5, 14.3 and 13.7 years, respectively) than swimmers, who attained menarche at 13.1 years. Low to moderate correlations were found in age of menarche and family size and birth order. Athletes from larger families tended on the average to have later ages of menarche than those of smaller families, especially in rowers and track and field athletes.

Malina offers the following two-part hypothesis for the late age of menarche observed in athletes: 1) the physique characteristics (long-legged, narrow-hipped, less weight for height, and linear builds) of the late maturer make her more suitable for success in athletics and 2) the early maturing girl may be socialized away from sports competition early in adolescence while the late maturing girl experiences early success and

tends to perform at higher levels than early maturing peers of the same age later in adolescence. Malina states, "On the contrary, they /late maturers/ probably have heightened motivation levels associated with the success experienced in athletic competition, and thus comprise the female athlete population in the late teen-ages and early twenties" (Malina et al, 1978, p. 221).

Lending support to Malina's hypothesis, an early study by Baker (1940) sought to determine factors influencing the participation of females in physical education activities in women 15 to 25 years of age. Physical education activities included activities such as skiing, baseball, tennis, volleyball, basketball, and swimming. Girls who reached menarche after fifteen were found to participate more in physical education activities than those who reached menarche earlier.

Espenschade (1940) found that performance in several track and field-related items was not related to skeletal age or age of menarche in a group of non-athlete adolescent girls. Late maturers, however, tended to be the better performers. Cumming, Garand, and Borysyk (1972) related bone age with performance in track and field events of 158 girls at a camp for track and field athletes. A slight delay in the mean skeletal age (14.6 years versus 15.0 years in chronological age) was found in the girls. Bone age showed a higher correlation to performance than did chronological age in seven of the ten events. A significant correlation between bone age and performance was found in four of the ten events: high jump, 440 yard and 100 yard runs, and broad jump. Another study by Beunen, de Beul, Ostyn, Renson, Simons, and van Gerven (1978) indicated that motor performance of girls was poorly related to

maturity status, with better performances reported for late maturing girls. Differences in maturity groups were most evident in late adolescence.

Malina et al (1979) cites two studies supporting the second part of his hypothesis that young girls may be socialized away or into sport. Snyder and Spreitzer (1976) note that the socialization process for sport for girls begins early in childhood and is influenced by significant others, such as family, peers, teachers and coaches. As suggested by Jones (1949), results of the Oakland Growth study show that late maturing girls are more in-phase, developmentally, with early and average maturing boys of the same chronological age. An early-maturing girl who is 1-2 years more physically advanced in relation to her female peers is 3-4 years advanced to her male chronological counterpart, which makes a difference in social interaction. The early maturer may seek out older friends closer to her physiological age. The girl is socialized away from physical activity and sport within her age group. Jones (1949) observes:

> The first thing to note is that she finds that she has become physically very conspicuous, at a time when conspicuousness is not valued . . . she is handicapped when she attempts to participate in the active playground games which are still within the interests of her classmates--for in the case of girls, sexual maturing, although it brings greater strength, often leads to a decreased skill in physical activities involving running and jumping (p. 77).

Other authors have reported late ages of menarche among athletes. Frisch et al (1981) examined the age of menarche of 21 Harvard college swimmers and 17 runners to 10 non-athlete Harvard students. She found the average age of menarche to be 13.9 years, compared with 12.7 years for the control subjects, which was significantly different. One of the runners achieved menarche at 18.2 years and two of the swimmers had not achieved menarche as of 19.1 years of age. The average age of menarche

for the swimmers and runners was 13.9 years and 13.8 years, respectively.

Several studies have found the age of menarche to be delayed in ballet dancers (Calabrese, Kirkendall, Floyd, Rapoport, Williams, Weiker, and Bergfeld, 1983; Cohen, Kim, May, and Ertel, 1982; Frisch et al, 1980; Warren, 1980). Warren (1980) studied the effects of exercise on pubertal progression and reproductive function in 15 ballet dancers, ages 13-15 years, for a four year period. Menarche was delayed, occurring at 15.4 years, significantly different from normal controls (12.5 years) and a group of music students (12.6 years). Two of the dancers had not achieved menarche as of age 18. A delay was found in breast development but not in pubic hair development. The author stated, "In conclusion, 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).

Another study by Frisch et al (1980) studied the age of menarche of 67 dancers at three professional ballet schools. The mean age of menarche was 13.7 years, significantly later than mean ages of 12.8 and 12.9 years reported by American girls. Fifteen of the dancers attained menarche at 18.0 years of age or later. In another study of professional dancers, Cohen et al (1982), found the average age of menarche to be 14.2 years, later than 12.5 years for controls. Nine of the dancers, ages 18-20 years, had not reached menarche. Calabrese et al (1983) reported a delayed menarche of 14.3 years, which was significantly later than age of menarche of other published control groups.

Two studies on Indian sportswomen indicate a later age of menarche in athletes compared to non-athletes. Sidhu and Grewal (1980) reported

the age of menarche of 264 Indian sportswomen attending training camps at Patiala, India. The women specialized in hockey, volleyball, basketball and other athletics. The mean age of menarche of the combined sample of athletes was 15.19 years, which was significantly later than the age of menarche, 14.05 years, of a group of 108 women serving as controls. The authors concluded that menarche was delayed by about one year in the sportswomen.

Another study on 220 Indian college sportswomen by Sidhu and Singal (1981) found the mean age at menarche to be 15.04 years, which was also later than the 14.05 years of the control group. Based on anthropometric measurements, the early maturing girls were heavier, taller and had broader skeletal diameters than late maturing girls at adult age; but the differences were not found to be significant.

Thus, the literature reports a delay in menarche among athletes at higher levels of competition. This is found to be true among athletes of many nations where the age of menarche is later than the average for that respective country. In particular, late ages of menarche are reported in athletes in gymnastics, track, and ballet.

Menarche and Training

Researchers have attempted to explain the delay of menarche observed in athletes. While Malina et al (1978) proposed that late maturers were more biologically predisposed to be successful in sport and were socialized into sport, another viewpoint taken suggests that early training is responsible for the delay in menarche. This is based on the observation that athletes who train before menarche report later ages of menarche than

athletes who begin training after the age of menarche (Frisch et al, 1981; Sidhu and Grewal, 1980).

In the study by Frisch et al (1981), examining the age of menarche of 21 Harvard college swimmers and 17 runners, the athletes reported a later age of menarche, 13.9 years, compared to the age of menarche of the control group, 12.7 years. The athletes were further classified according to whether their training began before menarche (premenarche-trained) or whether their training began after menarche (postmenarche-trained). The premenarche-trained group was composed of 12 swimmers and 6 runners; the postmenarche-trained group was formed by 9 swimmers and 11 runners. The mean age of the premenarche-trained group was 18.7 years and the mean age of the postmenarche-trained group was 19.4 years. The average duration of past training for the athletes of the first group was 7.9 years and for that of the second group was 4.2 years. Results showed that the 18 premenarche-trained athletes attained menarche at a later age, 15.1 years, than the 20 postmenarche-trained group, who reached menarche at 12.8 years of age. The authors concluded that "For all premenarche-trained athletes, menarche was delayed 0.4 year (five months) for each year of training before menarche" (p. 1560). Frisch continues, "Our findings . . . indicate that intense physical activity does in fact delay menarche, since the runners and swimmers who began their training before menarche attained menarche more than two years later than their teammates whose training began after menarche" (p. 1562). In this study, the type of intense training previously experienced by the athletes was not reported.

Sidhu and Grewal (1980) examined the age of menarche in 264 Indian sportswomen attending training camps in Patiala, India, and found a delay

in menarche associated with training. The sportswomen, who specialized in hockey, volleyball, basketball and other activities, achieved a mean age of menarche of 15.19 years, significantly later than the 14.05 year age of menarche of the control group. The data was further divided into girls who "started taking part in sports" before menarche; girls who took up sports after menarche; and girls who attained menarche and took part in sports at the same time. From this classification, about 60 percent of the girls in all sports took up sports before menarche and 36 percent of the girls began sport after menarche. The group who began sport before menarche reported a mean age of menarche of 15.69 years while that of the group taking up sport after menarche was 14.38 years. T-tests showed the two groups to be significantly different in age of menarche, with the first group attaining menarche later than the second group and the control group, whereas the age of menarche of the second group was similar to the age of menarche of the control group. The authors concluded that "It thus seems most probable that menarche is delayed under the influence of strenuous physical activity" (p. 202). The authors did not indicate the age when the girls began to take part in sports nor the nature of the early participation or strenuous physical activity.

A popular hypothesis recently used to explain the delay in menarche is one of a critical relationship between body weight and menarche. Developed by Frisch and Revelle (1970), this hypothesis was refined to a critical lean/fat ratio, proposing that menarche occurs at a body composition of about 17 percent fat and menstrual cycles that had been interrupted could be restored at a level of 22 percent fat (Frisch and McArthur, 1974). The lower metabolic rate was believed to lead to endocrine changes

causing the onset of menstrual cycles. According to this theory, loss of fat as a result of training by athletes may prevent them from reaching menarche or maintaining regular menstrual cycles.

In a study by Frisch et al (1980) on 89 young female ballet dancers, a high incidence of primary amenorrhea (menarche not achieved), secondary amenorrhea (lack of cycles for three months), and irregular cycles (intervals between menstruation of more than 38 days but less than 3 months) was found. The dancers attended professional schools or danced in companies. Nine of the dancers had not achieved menarche by 18.0 years of age or later and 11 of the dancers had not reached menarche by 14.3 years. Fifteen percent reported secondary amenorrhea; 30 percent had irregular cycles and 33 percent reported regular cycles. Frisch et al reported that dancers with amenorrhea or irregular cycles were significantly leaner than dancers with regular cycles and those dancers who had not achieved menarche were leaner than dancers of the other groups. The weight for height of the dancers was below the critical weight for height for attaining menarche. Because two of the dancers with irregular cycles were in the range of normal fatness for maintaining cycles, the authors noted that stress (emotional or physical) could override the effect of weight. The researchers stated that the delayed menarche of the dancers may show that late maturers choose to be dancers, but, more than likely, the low food intake typical of ballet dancers and hard training causes thinness, which in turn, is responsible for the delay in puberty. This was reflected in the fact that most of the dancers started training at an early age (7.4 years) and had a high incidence of amenorrhea and irregular cycles. The age of onset of training for dancers who had not achieved menarche at 16 years of age or later was

8.4 years and was 7.8 years of age for those with secondary amenorrhea. Girls with irregular cycles began training at 7.2 years of age and those with regular cycles started training at 7.4 years. Although early training was viewed as being responsible for late menarche and irregular cycles, those dancers with regular cycles reported beginning training close to or earlier than the age of dancers with amenorrhea and irregular cycles. The fact that some subjects with regular cycles had early training does not support Frisch's hypothesis that training delays menarche or prevents them from maintaining regular cycles, but is consistent with the selectivity theory. This study focuses only on those dancers who have achieved a certain level of success in dance and does not look at those dancers who had early training but did not continue to participate in ballet. The term "hard training" is not defined in this study nor is the type of early training experienced by the dancers.

Warren (1980) reported a significant delay in the age of menarche in 15 young ballet dancers, ages 12-15 years of age, in a four-year longitudinal study measuring the effects of exercise on pubertal progression and reproductive function. The age of menarche was 15.4 years of age for the dancers, compared to 12.5 years of age for age-matched controls. Two dancers had still not reported reaching menarche by the age of 18. Training history was recorded in terms of the number of hours danced per week. Starting at age 8, the ballet dancers trained 3.5 hours per week, on the average, and increased year by year to 30.0 hours per week of training at age 17 or more. The dancers had a delay in menarche and breast development but none in pubic hair development. The authors noted a delay in bone age in the dancers. They also had a decreased upper to lower body

length ratio and a greater arm span compared to other family members, although their final height did not differ. The body weight and body fat of the dancers were less than that of the controls at all ages. Low to low-normal levels of gonadotropin hormones were reported among the dancers.

In support of Frisch's critical lean/fat ratio hypothesis, Warren suggested that exercise may have an effect on the set point at puberty and, along with low body fat, may prolong the prepubertal period. Warren also notes, in agreement with Malina et al (1978), that ballet may attract girls with specific physique characteristics, such as the long bone growth observed in the dancers.

A study by Vandenbrouke, van Laar, and Valkenburg (1982) reinforces and refines the hypothesis proposed by Frisch et al (1978). In this study an association was found between thinness, intensive sports activity and delayed menarche. Vandenbrouke et al categorized 648 Dutch girls, aged 10-14, as to whether they were thin and engaged in intense physical activity or not and to whether they were not thin and engaged in intense physical activity or not. Being involved in physical activity meant that the person was a member of a sports club and/or she participated in a competitive sport. Attainment of menarche was noted for each group. The authors noted that the presence of either thinness (measured by body mass index) or intensive sports activity was associated with nearly a twofold decrease in the number of girls who had reached menarche. With both factors present the decrease was fourfold. The incidence of menarche reported in girls who were both thin and involved in intensive sport was 15 percent; those who were thin and not in sport who reached menarche was

37 percent. Forty-seven percent of the girls who were not thin and in sport reached menarche while 75 percent of the girls who were not thin nor involved in sport had attained menarche. The authors concluded that their data supported the hypothesis that thinness and physical activity may cause the delay in menarche. They indicated that the two factors were synergistic, in that many girls who were thin and involved in sport had not reached menarche. Vandenbrouke et al deemed this reasonable in that metabolic changes were related to both factors. The authors of the study noted that limitations of the study were the use of body mass index to denote thinness and changes in body mass index that were likely to naturally occur in this age group. Although according to this study it may seem likely that thinness and intense activity does delay menarche, the design of the study does not allow for an assessment of a cause-effect relationship.

The studies cited indicate that the lean/fat ratio hypothesis proposed by Frisch and McArthur (1974) has been used to explain the delay of menarche in athletes. However, a comprehensive review by Scott and Johnston (1982) indicated that the hypothesis has a number of serious flaws, namely: 1) the methodological errors present for estimation of percent fat, based on the regression equation expressing body water as a function of weight and height; 2) the critical levels of fat do not apply to many other exceptions reported in the literature; and 3) other confounding factors that may be equally responsible.

Inferences to delayed menarche as a result of training are based on associations between girls who train early and those athletes involved in strenuous sports. The effects of physical activity and exercise on human growth are positive (Corbin, 1980; Espenschade, 1960; Rarick, 1973). Rarick

(1973) states, "Exercise has a profound impact on body composition during growth as in all other periods of life. A physically active life develops lean body mass at the expense of fat both in boys and girls" (p. 122). Rarick adds that adaptation to exercise also results in increased functional aerobic capacity and overall improved fitness, with the same workload performed at a lower heart rate. Espenschade (1960) notes that exercise of all sensory and neuromuscular functions is essential for formal development. She reports that desirable changes in bones, connective tissues, fat and musculature occur as a result of exercise. Corbin (1980) states that "Children have great potential for physical fitness performance. While their gross performances rarely equal those of adults, within their own size limitations, children are virtually unlimited in their performance potential" (p. 132). The question arises as to whether too much training and competition can affect the natural onset of menarche. Studies reporting early training patterns of young females in sport are limited.

A three-part study performed in Michigan on youth sports of females, ages 5-17 years of age, found that peak participation levels in most agency-sponsored sports occurred at 12 to 13 years of age, with progressive increases preceding these years and declines following these years (Seefeldt, Gilliam, Blievernicht, and Bruce, 1978, chap. 2). Girls in competitive sports were introduced to their sport largely through recreation play, agency-sponsored sports or private lessons around 9-10 years of age while almost all children were introduced to their sport by age 12 (State of Michigan, 1978, chap. 3). A "1982 Sports Participation Survey" (NFSHSA, 1982) reported that the number of girls participating in junior and senior high school sports during 1970-71 was 294,000 and had increased to approximately 1.8 million in the 1981-82 school year.

Butts (1982) reported physiological profiles of high school female cross country runners, ages 13-18, attending summer camps in 1978, 1979 and 1980. She found that the girls had higher VO_2 max values than what was previously reported for their age group, but were lower than those of national caliber distance runners. In the two months prior to the testing, the subjects ran an average of 25 miles per week, but most said they ran more during cross country in the fall and track in the spring. The average age of the runners was 15.6 years and the mean number of years in competition was 2.2 years. A study by Wakat et al (1982) reported no differences in the age of onset of training among 41 college cross country runners who were classified as having regular or oligomenorrheic (irregular)/amenorrheic cycles. Both groups started training at approximately 14 years of age, had trained competitively for 5 years and had trained an average of 10 months per year. The group of runners with regular menstrual cycles started training about 2 years after menarche, while those with irregular cycles started training around the time of menarche (0.1 years before menarche). The mean age of menarche for the runners with regular cycles was 12.9 years, which was significantly earlier than the 14.3 years age of menarche of the oligomenorrheic/amenorrheic runners.

Four swimmers, ages 15-19 years, who were 2-4.5 years past the age of menarche reported training schedules of 2-3 hours/day, 6 day/week for 3-6 years (Bonen, Belcastro, Ling, and Simpson, 1981). Although the swimmers had attained menarche, the authors suggested that depressed hormone levels were responsible for anovulatory cycles in the girls. An earlier study by Astrand, Engstrom, Eriksson, Karlberg, Nylander, Saltin, and Thoren (1963) reported no delay in menarche associated with intensive

training of young females, and in fact, found them to be more mature. In the sample of 30 girls, differences in lung and heart volume and functional capacity were related to each girl's training volume reported in hours/week and meters/week.

While these few studies given an indication of the nature of early training, those studies proposing a cause-effect relationship between intense physical activity and a delay in menarche do not. Reports of training history related to age of menarche are limited to a few studies on swimmers, ballet dancers and girls in track and/or cross country. The studies cited in the literature relating training and menarche indicate that those athletes who train before menarche report a later age of menarche than those who begin training after menarche (Frisch et al, 1981; Sidhu and Grewal, 1980). This association has been interpreted as a cause-effect relationship by some authors, hypothesizing that the early training causes a delay in menarche. Studies closely examining the nature of early training responsible for the delay, however, are limited. Authors who suggest that intense physical training delays menarche do not define what is meant by "intense" physical training nor do they give a description of the type of early training experienced by the athletes. Limited training histories are reported for swimmers, ballet dancers and runners.

Summary

In summary, the onset of menarche, or the first menstrual flow, is a significant event in the life of a female. Physiological changes occur in her body which prepare her for reproduction. Other maturational factors have been found to be related to the timing of menarche. Caused by a

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maturation of the hypothalamus, menarche occurs late in the puberal sequence and is usually preceded by peak height velocity. Development of secondary sex characteristics are established by the time menarche is attained.

The age of menarche reported in athletes at high levels of competition is later than the age of menarche of the non-athlete population for females of that respective group. Ballet dancers, gymnasts and runners report the latest ages of menarche. Recently, early training has been proposed as a factor being responsible for the delay in menarche, based on the observation that girls who begin training before the onset of menarche attain menarche at a later age than those girls who begin training after the onset of menarche. However, few studies have examined the early training patterns of females.

It has also been proposed that late maturers, having a predisposition to mature late, may have a specific physique conducive to early success, training and continued participation in sports. This may be reflected in the late age of menarche observed in athletes at high levels of competition. According to this hypothesis, late maturity and early training may co-exist in the athlete without a causal relationship existing between the two variables. This hypothesis is supported in the literature (Baker, 1940; Beunen et al, 1978; Cumming et al, 1972; Espenschade, 1940; Jones, 1949; Warren, 1980).

The studies (Frisch et al, 1981; Sidhu and Grewal, 1980) purporting a cause and effect relationship between early training and late menarche have not controlled in any way for the selectivity factor, thus cannot conclude that it, rather than the early training, delayed menarche. For example, almost all girls wanting to take part in ballet will start very

young. Many will find that they will not be best suited for it and will drop out. By studying only those girls who advanced in ballet, researchers have not isolated the effect of early training since they are not studying the drop-outs who started training at the same early age. The product of both selection and training are seen in the results of these studies. While not demonstrating cause and effect, studies on late menarche and early training are consistent with the selection or physique hypothesis.

CHAPTER 3

PROCEDURES

The procedures of this study are divided into the following sections: 1) selection of subjects; 2) development of instruments; 3) collection of data; and 4) analyses of the data.

Subjects

Subjects for the study included 118 females, ages 18 to 29, currently enrolled at the university level. The average age of the subjects was 20.51 years of age. Participation in the study was voluntary. Subjects were grouped into one of the following categories: 1) non-athletes--females who had not been involved in formal training or athletics of any kind; 2) former high school athletes who had competed in track and/or cross country running events at the junior or senior high school level at least two years but not at the university level; and 3) university athletes currently competing at the university level in track and/or cross country running events during the 1982-83 academic year. The purpose of the classification of the three groups was to test subjects at different competitive levels; high school and university level athletes, with non-athletes serving as the control group.

Originally, there were 38 subjects in the non-athletic group; 41 subjects in the former high school runner group; and 39 subjects in the university level runner group. Data from three subjects of the first

group; three subjects of the second; and six subjects of the third group were deleted because of the subjects' failure to complete the study or failure to meet the requirements for being in one of the three groups. Total data was reported for 106 subjects consisting of 35, 38, and 33 subjects in the non-athlete, former high school runner, and university level runner athletic group, respectively.

The 35 non-athletes and 38 former high school athletes were presently or formerly enrolled in Concepts of Physical Education, a required class, or lifetime sports classes at Kansas State University, Manhattan, Kansas. Six of the non-athletes were enrolled in Manhattan Christian College, a small college located close to Kansas State University. Ten university level athletes were members of the track and/or cross country teams from Kansas State University; 17 athletes were from the University of Nebraska at Lincoln, Nebraska; and six of the athletes were from Wichita State University, at Wichita, Kansas. The University of Nebraska, Kansas State University, and Wichita State University are members of the National Collegiate Athletic Association. The University of Nebraska and Kansas State University belong to the Big Eight Conference and Wichita State University is a member of the Missouri Valley Conference. The teams represent average to high level competitors, with many competing nationally and some internationally. Thirteen of the 33 athletes were classified as sprinters while the remaining 20 were middle- and long-distance runners.

Instruments

A survey (Appendix A) was developed by the researcher and committee members, Dr. Anthony Wilcox and Dr. Mary McElroy, of the Health, Physical

Education and Recreation Department at Kansas State University, to assess the training and menstrual history of the subjects. The survey was modeled after a questionnaire developed by Rose E. Frisch et al (1981) concerning menstrual and training histories of athletes. Modifications and additions were made requesting information pertaining to age of menarche; menstrual history since onset of menarche; specific menstrual patterns within the past 12 months; and training history from onset to the present. The age of menarche, in terms of years and months, was requested. If the exact month could not be recalled, the age of menarche was referred to as the age in years on the previous birthday. Age of onset of training was requested in a similar manner. Training referred to regular or formalized training in a club or school sport. Examples included Amateur Athletic Union (AAU) or school swimming, track, cross country, volleyball, gymnastics and basketball. Recreational and intramural activities were not considered as training. Information requesting the number of intense months in training, average mileage and year by year menstrual patterns was requested. Included in the survey were two measures of psychological stress (Sport Competition Anxiety Test and the College Schedule of Recent Experience), a questionnaire on current diet, and a comment on the accuracy of the subject's responses. In addition to completing the survey, anthropometric measurements were taken. Survey responses to the variables age of menarche, age of onset of training and months involved in training per year are reported in this study. Data concerning the other variables will be reported at a later date.

Before the survey was given to the subjects in the study, it was completed by three physical education graduate students to give the

researcher an indication of time required to complete the survey and to test the clarity of the questions. Modifications were made as necessary. Approximate time to fill out the survey was estimated at 45 minutes for an athlete with an extensive training history.

The survey and a proposal of the study were presented for review to the Committee for Rights and Welfare of Human Subjects, Department of Health, Physical Education and Recreation at Kansas State University. Upon approval, data collection began.

Collection of Data

Data was collected over a five week period, from mid-March to mid-April, 1983. The researcher introduced the nature of the study to students and requested volunteers from those students enrolled in Concepts of Physical Education and lifetime sport classes in the HPER department at Kansas State University. Former Concepts of Physical Education students and students at Manhattan Christian College were also contacted. The researcher called coaches of the women's track and cross country teams at Kansas State University, the University of Nebraska and Wichita State University. Letters (Appendix B) explaining the nature, purposes, and procedures of the study as well as a copy of the survey which was to be given to each athlete, were sent to each coach for review.

Subjects in the non-athlete and former high school athlete group and members of the Kansas State University track team completed the survey in a designated testing room of the HPER department of Kansas State. The testing was conducted at various times of the day. Athletes from the University of Nebraska and Wichita State University were tested over a

1 to 2-day period at their respective universities. The survey was administered by the researcher during testing at Kansas State University and by the researcher and two other physical education students at the University of Nebraska and Wichita State University.

Before completing the survey, each subject read and completed an informed consent form (Appendix C) containing the purposes, procedures, and confidentiality of the study. Subjects recorded a school and permanent address on a paper attached to the informed consent form, as a reference for the researcher to verify responses, make later contact for future studies, and to send results of the study to the subject when the study was completed.

Upon completion of the informed consent form, the subject was assigned a coded survey corresponding to a code on the address sheet attached to the informed consent form. The informed consent form, address sheet and master list of codes corresponding to the survey codes were kept by the researcher in a confidential file. Anthropometric measurements were taken on the subjects. Then subjects were allowed to fill out the survey at their own pace. The researcher was available for questions during the testing.

Analyses of Data

The following variables were evaluated from the surveys: age when tested, age of menarche, age of onset of training, the number of months trained per year in sports and the number of months trained per year in track and/or cross country. Age variables were converted from years and months to the number of years, calculated to the nearest second decimal.

All variables were coded and analyzed using the Statistical Analysis System (SAS) programs available on the Kansas State University computer facilities.

Means, standard deviations and ranges of age when tested, age of menarche, and age of onset of training for each group, separately and combined, were reported. ANOVA and the Least Squared Means Method were performed for the variable, age of menarche, in the three groups, to note differences existing between them. A correlation analysis was performed on the age of menarche and age of onset of training variables of the former high school and current university level athletes, separately and combined, to see if there was a relationship between the two variables.

Athletes were further classified according to whether the age of onset of training preceded or followed the age of menarche. The mean age of menarche was reported for each of these groups according to this classification, and according to whether the subject was in the high school or university level group. ANOVA and single degree of freedom comparisons were used to identify any differences and interactions present according to classification or group effect. Age of onset of training was analyzed in a similar manner, with subjects classified according to whether the age of onset of training preceded or followed the age of menarche.

The means and standard deviations of the number of months trained per year, from ages 5 through 17, of each athletic group were computed. T-tests were used to find differences between the former high school and university level athletes in the number of months trained at each year. Total months in training were accumulated year by year, starting at year 9 through year 17, for each group. T-tests were again used to detect differences between the two groups.

The number of months trained per year in track and/or cross country was analyzed in a similar way, with comparisons being made between the former high school and university level athletes on a year by year basis, from year 5 through 17. T-tests were also used to compare the number of accumulated months of training in track and/or cross country of the two groups, from years 9 through 17.

An alpha level of .05 was used for determining statistical significance, except in the analyses using multiple t-tests, where the alpha level of .05 was adjusted for the number of comparisons made using the Bonferroni technique.

CHAPTER 4

RESULTS AND DISCUSSION

Data for 106 subjects was collected and analyzed. Included in this chapter are the results of the data analysis, the interpretation of the analysis, and a discussion of the significance of the results.

Descriptive Characteristics

Descriptive characteristics of the non-athlete (NA), former high school (HS), and university (U) groups are presented in Table 1. The number of subjects in each group, means, standard deviations and ranges of age when tested, age of menarche, and age of onset of training are listed for each group. The overall mean age for 106 subjects was 20.51 $\pm$ 2.16 years. The average age of menarche for the three groups was 13.39 $\pm$ 1.64 years. The average age of onset of training for the HS and U groups combined was 12.42 $\pm$ 2.00 years.

Table 1. Age when tested, age of menarche and age of onset of training of NA, HS and U groups (means, standard deviations, ranges)

	n	Age, Yrs	Age of Menarche, Yrs	Age of Onset of Training, Yrs
NA	35	20.86 $\pm$ 3.14	13.26 $\pm$ 1.27	
Range		(18.38-29.38)	(10.83-15.42)	
HS	38	20.46 $\pm$ 1.61	12.95 $\pm$ 1.69	12.38 $\pm$ 1.68
Range		(18.71-25.67)	(8.17-17.00)	(7.00-15.75)
U	33	20.19 $\pm$ 1.26	14.03 $\pm$ 1.76	12.46 $\pm$ 2.35
Range		(18.46-23.21)	(11.83-18.00)	(6.08-18.33)
Total	106	20.51 $\pm$ 2.16	13.39 $\pm$ 1.64	12.42 $\pm$ 2.00

Table 2 contains the one-way ANOVA for the age of menarche of the NA, HS and U groups. The analysis reported a significant difference in the mean age of menarche among the three groups $/\overline{F}$ (2, 103 = 4.27, $p < .05/$. Further analysis, using the least square means method, showed that the mean age of menarche of the U group, 14.03 $\pm$ 1.76 years, was significantly later than that of the HS and NA groups, 12.95 $\pm$ 1.69 and 13.26 $\pm$ 1.27 years.

Table 2. One-way ANOVA for age of menarche for NA, HS and U groups

Source	DF	Sum of Squares	Mean Square	F-Value	P-Value
Model	2	2155.31	1077.66	4.27	.0166
Error	103	26018.57	252.61		
Corrected Total	105	28173.88			

Least Square Means Analysis for Difference Between Groups

Group	Age of Menarche, Yrs	Group	P-Values	
			HS	U
NA	13.26 $\pm$ 1.27	NA	.4047	.0483*
HS	12.95 $\pm$ 1.69	HS		.0051*
U	14.03 $\pm$ 1.76			

*$p < .05$

Pearson product-moment correlations were computed between the age of onset of training and the age of menarche for HS and U groups, separately and combined. Within the HS group, the age at onset of training did

not correlate with the age of menarche ($r = .13$, $p = .4358$). The same was true of the U group, where $r = .10$ ($p = .5706$). When both groups were combined, there was still no correlation between the variables ($r = .02$, $p = .8645$). Thus for both groups, no relationship was found between the age of onset of training and age of menarche.

One way to examine the relationship of training and age of menarche that has been used in previous studies is to classify athletes according to whether their onset of training occurred before or after their age of menarche. Table 3 lists the means and standard deviations of age of menarche, in both the HS and U groups, for those athletes whose age of menarche preceded their onset of training (postmenarche-trained) and of those athletes whose training preceded their age of menarche (premenarche-trained). The average age of menarche of both HS and U postmenarche-trained groups, combined, was 12.24 $\pm$ 1.48 years. The combined average age of menarche for the premenarche-trained HS and U groups was 14.15 $\pm$ 1.59 years (Table 3).

Table 3. Age of Menarche of HS and U groups (means and standard deviations) according to whether menarche preceded onset of training or training preceded menarche

	n	Menarche < Training	n	Training < Menarche
HS	15	11.78 $\pm$ 1.58 yrs	23	13.71 $\pm$ 1.29 yrs
U	11	12.88 $\pm$ 1.10 yrs	22	14.61 $\pm$ 1.76 yrs
Total	26	12.24 $\pm$ 1.48 yrs	45	14.15 $\pm$ 1.59 yrs

The ANOVA for the mean age of menarche in the HS and U groups, classified according to whether they were postmenarche- or premenarche-trained, is presented in Table 4. The analysis indicated a significant

model effect /F (3, 67 = 11.44, p = .0001/. Single degree of freedom comparisons showed no interaction between the group and classification factors /F (1, 67 = .08, p = .7829/. The group effect was statistically significant /F (1, 67 = 7.26, p = .0089/, indicating the average age of menarche of the HS group was earlier than the average age of menarche of the U group. The statistically significant classification factor, /F (1, 67 = 24.38, p = .0001/ means that the age of menarche of the girls whose menarche preceded their onset of training was earlier than the age of menarche of girls whose training began prior to reaching menarche.

Table 4. ANOVA for mean age of menarche in the HS and U groups for girls whose menarche preceded onset of training and for girls whose training preceded age of menarche

Source	DF	Sum of Squares	Mean Square	F-Value	P-Value
Model	3	7644.03	2548.01	11.44	.0001
Error	67	14922.67	222.72		
Corrected Total	70	22566.70			

Single Degree of Freedom Comparisons

Source	DF	Sum Squares	F-Values	P-Values
Classification	1	5429.93	24.38	.0001
Group	1	1616.01	7.26	.0089
Interaction	1	17.04	.08	.7829

To further study the relationship between the age of onset of training and the age of menarche, the age of onset of training was analyzed in a parallel manner as the age of menarche. Table 5 contains the age of onset of training for the HS and U athletes whose menarche preceded their onset of training and for the HS and U athletes whose training began prior to their menarche.

Table 5. Age of onset of training of HS and U groups according to whether menarche preceded onset of training or training preceded menarche (means, standard deviations)

	n	Menarche < Training	n	Training < Menarche
HS	15	13.23 ± 1.42 yrs	23	11.83 ± 1.63 yrs
U	11	14.54 ± 1.56 yrs	22	11.42 ± 1.96 yrs
Total	26	13.78 ± 1.59 yrs	45	11.63 ± 1.79 yrs

The mean age of onset of training of the postmenarche-trained HS and U groups, together, was 13.78 ± 1.59 years. The premenarche-trained HS and U athletes had an average age of onset of training of 11.63 ± 1.79 years, combined.

The ANOVA for mean age of onset of training of HS and U groups classified as postmenarche- or premenarche-trained is presented in Table 6. The analysis indicated a significant model effect $F(3,67) = 10.35$, $p = .0001$.

Single degree of freedom comparisons showed the interaction between the classifications and groups to be borderline statistically significant $F(1, 67) = 4.18$, $p = .0449$. The single degree of freedom comparisons

revealed a statistically significant classification effect /F (1, 67) = 28.82, p = .0001/, indicating that the girls whose menarche preceded their onset of training started their training at a later age than those girls whose training began prior to their age of menarche. Due to the statistically significant interaction term, t-tests were computed between the means involved in the classification effect analysis. The t-tests showed the ages at the onset of training to be significantly higher in the postmenarche-trained group for both the HS /t (36) = 2.49, p = .015/ and the U groups /t (31 = 4.98, p < .0001/. Thus the classification effect can be accepted as being statistically significant.

Table 6. ANOVA for mean age of onset of training of HS and U groups according to whether menarche preceded onset of training or training preceded menarche

Source	DF	Sum of Squares	Mean Square	F-Value	P-Value
Model	3	8899.94	2966.65	10.35	.0001
Error	67	19202.11	386.60		
Corrected Total	70	28102.05			

Single Degree of Freedom Comparisons

Source	DF	Sum of Squares	F-Values	P-Values
Classification	1	8259.82	28.82	.0001
Group	1	332.87	1.16	.2850
Interaction	1	1196.87	4.18	.0449

The single degree of freedom comparisons did not reveal a statistically significant group effect /F (1, 67 = 1.16, p = .2850/, indicating no difference in age of onset of training between the HS and U groups. Due to the statistically significant interaction term, t-tests were computed between the means involved in the group effect analysis. The t-tests did not show the age of onset of training to be significantly different between the HS and U postmenarche-trained groups /t (24) = 1.95, p = .055/, nor between the HS and U premenarche-trained groups /t (43) = .80, p = .42/. Thus it can be concluded that there is no statistically significant difference in the age of onset of training between the HS and U groups.

In order to examine training history more closely, the number of months in training per year (means, standard deviations) was analyzed for each girl in the HS and U groups, from year 5 to year 17. This data is presented in Table 7. The years were oriented to grade classification in school. For example, year 5 referred to the age in which the girl was at least 5 years old at the beginning of September (of that year) and included the months of training from then until the next September. In the majority of subjects, year 5 corresponded to the kindergarten year in school; year 6 corresponded to the first grade year, and on, until year 17, which corresponded to the senior year in high school. Some girls turned 6 during year 5, while others were 5 for the majority of that year, depending on their birthdates.

As indicated in Table 7, few girls from either HS or U groups trained during years 5 through 9. By year 12, however, more than half of each of the two groups were involved in sports training. In the HS group, the average number of months in training ranged from 2.50 months

Table 7. Comparison of number of months per year in training for years 5 to 17 of HS and U groups (means, standard deviations)

	YEAR												
	5	6	7	8	9	10	11	12	13	14	15	16	17
Group													
HS n= (Total n=38)	(0)	(2)	(2)	(1)	(1)	(3)	(13)	(28)	(32)	(32)	(33)	(30)	(25)
Months		2.50±	2.50±	3.00	3.00	4.33±	5.77±	6.11±	5.94±	6.75±	6.52±	6.83±	6.56±
		.71	.71			1.15	3.24	3.30	2.78	2.53	2.41	2.85	2.77
U n= (Total n=33)	(1)	(1)	(1)	(2)	(5)	(11)	(14)	(19)	(26)	(31)	(31)	(32)	(32)
Months	3.00	10.00	10.00	7.50±	7.40±	5.64±	6.43±	6.79±	7.08±	8.39±	9.06±	9.41±	9.94±
				3.54	2.41	3.26	3.32	3.10	2.86	2.80	3.37	2.67	2.76
T-Values		-8.66	-8.66	-1.04	-1.67	-0.66	-0.52	-0.71	-1.53	-2.44	-3.50	-3.66	-4.58
P-Values		.0732	.0732	.4878	.1707	.5198	.6068	.4802	.1309	.0177	.0009*	.0005*	.0001*

*p < .00625

at year 6, to 6.83 months at year 16. In the U group the number of months in training ranged from 3.00 months at year 5 to 9.94 months at year 17. In this group, the number of months trained gradually increased from year 5 to year 17, whereas the number of months in training for the HS group levelled off to over 6 months after year 12.

The Bonferroni procedure for multiple t-tests was used to determine the alpha levels for comparisons of the number of months trained per year of the HS and U groups. By this method, an alpha level of .00625 was set. Significant differences were found between the HS and U groups at year 15 $/\overline{t}$ (62) = -3.50, p = .0009$/\overline{}$; year 16 $/\overline{t}$ (60) = -3.66, p = .0005$/\overline{}$ and year 17 $/\overline{t}$ (55) = -4.58, p = .0001$/\overline{}$. These differences grew larger through year 17 (Table 7). This analysis indicates that the U group trained significantly more months per year, compared to the HS group, during years 15, 16 and 17.

Table 8 presents a comparison of the average number of accumulated months in training from years 9 through year 17 for the HS and U groups. Since there were few subjects training in years 5 to 8, the accumulation comparisons were reported beginning at year 9. Again, the Bonferroni procedure for multiple t-tests was used to determine the appropriate alpha level, which was .0055. For both HS and U groups, there was an increase in the average number of accumulated months trained from year 11 through 17. Differences between the two groups occurred at year 16 $/\overline{t}$ (68) = -2.96, p = .0047$/\overline{}$ and year 17 $/\overline{t}$ (70) = 3.82, p = .0004$/\overline{}$. The number of accumulated months of training for the HS group was not significantly different from the number of accumulated months of training for the U group until years 16 and 17. The final number of accumulated months for the HS group was 33.29 months while that of the U group was 53.13 months.

Table 8. Comparison of number of accumulated months in training from year 9 to year 17 for HS and U groups (means, standard deviations)

	YEAR 9	10	11	12	13	14	15	16	17
Group									
HS n= (Total n=38)	(2)	(3)	(13)	(28)	(33)	(35)	(38)	(38)	(38)
Months	8.00±	9.67±	8.00±	9.82±	14.09±	19.46±	23.58±	28.97±	33.29±
	5.66	5.03	4.90	7.36	8.87	10.17	12.86	14.16	16.50
U n= (Total n=33)	(5)	(11)	(14)	(19)	(26)	(31)	(32)	(32)	(32)
Months	15.00±	12.45±	16.21±	18.74±	20.77±	25.81±	33.78±	43.19±	53.13±
	15.78	14.67	15.76	17.27	18.69	20.19	22.15	23.82	25.18
T-Values	-.58	-.32	-1.86	-2.12	-1.68	-1.58	-2.30	-2.96	-3.82
P-Values	.5849	.7574	.0824	.0499	.1023	.1210	.0259	.0047*	.0004*

*$p < .0055$

Table 9 represents the comparison of the average number of months trained per year in track and/or cross country from years 5 to year 17, for HS and U groups. The table indicates that only one or two girls trained from year 5 to year 9 in both groups. In the HS group, the number of subjects in training showed a large increase from year 11 to year 12. The number of subjects in the U group involved in training, on the other hand, increased gradually from year 9 through year 17. The average number of months in training for the HS group from year 10 to year 17 ranged from 3.68 months at year 12 to 5.00 months at year 10. No increasing or decreasing trends were observed over the years for the HS group. The range of months in track and/or cross country training for the U group was 4.25 months at year 10 to 8.72 months at year 17. There was a nearly steady increase in months trained from year 10 to year 17.

An alpha level of .00625 was established, using the Bonferroni technique, in comparing the months trained per year of the two groups. T-tests indicated a significant difference in the number of months trained at year 14 $/\overline{t}$ (54) = -3.53, p = .0011$\overline{/}$; year 15 $/\overline{t}$ (57) = -3.48, p = .0011$\overline{/}$; year 16 $/\overline{t}$ (54 = -3.80, p = .0004$\overline{/}$; and year 17 $/\overline{t}$ (49) = -5.40, p = .0001$\overline{/}$. This showed that differences in the average number of months trained in track and/or cross country occurred at year 14, 15, 16 and 17, with these differences becoming greater by the end of year 17.

Table 10 reports the comparison of the average number of accumulated months in track and/or cross country training from years 9 through year 17 for the HS and U groups. An increase in the number of subjects represented was evident for both HS and U groups throughout the comparisons. The average total number of accumulated months for the HS group at year 17 was

Table 9. Comparison of number of months per year in track and/or cross country training from years 5 to 17 for HS and U groups (means, standard deviations)

	YEAR												
	5	6	7	8	9	10	11	12	13	14	15	16	17
Group HS n= (Total n=38)	-	(1)	(1)	-	-	(2)	(9)	(22)	(25)	(29)	(29)	(25)	(19)
Months		2.00	2.00			5.00	4.00±	3.86±	3.68±	3.69±	4.17±	4.76±	3.95±
							1.58	2.12	1.95	1.89	2.21	2.54	2.32
U n= (Total n=33				(1)	(2)	(8)	(12)	(16)	(21)	(27)	(30)	(31)	(32)
Months				5.00	7.50±	4.25±	4.83±	4.69±	5.00±	6.30±	6.93±	7.81±	8.72±
					3.54	2.60	3.33	3.22	3.56	3.37	3.72	3.30	3.40
T-Values						.39	-.76	-.95	-1.52	-3.53	-3.48	-3.80	-5.40
P-Values						.7072	.4574	.3477	.1398	.0011*	.0011*	.0004*	.0001*

*p < .00625

17.08 months and for the U group, 37.22 months. To compare the number of months trained per year of each group, from years 10 through 17, an alpha level of .00625 was set, using the Bonferroni technique. T-tests revealed significant differences in the average total number of months trained in track and/or cross country beginning at year 15 /t (66) = -2.97, p = .0049/; year 16 /t (67) = -3.64, p = .0007/ and year 17 /t (68) = -4.67, p = .0001/, with differences becoming increasingly larger. This indicated that the U group accumulated more months of training in track and/or cross country from year 15 on.

Discussion

The purpose of the study was to examine the relationship between age of menarche and training histories of college females. The age of menarche was evaluated for college non-athletes, former high school runners, and university level runners. The age of onset of training and quantity of training (months per year) were reported for the former high school and current university level runners.

The age of menarche of the university level runners, 14.03 ± 1.76 years, was significantly later than that of the non-athletes, 13.26 ± 1.27 years, and of the former high school athletes, 12.95 ± 1.69 years, who did not differ from each other. These findings are in agreement with studies by Malina et al (1973, 1978, 1979) and Frisch et al (1981), who found later ages of menarche in college track athletes compared to controls. The findings are not in agreement with Malina et al (1978) who found no significant differences in the age of menarche between two competitive levels of high school and college level athletes. The study by Malina et al (1978), how-

Table 10. Comparison of number of accumulated months in track and/or cross country training from year 9 to year 17 for HS and U groups (means, standard deviations)

	YEAR 9	10	11	12	13	14	15	16	17
Group									
HS n= (Total n=38)	(1)	(2)	(9)	(22)	(26)	(33)	(38)	(38)	(38)
Months	4.00	7.00±	5.56±	6.14±	8.73±	10.12±	11.97±	15.11±	17.08±
		2.83	4.07	4.94	6.42	7.96	9.61	11.02	12.83
U n= (Total n=33)	(2)	(8)	(12)	(17)	(21)	(27)	(30)	(31)	(32)
Months	10.00	6.75±	9.33±	11.00±	13.90±	17.11±	22.33±	29.42±	37.22±
		6.84	8.62	10.68	12.92	14.70	17.09	19.49	21.34
T-Values		.05	-1.33	-1.74	-1.68	-2.22	-2.97	-3.64	-4.67
P-Values		.9623	.2004	.0963	.1050	.0325	.0049*	.0007*	.0001*

*p < .00625

ever, represented former high school and current university athletes involved in a variety of sports while this study represented former high school athletes involved in high school track and/or cross country at least two years and athletes competing solely in track and/or cross country at the university level.

The age of menarche reported by the 33 university athletes of this study, 14.03 years, was later than the age of menarche, 13.58, reported by Malina et al (1973) for 66 track and field athletes. This age was also later than the age of menarche, 13.21 years, of 6 gymnasts and college track athletes but less than the 14.18 years menarcheal age of Olympic volleyball players reported by Malina et al (1978). The age of menarche was in close agreement with 17 college runners reported by Frisch et al (1981) who reached menarche at 13.8 years.

It may deserve mentioning that seven of the university athletes from this study were originally from countries other than the U.S. Two were from Jamaica, two from Canada, and one each from Norway, Ireland and the Netherlands. One of these athletes had competed at the Olympic level. The athletes from Jamaica, Norway and the Netherlands reported ages of menarche from 14 to 15.5 years. These athletes may have attained menarche later than the normal population of non-athletes of their countries and the non-athlete population of the United States. For example, in a review paper on menarche in athletes, Malina (1983) reported the mean age of menarche for the normal population of females from the Netherlands to be 13.4 years and that of Olympic athletes from the same country to be 14.0 years. The 13.4 years of menarche is later than the 12.8 norm cited for U.S. females.

The age of onset of training was 12.42 $\pm$ 2.00 years for the high

school and university groups combined. This corresponds to approximately the seventh to eighth grade in school. With the increase in women's sports, it seems reasonable that girls would start sports upon entering junior high school. A Joint Legislative Study (State of Michigan, 1978) done in Michigan reported that almost all children were introduced to their sport by age 12 and that peak participation levels in most agency-sponsored sports occurred at 12 to 13 years of age (Seefeldt et al, 1978).

The lack of relationship between the variables age of menarche and age of onset of training was in agreement with the finding by Frisch et al (1981), who reported an $r = -.257$ correlation for swimmers and runners. This study reported an $r = .13$ for the high school group; $r = .10$ for the university group and $r = .02$ for both groups combined. These correlations were not strong enough to suggest a relationship between the two variables. Frisch et al (1981), however, concluced from regression analysis, that each year of training before menarche caused a delay in menarche of five months (.4 years). The lack of relationship between the variables of age of onset of training and age of menarche found in this study does not support Frisch's conclusion. Also, Frisch regressed years of training versus age of menarche. In her analysis, those subjects with a late age of menarche could have more years of training even if they started training at a normal age. This would bias the analysis.

In examining the age of menarche of the athletes according to whether they were premenarche- or postmenarche-trained, this study found similar results as Frisch et al (1981) and Sidhu and Grewal (1980). A later age of menarche was found in the premenarche-trained athletes as compared to the postmenarche-trained athletes. In performing the ANOVA for the age of onset

of training on the high school and university level athletes classified according to whether they were premenarche- or postmenarche-trained, differences in age of onset of training were found only between the premenarche-trained high school and university athletes as compared to the postmenarche-trained high school and university athletes. There were no significant differences in the age of onset of training between the postmenarche-trained high school and the postmenarche-trained university groups nor between the premenarche-trained high school and premenarche-trained university groups. If training did have an effect on the age of menarche, one would expect to find differences in the age of onset of training between the high school and university groups, since a later age of menarche was found in the university athletes. However, in comparing the premenarche- and postmenarche-trained groups of the high school to university athletes, the analysis revealed that there was no difference between the HS and U groups in the age at which they began training. Thus the late age of menarche observed in the premenarche-trained girls would not appear to be the result of their training. The analysis in this study indicates that it may merely be the outcome of the way in which the premenarche- and postmenarche-trained groups were formed. When each group is subdivided according to the relationship between their age of menarche and age of onset of training, the girls in the postmenarche-trained group will have to be early maturers, since their age of menarche must be earlier than approximately 12.42 years, the average age of onset of training for both HS and U groups combined. At the same time, the girls in the premenarche-trained group will be the more normal and late maturers, since their age of menarche will follow the onset of training, which aver-

aged 12.42 years in this study. The comparison of the age of menarche between the premenarche- and postmenarche-trained groups does not indicate a training effect, for it can be an artifact of the way in which the variables were constructed, as described above.

The later age of menarche for the premenarche-trained group was found in the HS as well as the U group (Table 3), yet the HS athletes did not, as a group, have a late menarche. This indicates that the creation of such a division will show a difference in the age of menarche within a group that has a normal age of menarche. Previous studies (Frisch et al, 1981; Sidhu and Grewal, 1980) did not use a comparison group in analyzing age of menarche according to whether athletes were premenarche- or postmenarche-trained. Their results gave an appearance of a training effect on the age of menarche.

The training history data indicated that both high school and university groups began sports training at about the same age, 12.38 and 12.46 years, respectively. Differences in sports training (number of months per year) became apparent at year 15 and became increasingly greater through year 17. Differences in training in track and/or cross country became apparent at year 14. The increases in training by the U group at year 14 in track and/or cross country and year 15 in total sports training is close to or beyond the 14.03 age of menarche attained by the university athletes. Since there was no difference between the groups in the age at which they started training or the number of months trained per year until year 14 or 15, the training does not appear to be the reason the U group did not reach menarche at 12.95 years, when the HS girls did.

The university group reported training six to eight months per year in track and/or cross country, on the average. These values were less than the 10 month average per year reportedly trained by cross country runners in the study by Wakat et al (1982). However, the current study represented sprinter and middle-distance runners as well, who may not train year round. The increase in training during year 14 did coincide with the same year the female cross country runners (Wakat et al, 1982) reported beginning competitive training for cross country. Thus it seems that by year 14, young females were training to a greater extent in track and/or cross country than during previous years.

In summary, this study found that early training does not appear to be responsible for the later age of menarche observed in the university level athlete runners as compared to former high school level and non-athlete controls. It could be that some other factor, such as a biological predisposition to mature late (Malina et al, 1978), may be responsible. The body-types of late maturers may be more conducive to success in sport, so the late maturing university athletes were most likely more successful than the former high school athletes and continued on to higher levels of competition.

The late ages of menarche reported by some individuals in this study, 16, 17 and 18 years of age, should not be overlooked. It could be that while these athletes were meant to mature late, the intense training may have further delayed the onset of menarche if the training occurred around the athlete's natural set point of menarche. This may be more important in relating training to the age of menarche than measuring the total amount of early training occurring before menarche. It may be that in some cases training interacts with late maturity to further delay menarche in athletes.

The results of this study, however, suggest that the delay in menarche observed in most athletes is not due to the early training experienced by the athletes.

CHAPTER 5

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Included in this chapter are a summary of the procedures and results of this study, conclusions based on the results, and recommendations for future research related to the study.

Summary

In order to examine the relationship between the age of menarche and the training history of college females, the variables age of menarche, age of onset of training and quantity of training (measured in months per year) was evaluated in 35 non-athletes, 38 former high school runners, and 33 university level runners. Subjects completed a survey requesting age of menarche, age of onset of training and the number of months in training per year in sports from the onset of training through year 17.

Statistical analyses showed that the mean age of menarche of the university runners, 14.03 years, was significantly later than that of both the former high school runners, 12.95 years and the non-athlete group, 13.26 years, which did not differ from each other. No relationship was found between the age of onset of training and age of menarche for the two athlete groups, separately or combined.

An ANOVA for the mean age of menarche in the high school and university groups, classified according to whether they were postmenarche-trained or premenarche-trained, indicated that the age of menarche of

the girls whose training preceded their age of menarche was later than those girls whose menarche preceded their onset of training.

Age of onset of training was analyzed in a similar way as the age of menarche, by classifying the athletes of both groups according to whether they were postmenarche- or premenarche-trained. ANOVA and single degree of freedom comparisons indicated that the girls whose menarche preceded their onset of training started training at a later age than those girls whose training began prior to their age of menarche. However, there were no differences in the age of onset of training between the high school postmenarche-trained and university postmenarche-trained groups nor between the premenarche-trained high school and university premenarche-trained groups. Thus there was a significant classification effect between the postmenarche- and premenarche-trained groups but no difference in the age of onset of training between the high school and university level runners.

Differences in the number of months in training per year between the high school group and university group became apparent by year 15, with the university group training significantly more months than the high school athletes. These differences became larger through year 17. Differences in the number of accumulated months of training did not become significant until years 16 and 17.

Differences in the number of months in training per year in track and/or cross country between the high school and university athletes were significant at years 14, 15, 16 and 17 with the differences becoming increasingly greater through year 17. The number of accumulated months of training in track and/or cross country was greater in the university athletes than the high school athletes beginning at year 15 and continued to be larger at years 16 and 17.

Conclusions

Based on these results, it is concluded that while a later age of menarche was observed in the university level athletes as compared to the former high school athletes and controls, the delay in menarche was not due to early training. Athletes of both groups began training at similar ages and differences in the quantity of training between the high school and university athletes were not apparent until years 14 and 15, which was very close to or later than the age of menarche achieved by most athletes. Differences in age of menarche resulting from classifying athletes according to whether they were premenarche- or postmenarche-trained biased the analysis of age of menarche, placing early maturers in the postmenarche-trained group and late maturers in the premenarche-trained group. Differences in training patterns in track and/or cross country between the high school and university level athletes occurred at year 14, with the university athletes training more months per year than the former high school group. These differences became more significant through year 17. The university athletes were specializing in track and/or cross country in their latter years of high school.

Recommendations

The following recommendations for future studies include:

1. A similar study examining the variables of age of menarche, family size, birth order, race and training history of track and/or cross country athletes.

2. A longitudinal study beginning at seventh grade to the twelfth grade examining training history, age of menarche and menstrual patterns,

skeletal age, anthropometric measurements and hormonal assessments at regular intervals of females in track and/or cross country and non-athletes. Training patterns should include information such as type of workouts and the difficulty of the workouts as perceived by the athletes and coach. This type of study would allow for more accurate accounts of training history. Growth patterns and any relationships to training occurring during these years could be noted.

3. Follow-up studies concerning the athlete and her ability to have children in later years should be done to evaluate any long-term relationships between training and fertility.

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APPENDIX A

THE FEMALE ATHLETE

KSU RESEARCH 1983

Department of Health, Physical
Education and Recreation

KANSAS STATE UNIVERSITY

PART I
MEASUREMENTS

1. Birthdate _____ / _____ / _____
   month / day / year

2. Height _____

3. Weight _____ lbs _____ kg

SKINFOLDS	I	II	III	IV
4. Subscapular				
5. Tricep				
6. Iliac				
7. Abdomen				
8. Thigh				

CIRCUMFERENCES

9. Chest _____

10. Waist _____

11. Hips _____

12. Thigh _____

DIAMETERS

13. Wrist _____

14. Biacromial _____

15. Bi-iliac _____

16. Bitrochanteric _____

PART II
MENSTRUAL HISTORY

The following study has been designed within the guidelines of Kansas State University and the Department of Health, Physical Education and Recreation. By answering the following questions, the investigators of this study hope to learn more about relationships between physical training and menstrual patterns in young females.

Information gathered from this survey will be entirely confidential.

Please read each question carefully and answer it to the best of your ability. Take your time and try to remember dates as accurately as possible.

1. What is your birthdate? _____ _____ _____
   Month Day Year

2. What is your year classification in school? (Circle one)

   Freshman Sophomore Junior Senior Graduate Student

3. At what age (years, months) did you have your first menstrual period? (Example--if your 12th birthday was in June and your period began in August, your age would be 12 years 2 months.) If you cannot remember the exact month, refer to the age at the last birthday.

   _____years _____months

   _____ Check if you have not had your first menstrual period as of yet.

   If you have not had your first period as of yet, skip Question 4 - 11. Then proceed to Question 12. If you have had a menstrual period, go on to Question 4.

   MENSTRUAL PATTERNS DURING PAST 12 MONTHS - Be as accurate as possible.

4. In the last 12 months, how many periods have you had? _____ periods

5. If your periods have been regular, how often does your period occur?

   (Example - My period occurs every 28 days or every 4 weeks.)

   (Complete) My period occurs every _____ days or every _____ weeks.

   Describe other variations of cycle lengths (number of days from one period to next) _____

   _____

MENSTRUAL HISTORY (Continued)
PATTERN DURING LAST 12 MONTHS

6. If your periods have been regular, do the cycle lengths (number of days) from the start of one period to the start of the next period) seem: (Check one)

_____ shorter than previous years

_____ longer than previous years

_____ about the same length as previous years

Describe other changes in cycles if necessary: _____

_____

_____

7. When you do have your period, how many days does it last? _____ days

8. Any variations in the past 12 months in length of flow? ____ yes ____ no

If so, describe: _____

_____

_____

If your periods have been regular, without skipping any periods, skip Question 9 and proceed to the Menstrual History Overview and Question 10. If you have skipped periods or noticed a change in the cycle length of your menstrual flows, go on to Question 9.

9. What reason(s) would you give for cycles becoming shorter, longer: skipping periods or stopping menstruation during the past 12 months? Choose up to 4 reasons. Put a "1" in front of the most important reason, a "2" in front of the second most important reason, a "3" in front of the third and so on.

1. _____ change in diet
2. _____ weight gain
3. _____ weight loss
4. _____ sports training
5. _____ emotional stress
6. _____ physical stress
7. _____ death in family or family crisis
8. _____ illness
9. _____ contraceptive use
10. _____ change in residence

Describe any other reasons you feel were responsible for menstrual cycle irregularity such as skipping periods, absence of menstruation, shorter or longer cycles during the past 12 months: _____

_____

MENSTRUAL HISTORY OVERVIEW

The next group of questions refer to your menstrual cycles from the year in which you started your period to the present. Please try to be as accurate as possible.

10. After your first period, were your periods regular from the start (similar cycle lengths, without skipping months)? _____ yes _____ no

11. If no, how many year(s) did it take for your periods to become regular?

_____ year(s) _____ Check if they never were regular.

Describe any other variations if needed. _____

_____

12. Do you or have you at one time use(d) oral contraceptives?

_____ yes _____ no (Check)

If no, skip Questions 13 and 14 and go on to Question 15. If yes, go on to Question 13.

13. When and for how long did you use oral contraceptives?

_____/_____ to _____/_____ age when in use _____ years
month year month year

Indicate other dates if you went on and off of contraceptives at different time periods:

_____/_____ to _____/_____ age when in use _____ years
month year month year

14. Have you ever taken birth control pills specifically to regulate period length and/or frequency? _____ yes _____ no If yes, for how long?

_____/_____ to _____/_____ age _____ years
month year month year

15. Have you ever received other medical attention regarding your menstrual patterns? _____ yes _____ no If yes, for what reason and when?

Reason _____

_____

When? _____/_____
Month(s) Year(s)

Treatment _____

16. Have you ever been pregnant? _____ yes _____ no
If yes, (check)
____ Are currently pregnant ____ Have had a life birth, full term
____ Other (premature birth, miscarriage, interruption of pregnancy)

DIET

Below are listed a variety of foods which may or may not comprise your current diet. Please circle "A" if your diet contains a high percentage of the food listed; a "B" if your diet contains an average amount of the food listed; "C" if your diet contains a low amount, and "D" if your diet contains none of the foods listed.

How much of your current diet is composed of the following foods? (Circle appropriate letter)

		High A	Average B	Low C	None D
1.	White meat--fish, chicken	A	B	C	D
2.	Red meat--beef, pork, lamb	A	B	C	D
3.	Breads, cereals	A	B	C	D
4.	Salads, raw vegetables	A	B	C	D
5.	Broccoli, spinach, squash	A	B	C	D
6.	Carrots	A	B	C	D
7.	Milk, cheese, eggs	A	B	C	D
8.	Doughnuts, cakes, pies	A	B	C	D
9.	Potatoes, macaroni, spaghetti	A	B	C	D
10.	Fresh fruit--applies, oranges	A	B	C	D
11.	Chocolate, candy bars	A	B	C	D
12.	Fried foods	A	B	C	D
13.	Coffee	A	B	C	D
14.	Pop	A	B	C	D

Complete the following statement:

I consider myself to be a:
(check one)

_____ strict vegetarian (eats no animal flesh or animal products--no meat, eggs, milk, sausage)

_____ lacto-ovo vegetarian (eats no animal flesh, but can eat milk, cheese, eggs)

_____ non-vegetarian (eats variety of foods)

PART III
TRAINING HISTORY

Part III deals with your past experience in sports training. This section will indicate the quantity and type of training you have been involved in since you started training up to the present year. Please answer questions to the best of your ability.

1. What main events have you or do you compete in during this year? (Ex. - cross country, 800 m, 1500 m, sprints)

_____

2. Birthdate _____ / _____ / _____
Month Day Year

3. At what age did you begin your first regular training in a club or school sport? Club or school sports include activities such as AAU or school track, cross country, gymnastics, swimming, basketball, dance, volleyball.

Age _____ / _____
Years Months

4. What was the first sport you began formalized training in? List one.

_____

The next section will allow you to describe your training experience in more detail. Turn the page and begin reading directions to complete training history.

You will be giving an account of your training history and other information in the next few pages. Try to remember dates as accurately as possible. To answer the following section:

(1) Complete the following pages, year by year, describing your training history. You may refer to your training log if you kept one.

** (2) Start with the age at which you first started training or at which you first started your menstrual period, whichever came first. Refer to the age at the last birthday.

(3) Beginning at the top of the page, indicate your age in years in which you first started training or your period, whichever came first. Then continue to describe events which took place during that year, as is requested from the far left column. Work downward until you have described the events for that year.

(4) Continue to do this for each year after, until you have described your history up to and through the current year. Do not skip any years.

Example--If your period started when you were 12 years old and you began training at age 13, the beginning of the first few columns would look like this:

Age	12 yrs	13 yrs	14 yrs
Grade in School	7th	8th	9th
Height, Weight (If recall)	5' 2" 120 lb.	5' 4" 128 lb.	5' 6" 130 lb
Sport(s) and Season(s) in Training		Track F, Sp Basketball, W	Track Sp Basketball, W
Total Months?		7	5
Indicate "no training"	No training		

Age	yrs	yrs	yrs
Grade in School			
Height, Weight (if recall)			
Sport(s) and Season(s) in training during year? Ex: Track F, Sp Basketball, W (F-fall, W-winter, Sp-spring, S-summer) Total Months in Training?			
Indicate "no training" if none occurred			
What were average training patterns? Indicate Miles/Day, Days/Wk, Miles/Wk If training varied during year, break down by season If other sport besides running, answer: Hrs/Day, Days/Wk, Hrs/Wk trained			
If not in training, other forms of regular exercise? If so, what? Season(s)? Days/Wk, Hrs/Day?			
Did any of the seasons include high intensity training? If yes, list season(s) and how they were intense: more mileage? more speedwork? Other? OR were all workouts similar in intensity during year?			
Any time off during training for injury, illness? How long? What part of year?			
MENSTRUAL PATTERNS Were cycles regular, irregular, or no periods? If irregular, how? Describe. What season(s) did irregularities occur (F, W, Sp, S)? Why do you think they occurred?			
Were there any weight gains or losses during year? If so, which? How much? When did it occur?			

1. How would you rate the accuracy of your responses in this questionnaire concerning your menstrual history?

(Circle one)

Very Accurate	Quite Accurate	In Between	Not Quite Accurate	Inaccurate
1	2	3	4	5

2. How would you rate the accuracy of your responses in this questionnaire concerning your training/exercise history?

(Circle one)

Very Accurate	Quite Accurate	In Between	Not Quite Accurate	Inaccurate
1	2	3	4	5

3. How would you rate the accuracy of your responses concerning your diet?

(Circle one)

Very Accurate	Quite Accurate	In Between	Not Quite Accurate	Inaccurate
1	2	3	4	5

Other comments you may have concerning menstrual history, training or exercise history, patterns or problems you have had in the past?

(Sport Competition Anxiety Test)

PART IV
ILLINOIS COMPETITION QUESTIONNAIRE

DIRECTIONS: Below are some statements about how persons feel when they compete in sports and games. Read each statement and decide if you HARDLY-EVER, or SOMETIMES, or OFTEN feel this way when you compete in sports and games.

If your choice is HARDLY-EVER, circle the letter A, if your choice is SOMETIMES, circle the letter B, and if your choice is OFTEN, circle the letter C. There are no right or wrong answers. Do not spend too much time on any one statement. Remember to choose the word that describes how you usually feel when competing in sports and games.

		HARDLY-EVER	SOMETIMES	OFTEN
1.	Competing against others is socially enjoyable.	A	B	C
2.	Before I compete I feel uneasy.	A	B	C
3.	Before I compete I worry about not performing well.	A	B	C
4.	I am a good sportsman when I compete.	A	B	C
5.	When I compete I worry about making mistakes.	A	B	C
6.	Before I compete I am calm.	A	B	C
7.	Setting a goal is important.	A	B	C
8.	Before I compete I get a queasy feeling in my stomach.	A	B	C
9.	Just before competing I notice my heart beats faster than usual.	A	B	C
10.	I like to compete in sports that demand considerable physical energy.	A	B	C
11.	Before I compete I feel relaxed.	A	B	C
12.	Before I compete I feel nervous.	A	B	C
13.	Team sports are more exciting than individual sports.	A	B	C

14.	I get nervous wanting to start the game or race.	A	B	C
15.	Before I compete I usually get up tight.	A	B	C

COLLEGE SCHEDULE OF RECENT EXPERIENCE

For each item below, check the letter labeled A if you experienced that occurrence one time WITHIN THE LAST YEAR, check the letter labeled B if you experienced the occurrence twice, C if you experienced the occurrence three times, D if four times or more, and E if no times WITHIN THE LAST YEAR.

		1 time	2 times	3 times	4 or more times	No times
		A	B	C	D	E
1.	Entered college.	A_	B_	C_	D_	E_
2.	Married.	A_	B_	C_	D_	E_
3.	Had either a lot more or a lot less trouble with your boss.	A_	B_	C_	D_	E_
4.	Held a job while attending school.	A_	B_	C_	D_	E_
5.	Experienced the death of a spouse.	A_	B_	C_	D_	E_
6.	Experienced a major change in sleeping habits (sleeping a lot more or a lot less or a change in part of day when sleep).	A_	B_	C_	D_	E_
7.	Experienced the death of a close family member.	A_	B_	C_	D_	E_
8.	Experienced a major change in eating habits (a lot more or a lot less food intake or very different meal hours or surroundings).	A_	B_	C_	D_	E_
9.	Made a change in or choice of a major field of study.	A_	B_	C_	D_	E_
10.	Had a revision of your personal habits (friends, dress, manners, associations).	A_	B_	C_	D_	E_

11.	Experienced the death of a close friend.	A_	B_	C_	D_	E_
12.	Have been found guilty of minor violations of the law (traffic tickets, jay walking, etc).	A_	B_	C_	D_	E_
13.	Have had an outstanding personal achievement.	A_	B_	C_	D_	E_
14.	Experienced pregnancy, or fathered a pregnancy	A_	B_	C_	D_	E_
15.	Had a major change in the health or behavior of a family member.	A_	B_	C_	D_	E_
16.	Had sexual difficulties.	A_	B_	C_	D_	E_
17.	Had trouble with in-laws.	A_	B_	C_	D_	E_
18.	Had a major change in the number of family get-togethers (a lot more or a lot less).	A_	B_	C_	D_	E_
19.	Had a major change in financial state (a lot worse or better off than usual).	A_	B_	C_	D_	E_
20.	Gained a new family member (through birth, adoption, older person moving in, etc.).	A_	B_	C_	D_	E_
21.	Changed your residence or living conditions.	A_	B_	C_	D_	E_
22.	Had a major conflict in or change in values.	A_	B_	C_	D_	E_
23.	Had a major change in church activities (a lot less or a lot more than usual).	A_	B_	C_	D_	E_
24.	Had a marital reconciliation with your mate.	A_	B_	C_	D_	E_

25.	Were fired from work.	A_	B_	C_	D_	E_
26.	Were divorced.	A_	B_	C_	D_	E_
27.	Changed to a different line of work.	A_	B_	C_	D_	E_
28.	Had a major change in number of arguments with spouse (more or less than usual).	A_	B_	C_	D_	E_
29.	Had a major change in responsibilities at work (promotion, demotion, transfer).	A_	B_	C_	D_	E_
30.	Had your spouse begin or cease work outside of home.	A_	B_	C_	D_	E_
31.	Had a marital separation from mate.	A_	B_	C_	D_	E_
32.	Had a major change in the usual type and/or amount of recreation.	A_	B_	C_	D_	E_
33.	Had a major change in use of drugs (a lot more or a lot less)	A_	B_	C_	D_	E_
34.	Took a mortgage or loan less than $10,000 (such as purchase of car, TV, school loan, etc.).	A_	B_	C_	D_	E_
35.	Had a major personal injury or illness.	A_	B_	C_	D_	E_
36.	Had a major change in the use of alcohol (a lot more or a lot less).	A_	B_	C_	D_	E_
37.	Had a major change in social activities.	A_	B_	C_	D_	E_
38.	Had a major change in the amount of participation in school activities.	A_	B_	C_	D_	E_

39.	Had a major change in the independence and responsibility (i.e., budgeting time).	A_	B_	C_	D_	E_
40.	Took a trip or vacation.	A_	B_	C_	D_	E_
41.	Were engaged to be married.	A_	B_	C_	D_	E_
42.	Changed to a new school.	A_	B_	C_	D_	E_
43.	Changed dating habits.	A_	B_	C_	D_	E_
44.	Had trouble with school administration (instructors, advisors, class scheduling, etc.).	A_	B_	C_	D_	E_
45.	Broke or had broken a marital engagement or a steady relationship.	A_	B_	C_	D_	E_
46.	Had a major change in self-concept or self-awareness.	A_	B_	C_	D_	E_

APPENDIX B

ILLEGIBLE DOCUMENT

THE FOLLOWING DOCUMENT(S) IS OF POOR LEGIBILITY IN THE ORIGINAL

THIS IS THE BEST COPY AVAILABLE

KANSAS STATE UNIVERSITY

Department of Health, Physical Education and Recreation

Ahearn Gymnasium
Manhattan, Kansas 66506
913-532-6765

March 15, 1983

Mr. Gary Pepin
102 South Stadium
University of Nebraska
Lincoln, Nebraska 68588

Dear Coach Pepin:

This letter is in response to our telephone conversation, March 14, 1983. I am glad that you have consented to have your team participate in my thesis study. More specifically, the study will seek to:

(1)Evaluate the relationship of age of menarche, age of onset of athletic training and quantity of training prior to menarche

(2)Examine the menstrual history, training/exercise history and current body fat levels of subjects

Hopefully, these measures will give a good indication of physical and/or psychological stress that may or may not influence menstruation in young females.

As we discussed previously, total time for survey and measurements is about 1 hour and 20 minutes on the average. We would like to administer the testing in a room in which subjects can sit and fill out the survey as well as have body measurements taken. Since I will have some assistants helping me take measurements, I would like to divide the group into two, with one taking the survey first and the other getting measurements taken.

It would be helpful if you could: 1)have a scale available to weigh subjects; 2)have subjects wear shorts and loose-binding tops so that skin-fold measurements may be taken quickly and 3)have subjects bring or look over log books if needed to record training history.

Enclosed is a sample copy of the survey which will be given to each athlete as well as a copy of the informed consent form. Please look over both to get an idea of what will be asked of your girls. Again, we are interested in testing the girls who are in running events. Thank you very much for your cooperation. I consider it an honor and privilege to work with the female athletes at your university. Unless something comes up, we will plan to be at the South Stadium between 4:30 and 4:45p.m. to begin testing at 5p.m. Please let me know if I should meet at a different location. Otherwise, we plan to come up March 28 (Mon.) and March 29 (Tue.) unless I hear from you.

Sincerely,

Barbara A. Janssen

Barbara A. Janssen
(913) 532-6765

KANSAS STATE UNIVERSITY

Department of Health, Physical Education and Recreation

Ahearn Gymnasium
Manhattan, Kansas 66506
913-532-6765

March 11, 1983

Mr. John Cornelison
Box 18
Wichita State University
Wichita, Kansas 67208

Dear Coach Cornelison:

This letter is in response to our telephone conversation, March 9, 1983. I am glad that you have consented to participate in my research study concerning college females and their menstrual/training histories. It is hoped by getting a more detailed account of past menstrual histories, training histories, body fat levels, and an indication of psychological stress (through questionnaires on competition and recent life events) we will better understand the physical and/or psychological stress that may or may not influence menstruation in young females.

As we discussed previously, we would like to administer the testing in a room in which subjects can sit and fill out the survey as well as have body measurements taken. If you had all your girls meet at 4 p.m., I could introduce the study and then divide them into 2 groups. One group could have their measurements taken while the other began the survey. The 2 groups could switch whenever they finished measurements or the survey. Since I will have 3 other assistants helping me with measurements, I think the whole process will be done between 5:30 and 6 p.m., with some finishing slightly earlier or later. If you would rather have some girls come in later or if they cannot all come at 4, I could stay later for testing however I think we could get them all tested at once pretty efficiently at 4.- whatever is most convenient for you.

It would be helpful if you could: 1)have a scale available to weigh subjects; 2)have subjects wear shorts and T-shirts or clothing that is not too binding for skinfold measurements and 3)have subjects bring or have looked at log books if needed to record training history.

Enclosed is a sample copy of the survey which will be given to each athlete as well as a copy of the informed consent form. Please look over both to get an idea of what will be asked of your girls. Thank you very much for your cooperation. I consider it an honor and privilege to work with the female athletes at your university. Unless something comes up, I will see you March 31 at about 3:45pm.

Sincerely,

Barbara A. Janssen

Barbara A. Janssen
(913) 532-6765

APPENDIX C

INFORMED CONSENT

Investigator: Barbara A. Janssen

Department of Health, Physical Education and Recreation
Phone Number: (913) 532-6240
Advisor: Dr. Wilcox

Title: The Relationship Between Training History, Age at Menarche, and Regularity of Menstrual Cycles of College-Age Females

This is to certify that I, _____, volunteer to participate in a research investigation at Kansas State University under the supervision of the Department of Health, Physical Education and Recreation. The purpose of the study is to examine the relationship between training history, age at menarche, and regularity of menstrual cycles of college-age females.

The study will evaluate age of menarche, menstrual history, training/exercise history and current body fat levels of subjects.

I understand the procedures of this study:

1) As a measure of body fat levels, the following measurements will be taken by the investigator using skinfold calipers, sliding calipers, and tape measures: skinfold thicknesses of my upper arm, back, hip, abdomen and thigh; diameter measurements of my wrist, shoulder and hip joint; and circumferences of my chest, waist, hip and thigh.

2) I will complete questionnaires describing past menstrual history, past physical training in sport or exercise, diet, competition and recent experiences.

I understand that questions I may have concerning the questionnaires will be answered by the investigator.

I understand that all the results will be processed using coded numbers. If the results of the study are used for publication, my name will not be used.

I understand that findings of the study will be made available to me upon request at the completion of the study.

I understand I have the right to withdraw my consent and participation in this study at any time.

I understand the procedures and agree to voluntarily participate in this study.

_____ _____

Date Signature

PERMANENT ADDRESS

Please indicate a permanent address in which you may be reached or in which someone living at that address would know of your whereabouts to contact you. This could be your home address or that of a relative (parents, grandparents, aunt, etc.).

In giving us an address and phone number, we could contact you in 4 or 5 years for a follow-up study. We will also be able to send you results of the present study if you are away from the university.

PLEASE PRINT CLEARLY:

NAME	PERMANENT ADDRESS	PHONE NUMBER	CODE NUMBER
	SCHOOL ADDRESS	PHONE NUMBER	

AGE OF MENARCHE AND TRAINING HISTORIES OF FORMER HIGH SCHOOL AND UNIVERSITY LEVEL RUNNERS

by

BARBARA ANN JANSSEN

B. S., Kansas State University, 1979

AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

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KANSAS STATE UNIVERSITY
Manhattan, Kansas

1983

ABSTRACT

Age of menarche, age of onset of training and quantity of training (measured in months per year) were determined by survey of 35 non-athletes (NA), 38 former high school runners (HS) and 33 university level female runners (U). Statistical analyses showed that the mean age of menarche of the U group, 14.03 $\pm$ 1.76 years, was significantly later ($p < .05$) than that of both the HS (12.95 $\pm$ 1.69 years) and the NA (13.26 $\pm$ 1.27 years) groups, which did not differ from each other. No relationship was found between the age of onset of training and age of menarche for the two athlete groups, separately (HS - $r = 0.13$, $p = 0.43$; U - $r = 0.10$, $p = 0.57$) or combined ($r = 0.02$, $p = 0.86$). ANOVA for the mean age of menarche in the HS and U groups, classified according to whether subjects were postmenarche or premenarche-trained showed that the age of menarche was later in the premenarche-trained group. Age of onset of training was also analyzed by classifying athletes of both HS and U groups into postmenarche- or premenarche-trained groups. ANOVA revealed that the postmenarche-trained females started training at a later age than the premenarche-trained females. However, there were no differences in the age of onset of training between the HS postmenarche-trained and U postmenarche-trained groups nor between the premenarche-trained HS and U premenarche-trained groups. Differences in age of menarche resulting from classifying athletes into premenarche- or postmenarche-trained groups biased the analysis of age of menarche, placing early maturers into the postmenarche-trained group and late maturers in the premenarche-trained group, making the analysis inappropriate for demonstrating

a training effect on the age of menarche. Differences in the number of months trained per year between the HS and U group were apparent by year 15, with the U group training more months than the HS athletes and was also true for the number of months trained per year in track and/or cross country, with differences becoming larger through year 17. Based on these results, it was concluded that the later age of menarche observed in the U group was not due to early training. Athletes of both HS and U groups began training at similar ages, and differences in quantity of training were not apparent until year 15, which was later than the age of menarche achieved by most athletes.