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The Effects of Strenuous Physical Activity on Female Hormonal Balance and Menstrual Dysfunction

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THE EFFECT OF STRENUOUS PHYSICAL ACTIVITY ON FEMALE HORMONAL BALANCE AND MENSTRUAL DYSFUNCTION

by

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TABLE OF CONTENTS

LIST OF GRAPHS

LIST OF TABLES

CHAPTER 1

INTRODUCTION

With an increase of participation in all types of physical activities, both athletic and recreational, a greater number of girls and women are experiencing problems with their menstrual cycles. It was the intent of this paper, therefore, to research menstrual dysfunction encountered by females who engage in strenuous physical activity as a result of direct training.

Statement of the Problem

The purpose of this study was to determine the effect of strenuous physical activity on the onset and maintenance of regular ovulatory cycles. Specifically this study attempts to answer the following questions:

1. Does strenuous physical activity cause menstrual dysfunction?

2. Does a combination of other factors including loss of body weight, loss of body fat, and the emotional stress of training which generally accompany strenuous physical activity, make it impossible to isolate one factor and draw specific conclusions?

3. Do the long-term consequences of strenuous physical activity cause irreversible infertility problems during child bearing years?

Hypotheses

In this study the following hypotheses will be tested in an attempt to answer the previous questions.

1. Strenuous physical activity does affect female hormonal balance, causing problems with the onset and maintenance of the menstrual cycle.

2. Various factors causing menstrual dysfunction such as weight loss and strenuous physical activity can be isolated.

3. Women who have experienced menstrual dysfunction caused by strenuous physical activity will experience infertility problems, since the maintenance of the menstrual cycle directly affects female fertility.

Importance of Study

The female role in athletics has increased significantly in the last decade. The October, 1980, issue of The Reader's Digest contained a condensed version of an article from the New York Times Magazine titled "Female Athletes: They've Come a Long Way, Baby". The article reported that since 1970 the number of women tennis players in the country had jumped from about three million to eleven million, and the number of

golfers from less than a half million to more than five million. Of the nation's 17.1 million joggers, over one-third are women--in 1970, there were too few to count. The number of high school female athletes had increased six times what it was in the early 1970's, and thirty percent of all college athletes are female, an increase in ten years of 250 percent (Wood, 12: 126). Because of the number of females involved, concern regarding the effect of strenuous physical activity on female physiology has surfaced.

Until recently little research had been done on the causal relationship of physical activity and the female hormonal function. The increased number of female participants has increased the number of females experiencing menstrual dysfunction. This increase has brought about a greater availability of testable females. "Because so many women participate regularly in sports activities, more critical and comprehensive evaluations of the reproductive function is now possible" (Shangold, 10: 66). No problem should be presumed exercise related or insignificant. Females experiencing problems should consult a gynecologist so any serious medical problem could be eliminated or treated. However, in the opinion of the writer, initial fears and anxiety could be eased if the existing research were better publicized and females, through education,

had a more knowledgable understanding of their reproductive system.

Definition of Terms

As part of the study, the researcher used several general terms or phrases which need defining in terms specific to this research study.

1. Strenuous physical activity: that activity associated with training for an athletic team or competition, or comparable physical activity (e.g. aerobic dance, ballet, synchronized swimming, etc.).

2. Menarche: the initial onset of the menstrual cycle.

3. Menstrual dysfunction: problems with the menstrual cycle which may be one or a combination of the following: (a) amenorrhea--no menarche to date or cessation of menstrual cycle, (b) primary amenorrhea--the individual has not menstruated by the age of sixteen, (c) secondary amenorrhea--six months interval between cycles and cycles differing in length by nine or more days, (d) oligomenorrhea--regularly recurring, nonconsecutive missed menstrual cycles.

Procedure

In conducting this study the data were acquired from the following resources:

1. St. Cloud Hospital Library

2. St. Cloud State University Library

3. Monticello High School Library

4. Periodicals obtained from Michael Parker, PhD, Sports-Medicine Director at Monticello-Big Lake Community Hospital

5. Melpomene Institute for Women's Health Research in St. Paul

CHAPTER 2

REVIEW OF RELATED LITERATURE

Leo Marty, assistant professor and director of sports medicine at Portland State University remarked:

> The role of women in sports, as it is in nearly all fields, is increasing. Until recently, the female stereotype didn't include athletic participation. Now females are more athletic and consequently we are seeing an increase in the acceptability of sports and physical education in the adolescent. (Marty, 6: 10)

With this changing trend of acceptability, and greater numbers of females participating in athletics, there are few reports and studies being conducted to answer questions dealing with exercise and its effect on female physiology.

Speroff and Redwine stated that there is a growing awareness that women who compete in sports or participate in strenuous activities have a high incidence of menstrual irregularity and amenorrhea, yet few studies in medical literature deal with the problem (11: 42). They further stated, "Indeed some prominent people are afraid to discuss this issue and believe that it could set back women's effort for equality in sports" (Speroff and Redwine, 11: 42).

The earliest recorded data obtained dealing with cessation of menstrual cycle (amenorrhea) were collected by Rose E. Frisch and Janet McArthur. In that study the researchers investigated only the effect of weight loss on the menstrual function. They indicated:

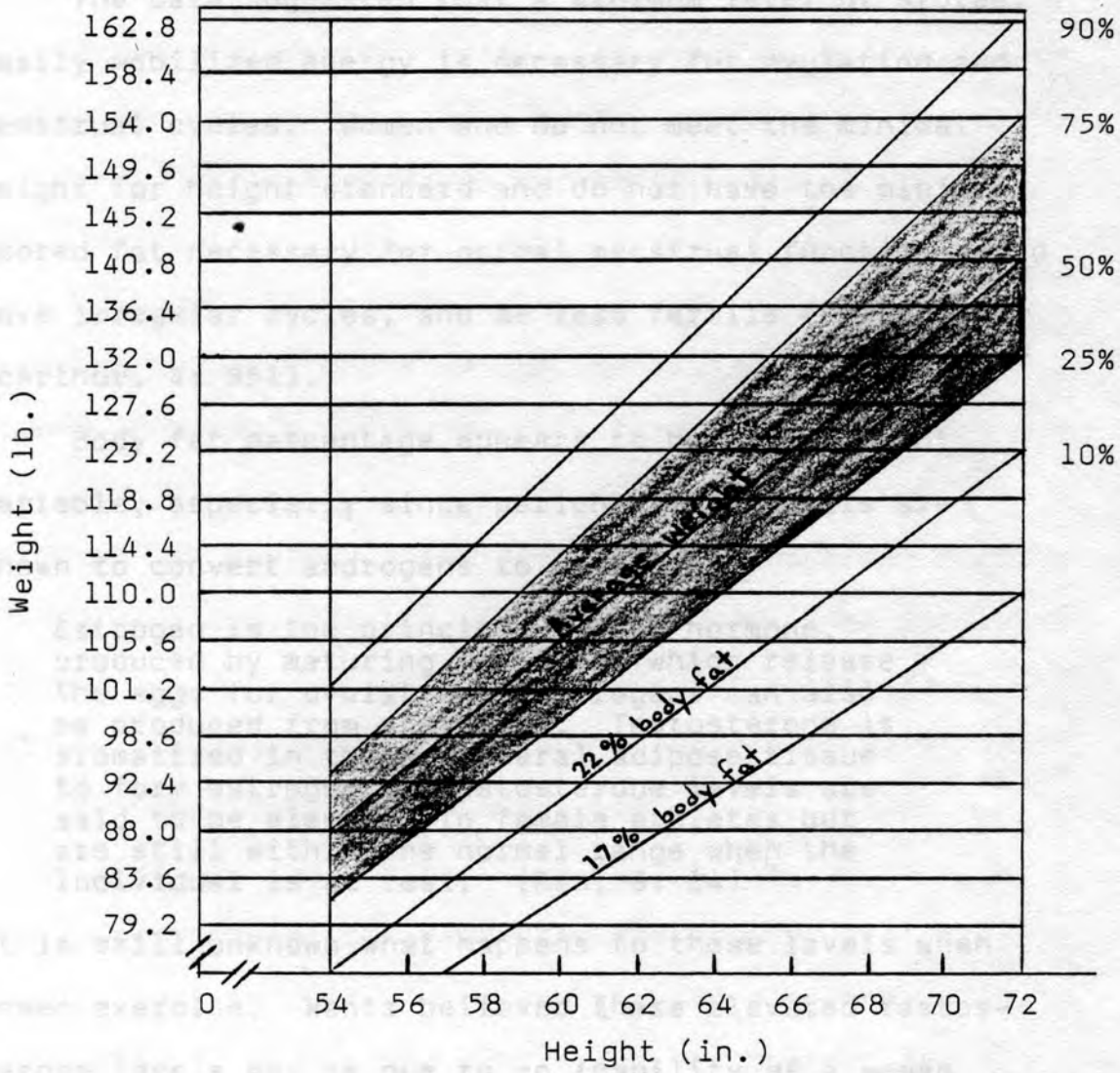
> The cessation of menstrual cycles (amenorrhea) following chronic undernourishment or rapid weight loss in otherwise normal women is a well documented, although often overlooked, fact of human reproductive physiology. (Frisch and McArthur, 4: 949)

The researchers concluded that weight loss causes loss of menstrual function and weight gain restores menstrual cycles. Earlier research conducted by Frisch estimated a minimal weight for height necessary for the onset and maintenance of menstrual cycles. Speroff and Redwine supported Frisch's critical weight concept and modified a graph constructed by Frisch.

Frisch's critical weight concept, shown on graph one, indicates that a weight loss of 10 percent to 15 percent below the range of normal weight may result in amenorrhea. This represents a loss of about one-third of the body fat and a fat content of less than 22 percent of body weight. Frisch reported that a minimum of 17 percent body fat is necessary in an adolescent girl for menarche, and secondary amenorrhea occurs below 22 percent body fat. If a woman past the age of 16 becomes amenorrheic a 22 percent body fat is required to restore regular cycles (Frisch cited in Speroff and Redwine, 11: 47).

Graph 1

Relationship of Weight to Maintenance of the Menstrual Cycle



Range of Normal Body Weight

This nomogram, modified from Frisch, estimates the minimal weight necessary for a particular height for menstrual cycles to begin (17 percent body fat) or for

menstrual cycles to be restored or secondary amenorrhea to occur (22 percent body fat) (Speroff and Redwine, 11: 47).

The data suggested that a minimum level of stored, easily mobilized energy is necessary for ovulation and menstrual cycles. Women who do not meet the minimal weight for height standard and do not have the minimum stored fat necessary for normal menstrual function would have irregular cycles, and be less fertile (Frisch and McArthur, 4: 951).

Body fat percentage appears to be an important variable, especially since peripheral fat cells are known to convert androgens to estrogens.

> Estrogen is the principal female hormone, produced by maturing follicles which release the eggs for ovulation. Estrogens can also be produced from androgens. Testosterone is aromatized in the peripheral adipose tissue to form estrogens. Testosterone levels are said to be elevated in female athletes but are still within the normal range when the individual is at rest. (Rau, 8: 14)

It is still unknown what happens to these levels when women exercise. Wentz believed these elevated testosterone levels may be due to an inability of a woman without enough body fat to convert the testosterone to estrogen. The change in the hormone level may trigger a different or insufficient response from the pituitary gland to secrete the gonadotropins necessary for ovulation (Wentz cited in Rau, 8: 16).

Research dealing with the affect of exercise on female hormones and the menstrual function is very recent. The earliest of those studies was conducted in 1980.

Cohen, et. al., conducted a study of 32 professional ballet dancers by means of a gynecological questionnaire. All dancers were members of one major ballet company which had international ranking. There were two principal dancers, six soloists, and 24 members in the corps de ballet. The mean age was 24.9 years of age (range 18 to 34); all began ballet training at a mean age of 7.5 years (range 4 to 14). Cohen, et. al., selected 28 healthy, nonathletic women (hospital nursing staff) of comparable age and height to serve as controls without prior knowledge of the subjects' menstrual history (1: 94).

In compiling data on menstrual history, Cohen, et. al., found that the dancers had significantly later menarche and fewer "menses" per year than the control subjects. Thirty-seven percent of the dancers had a history of amenorrhea. Forty-seven percent of the dancers had a history of either delayed menarche, oligomenorrhea, or amenorrhea. The incidence of total menstrual dysfunction was far greater for the dancers than that of the control population (1: 95). The investigators reported that menstrual dysfunction was related to both strenuous

physical exercise and diminished body weight. The menstrual problems were reversible, often disappearing with significant weight gain or intervals of less intense exercise (1: 92-94). Like other research reported, Cohen, et. al., contended that "long-term follow up, especially regarding infertility, is necessary to establish the significance of menstrual dysfunction in these women" (Cohen, et. al., 1: 100).

The results of another such study were reported in The First Aider. In that study a group of 28 young girl swimmers who underwent strenuous swim training for 2.5 years had normal menstrual cycles ten years after discontinuing training (2: 15). The final contention of the researchers was "long-term effects of menstrual irregularities for young girls who have undergone strenuous exercise training are unknown at this time" (2: 15).

The most extensive study dealing with the results of physical training on female hormones and the menstrual function was reported by Frisch, et. al. To conduct their research, Frisch, et. al., recruited 21 Harvard swimmers and 17 runners (12 long distance, five middle distance) at the start of their training season. Control subjects were 10 nonathlete Harvard women recruited by advertisement. The age at menarche and menstrual periodicity were studied in relation to the

age of initiating training.

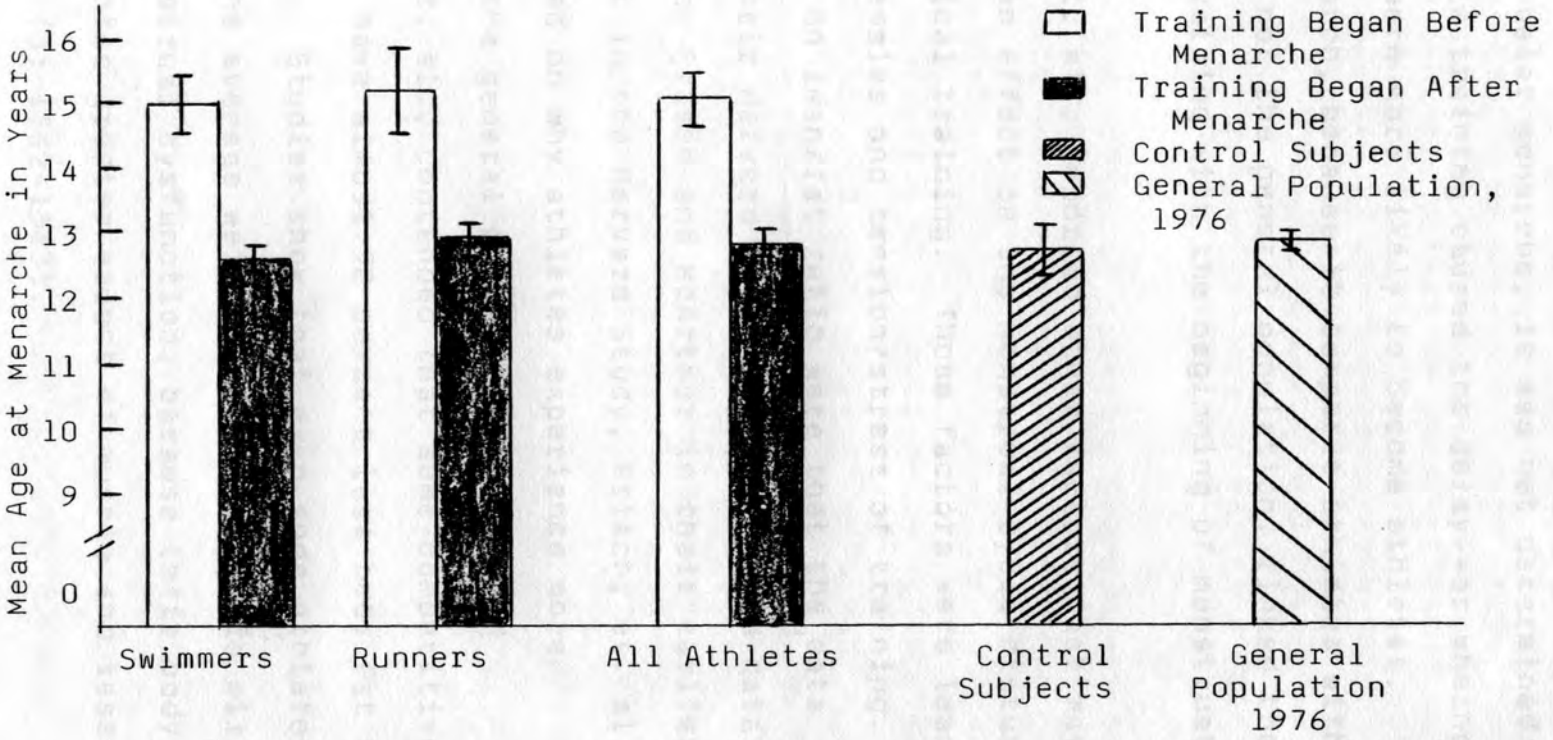
At the conclusion of their research the following data was reported. This data is graphically represented in graph two.

The 18 premenarche-trained athletes had a mean menarcheal age of 15.1 years (SD = $\pm$ 0.5), whereas the postmenarche-trained athletes had a mean menarcheal age of 12.8 years (SD = $\pm$ 0.2), similar to that of the control subjects, 12.7 years (SD = $\pm$ 0.4). Intense physical activity before menarche was found to contribute to irregular or nonexistent menstrual cycles. About 83 percent of the premenarcheal trained athletes had this problem compared to only 40 percent of the postmenarcheal trained athletes. For all the premenarche-trained athletes, menarche was delayed 0.4 years (five months) for each year of training before menarche.

During the athletic season both premenarche and postmenarche trained athletes had an increased incidence of oligomenorrhea (5: 1159-1563).

Graph 2

Data Comparing Age at Menarche of Athletes to a Control Group and General Population



Mean ages of menarche of swimmers, runners, and all athletes according to when training began, compared with mean age of control subjects and general population, 1976. (5: 1561)

Although earlier studies showed that intense physical activity could delay menarche, it was not determined whether athletic training caused the delay--or whether late maturers were more likely to become athletes. "This new research, because it compares athletes with each other and not the general population, linked the beginning of training with the beginning of menstruation" (3: 249).

Frisch, et. al., reported other factors that may have as great an effect on the menstrual cycle disturbances as physical training. Those factors were lean/fat ratio of females and tension/stress of training. Their findings on lean/fat ratio were that the data collected in their Harvard Study reinforced the data substantiated by Frisch and McArthur in their earlier study. However in the Harvard Study, Frisch, et. al., further reported on why athletes experience more problems than the general population.

Frisch, et. al., contended that some competitive women athletes have almost 50 percent less body fat than noncompetitors. Studies show that even some athletes who maintain the average weight for height ratio will experience menstrual dysfunction, because their body weight represented greater amount of muscle and less adipose tissue (5: 1562-1563).

> Since female adipose tissue of the breast, abdomen, omentum, and fatty marrow of long bones converts androgen to estrogen, adipose tissue is a significant extragonadal source of estrogen. Body weight, hence fatness, also affects the pathway of metabolism of estrogen to its most potent or least potent form. The amount of adipose tissue may thus directly affect hormonal regulation of short-term or long-term feedback mechanisms controlling the menstrual cycle and ovulation. (Frisch, et. al., 5: 1563)

In reporting on tension/stress of training Frisch, et. al., stated that:

> The tension and stress of training and competition may increase the secretion of adrenal cortico-steroids and cathecholamines, which affect the hypothalamic control and gonadotropius. (Frisch, et. al., 5: 1563)

The final conclusion of Frisch, et. al., reporting on the female athlete and long range effects was:

> Female athletes have an increased incidence of oligomenorrhea and amenorrhea, and a later age at menarche, compared with the general population. The physiological basis of this phenomenon is not known, nor is its significance, for health and later fertility (Frisch, et. al., 5: 1559)

In a research study dealing with menstrual patterns and female runners, Lutter and Cushman utilized a questionnaire to investigate the running and menstrual history of 353 female runners from the 1980 Boston Marathon and the Minneapolis-St. Paul Bonne Bell 10-Km race. In this study, Lutter and Cushman reported on body weight, training, mileage and menstrual patterns.

Lutter and Cushman found that other investigations disagree on the cause of menstrual dysfunction when

trying to isolate weight from mileage factors. They reported that Speroff and Redwine surveyed approximately 900 recreational runners and reported that weight losses greater than 10 pounds and body weight less than 115 pounds were associated with an increased incidence of oligomenorrhea or amenorrhea. They did not find that training mileage influenced menstrual frequency; however, only 18.6 percent of the participants ran more than 20 miles per week. In contrast, Feicht, et. al., studying 162 college track and cross-country runners, reported that body weight did not appear to affect menstrual function and that training mileage and intensity could be the cause of secondary amenorrhea (7: 69).

Lutter and Cushman believed that the differing results obtained by Speroff and Redwine and Feicht, et. al., may be partly due to differences in the elected population and to the multifactorial nature of oligomenorrhea and amenorrhea in runners (7: 69).

One very interesting point that Lutter and Cushman made dealt with the accuracy of using body weight as an indication of body fat, and the accuracy of measuring body fat in large study populations. They contended that:

> To date, no practical, accurate method for measuring body fat has been developed. Our work using skinfold measurements has revealed

> significant discrepancies when results are compared to those obtained by the more accurate but cumbersome method of underwater weighing. If a technique could be developed to accurately measure body fat in a large study population, it would be interesting to consider how the absolute amount of fat, as well as body fat percentage, affect menstruation. (7: 71)

In conclusion, Lutter and Cushman reported that the results of the study indicated a significant relationship ($p < .05$) between low body weight, high mileage, and oligomenorrhea or amenorrhea. However, less than one-fourth of the runners reporting irregular menstrual function had low body weight and high mileage. While the low body weight hypothesis helps explain a trend in female runners, other explanations for menstrual irregularity in this diverse group should be actively sought and considered during clinical evaluation (7: 72).

Several causes of secondary amenorrhea were discussed in many articles. These causes were stress, weight loss, anorexia nervosa, obesity, heavy exercise training, and age at onset of training. Literature has revealed that each of these causes contribute in some form of alteration in menstrual function.

In dealing with heavy exercise training Sasiene suggested that another proposed theory is that the level and/or type of sport participation affects the menstrual cycle. Among the athletes investigated have been

skiers, rowers, tennis players, swimmers, cross-country and long-distance runners. These athletes participated in activities that required much physical effort. Available data suggested that a greater number of menstrual disorders occurred in the above mentioned sports than in less vigorous sports (9: 61).

The author reported that due to the many variables that could be involved in the development of secondary amenorrhea, research on this topic is confounded.

The following is a table compiled by Sasiene. It reveals the occurrence of secondary amenorrhea among female athletes. It is a composite taken from nine studies (9: 62).

Table 1

Occurrence of Secondary Amenorrhea
Reported in Nine Studies

Author	Reference	Population	Number in Report	Occurrence of Secondary Amenorrhea
Anderson	1	West Point Women	70	86% regular menses upon entering program--one year later 20% secondary amenorrhea
			88	82% regular menses upon entering program--one year later 8% secondary amenorrhea 23% irregular menses
Astrand, P.O., et. al.	2	Swimmers	27	18.5% irregular menstrual cycle
Dale, et. al.	6	Distance Runners	168	51% runners 33% joggers 6% controls
Erdelyi, G.J.	9	Hungarian Female Athletes	557	11% exercisers had adverse affect 5% favorable changes 83.8% no change
Erdelyi, G.J.	10	Athletes		9.3% unfavorable changes

Table 1 (continued)

Author	Reference	Population	Number in Report	Occurrence of Secondary Amenorrhea
Feicht, et. al.	11	Track and Field/ Cross-Country	54	35.2% amenorrhea 64.8% regular
Malina, et. al.	28	Athletics		22.2% non-athletes 28.6% college athletes 33.3% Olympic athletes
Wakat & Sweeney	38	Cross-Country Runners	41	49% normal menstrual cycles
Zaharieva, E.	41	Sports Women at Tokyo Olympics: Track & Field Swimming Gymnastics Volleyball	66	1.5% no menses 6.1% irregular 92.4% normal

Menstrual Irregularities

In all the articles reviewed for this paper the "message" or final summary given by the researchers was that more research needs to be done and long term follow-up studies are necessary.

It is also important to note that many investigators reported that menstruation was resumed in most cases of amenorrhea following successful resolution of the conflict (e.g., weight gain, less activity, less stress).

Sasiene foresaw the future direction of study to include:

-An indepth investigation of the occurrence of secondary amenorrhea among female athletes.

-A comprehensive analysis of the acute and chronic effects of exercise on the menstrual cycle.

-Investigation of the mechanisms by which hormonal secretions are altered during training and how this alteration affects menstrual function.

-A more complete understanding of the physical and psychological stresses and the mechanisms leading to the developments of menstrual irregularities.

-Exploration of physical and psychological factors, if any, which predispose particular women to menstrual dysfunction. (9: 62, 63)

Summary of Related Literature

In the studies and literature reviewed the following observations were made:

With the exception of one researcher, Shangold, all agreed that physical activity does cause menstrual dysfunction. The reason for this difference in reporting may be because Shangold's research was reported before the report of Frisch, et. al., which specifically tested athletes.

All research reviewed agreed that in addition to the physical stress of training there is usually emotional stress, loss of body weight, loss of body fat, low weight, low fat, or combinations of these factors. It was reported that it is difficult, but not impossible, to isolate these variables apart from each other.

In regard to the question of long-range fertility problems, all investigations contended that there is no evidence that any exercise related menstrual problems are irreversible, and that long-term follow-up regarding infertility is necessary to establish the significance of menstrual dysfunction in the women tested.

CHAPTER 3

SUGGESTED TEACHING MODULE

Research has shown that with the increased number of females participating in athletics and other areas of strenuous physical activity, there are greater numbers of females experiencing various types of menstrual dysfunction. With this increase a number of individuals are concerned about the awareness and knowledge females and/or their coaches have concerning menstrual dysfunction.

Many research articles dealing with menstrual dysfunction are not written with terminology that the lay person or young female student can understand. In addition, the availability of the articles is reduced because the medical journals are not always available in local or school libraries.

As a teacher and coach, the author has experienced on many occasions questions from frightened and apprehensive students who are experiencing some type of menstrual problem. These students do not understand the physiology of their reproductive system.

For many females the extent of their knowledge dealing with their reproduction system is that a "normal" menstrual cycle is about 28 days in length and each individual may vary a couple of days one way or the other.

When their system alters from what is considered "normal" the questions begin: "Am I pregnant?", "Am I abnormal?", "What's wrong with me?".

For many adolescent girls menstruation is a very embarrassing topic; they are not comfortable talking about problems concerning menstruation.

It is strongly believed that by teaching a basic module on the effect of exercise on menstrual patterns, the students would have a better understanding of various factors which influence that cycle and the possible dysfunctions.

It is important that the students understand that this is an awareness program and not a medical seminar that will enable them to diagnose or confirm a problem. They must understand that if they are experiencing a problem they should consult a gynecologist.

The following is a teaching module that could be taught in one or two 50-minute class periods. The time needed would vary depending on the age of the students, their background concerning the basic physiological facts of the female reproduction system, and the number of

questions asked.

Effect of Exercise on Menstrual Patterns

I. Review of Menstrual Cycle
   A. Physiological look at the female reproductive system
   B. Menarche

II. Hormone--a product of living cells that circulates in body fluids and produces a specific effect on the activity of cells remote from its point of origin (a chemical messenger carried by the blood).
   A. Estrogen
   B. Androgen

III. Menstrual Dysfunction
   A. Amenorrhea
      1. Primary amenorrhea
      2. Secondary amenorrhea
   B. Oligomenorrhea

IV. Causes of Menstrual Dysfunction
   A. Weight loss
   B. Strenuous physical activity
   C. Tension and stress

V. Suggestions
   A. No problem should be presumed exercise related or insiginificant. Consult a gynecologist so any serious problem can be ruled out or treated.

B. Problems are reversible--generally following successful resolution of the conflict or adaptation of the body.

C. Do not take for granted you are infertile because you are experiencing amenorrhea. You may be for a number of months, but it may reverse at any time.

CHAPTER 4

CONCLUSION AND RECOMMENDATIONS

Conclusion

From the review of the literature the following conclusions have been drawn:

1. Strenuous physical activity does affect female hormonal balance causing menstrual dysfunction.

2. Factors causing menstrual dysfunction can be isolated.

3. Physicians need more information about the causes and long-term consequences of menstrual dysfunction due to exercise, especially regarding infertility. "Long-range follow-up studies are needed to compare the menstrual and reproductive histories and life spans of athletic and nonathletic women" (Frisch, et. al., 5: 1563).

Recommendations

After the review of the literature the following are recommendations for future study as related to menstrual dysfunction.

1. Conduct a study classifying the population into age levels to determine the effect of strenuous

physical activity on females.

2. Conduct a study utilizing preadolescents to determine the possible prolonging of age at menarche.

3. Conduct a follow-up study on the previous subjects of research suggesting the long-range problems.

BIBLIOGRAPHY

1. Cohen, Jerald L., Chung S. Kim, Philip B. May, and Norman H. Ertel. "Exercise, Body Weight, and Amenorrhea in Professional Ballet Dancers," The Physician and Sportsmedicine, Vol. 10, No. 4, April 1982, pp. 92-101.

2. "Distance Restrictions for Female Runners Should be Dropped." The First Aider, Vol. 49, No. 5, January 1980, pp. 1, 14-15.

3. "Exercise and Late Menstruation," Science News, Vol. 120, No. 16, October 17, 1981, p. 249.

4. Frisch, Rose E., and Janet W. McArthur. "Menstrual Cycles: Fatness as a Detriment of Minimum Weight for Height Necessary for Their Maintenance or Onset," Science, Vol. 185, No. 11, September 13, 1974, pp. 949-951.

5. Frisch, Rose E., Astrid V. Gota-Welbergen, Janet W. McArthur, Tenley Albright, Jelia Witschi, Beverly Bullen, Jason Birnholz, Robert B. Reed, and Howard Hermann. "Delayed Menarche and Amenorrhea of College Athletes in Relation to Age of Onset of Training," Journal of American Medical Association, Vol. 246, No. 14, October 2, 1981, pp. 1559-1563.

6. Marty, Leo W. "Female Health Problems Often Neglected," The First Aider, Vol. 49, No. 10, October 1980, p. 10.

7. Lutter, Judy Mahle, and Susan Cushman. "Menstrual Patterns in Female Runners," The Physician and Sportsmedicine, Vol. 10, No. 9, September 1982, pp. 60-72.

8. Rau, Julie. "Athletic Amenorrhea: A Review of Literature," Melpomene Institute, May 1983, pp. 14-16.

9. Sasiene, Gwen Hagenbuch. "Secondary Amenorrhea Among Female Athletes," Journal of Physical Education, Recreation, and Dance, Vol 53, No. 6, June 1983, pp. 61-63.

10. Shangold, Mona M. "Sports and Menstrual Function," The Physician and Sportsmedicine, Vol. 8, No. 8, August 1980, pp. 66-70.

11. Speroff, Leon, and David B. Redwine. "Exercise and Menstrual Function," The Physician and Sports-medicine, Vol. 8, No. 5, May 1980, pp. 42-52.

12. Wood, P.S. "Female Athletes: They've Come a Long Way, Baby," The Reader's Digest, Vol. 117, No. 702, October 1980, pp. 126-130.