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A COMPARISON OF HEMATOLOGICAL VALUES OF
PREGNANT ENDURANCE RUNNERS AND PREGNANT
NON-EXERCISERS DURING THE FIRST TRIMESTER OF PREGNANCY

BY

CAROLYN J. RYAN

PRESENTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF
MASTER OF SCIENCE
UNIVERSITY OF MONTANA

1987

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June 3, 1987
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Ryan, Carolyn J., M.S., June 1987 Physical Education

A Comparison of Hematological Values of Pregnant Endurance

Runners and pregnant Non-Exercisers During the First Trimester of Pregnancy

Director: Dr. Donald Hardin *DH*

The purpose of this study was to identify hematological values indicative of stage 3 iron deficiency in a group of pregnant endurance runners compared to a group of relatively sedentary pregnant controls in the first trimester of pregnancy. Seventeen pregnant runners participated (mean age= 30.3 yrs, range from 24-34 yrs), with an average weekly mileage of 26 miles, ranging from 10 to 50 miles, and were compared to seventeen relatively sedentary control subjects (mean age 28.4 yrs, range from 22 to 39). Hematological values were collected from individual subjects records from their own physician in the first thirteen weeks of pregnancy. Values collected were hemoglobin concentration, hematocrit, red blood cell count, mean cell volume, mean cell hemoglobin, and mean cell hemoglobin concentration. All subjects were evaluated for anemia. Mean group values were compared via t -tests. No significant difference was found between the two groups at $p < 0.05$. Anemia was not present in any of the subjects of this study. These results indicate that endurance runners, as compared to their sedentary controls, may not be at an elevated risk for iron deficiency anemia during pregnancy due to their endurance training.

ACKNOWLEDGEMENTS

The author is indebted to the members of the committee, Dr. Don Hardin, Dr. Sharon Dinkel and Ms. Jan Hulme, for their support through this study.

TABLE OF CONTENTS

	Page
Abstract	ii
Acknowledgements	iii
Table of Contents	iv
Chapter I INTRODUCTION	1
The Statement of the Problem	7
The Research Hypotheses	7
Level of Significance	8
Importance of the Study	8
Delimitations	8
The Limitations	10
Definition of Terms	10
Chapter II REVIEW OF LITERATURE	14
Iron Deficiency and Anemia	14
Causes of Iron Deficiency	16
Prevalence of Iron deficiency in Female Athletes	21
Pregnancy and Anemia	24
Effects of Iron Deficiency and Anemia	28
Conclusion	31
Chapter III RESEARCH PROCEDURES	32
Selection of Subjects	32
Scope of Subjects	32
Data Collection Instruments	34
Treatment of the Data	38
Chapter IV ANALYSIS OF THE RESULTS	39
Analysis of the Results	39
Chapter V DISCUSSION, CONCLUSION, RECOMMENDATIONS AND SUMMARY	46
Discussion	46
Summary of Results	53
Conclusion	54
Recommendations	54
Summary	55
APPENDIX	57
Appendix A.	57
REFERENCES	61

CHAPTER I

INTRODUCTION

The 1980's have introduced a change in health attitudes and practices for a large number of Americans. People are more concerned about living a healthy lifestyle than ever before. (Patton, Cory, Gettman, 1986) Exercise has become an integral part of this change. Millions of people are discovering the benefits of endurance aerobic exercise as a part of a total body fitness program. A sporting goods dealers' 1983 census report indicates there are approximately 17.7 million women who run. (Lutter, 1985) Women are finding a solution to weight loss and maintenance, as well as cardiovascular conditioning, through aerobic endurance exercises such as running.

In recent years investigators have identified problems which may be associated with endurance running. According to Clement (1984), one significant problem for female athletes involved in heavy endurance training is a tendency to have iron deficiencies. Williams (1985) states that in addition to iron deficiency, a condition known as "sports anemia" has also been described in which the athlete experiences a reduced hemoglobin as a result of an acute response to exercise.

Sports anemia is evidenced by hemoglobin and hematocrit values which fall in the low range of normal values and has

been observed for more than 30 years in highly trained endurance athletes. (Clement,1984; Pate,1983) Normal hemoglobin values for women are from 12.0 to 15.0gm/dl. (Tilkian, Conover, Tilkian, 1979) Studies have indicated lower hemoglobin levels in female endurance runners versus their sedentary controls, but subnormal levels below 12.0g/dl are rare. (Pate, 1981; Clement, 1984; Parr, et.al., 1984) According to Pate (1983), normal values may not be optimal for endurance athletes for performance and iron stores and female endurance runners should have hemoglobin concentrations well above 12 gm/dl.

Several theories have been offered to explain "sports anemia" in endurance athletes. One explanation of low hemoglobin levels may be due to an acute response to exercise. This acute response is detected when an athlete begins an endurance program or increases the intensity of their training. A reduction in hemoglobin has been attributed to a destruction of erythrocytes or hemolysis, which may be caused by a stress reaction to strenuous muscular exercise or from direct impact against the red blood cells. (Pate,1981;Clement,1984;Eichner,1986) Footstrike hemolysis is the second most common contributor to anemia in runners (Eichner, 1986). In theory, hemolysis can limit the expansion of red blood cell mass and can drain body iron by way of hemoglobinuria.

Another potential cause of "sports anemia" is an

increased plasma volume which causes a hemodilution effect on the hemoglobin value. An increase in serum plasma volume is part of the chronic adaption to endurance training and allows the body to become more efficient in sweating and cooling the body, while maintaining homeostasis of fluids and electrolytes. (McArdle, Katch, Katch, 1985)

Iron imbalance is another cause of anemia. If the amount of iron leaving the body exceeds the amount taken in and absorbed, the body draws upon stores to cover the imbalance. (Clement, 1984) A continuation of this process leads to a depletion of stores, iron-deficient erythropoiesis, and finally anemia. This may be the most common cause of sports anemia, especially for female athletes, who have an increased demand for iron due to menstruation. (Pate, 1981; Clement, 1984; Eichen, 1986)

A primary cause of iron imbalance may be due to poor nutritional intakes. According to Clement (1984), a nutritional analysis of female distance runners revealed an average iron intake of 12.5 mg per day which is well below the recommended amount of 18mg daily. The average Western diet supplies 5 to 6mg of iron per 1000 kcal, and most female runners had estimated caloric intakes of 2000kcal or less than this which is normally inadequate to attain enough dietary iron.

Other factors which may contribute to iron imbalances are abnormal blood losses and poor absorption of dietary

iron. Acute or chronic abnormal blood loss may lead to a depletion of iron stores and anemia. Gastrointestinal distress or heavy menstrual bleeding can lead to anemia. (Bothwell, 1981)

According to Clement (1984), female distance runners may also have a problem in the absorption of dietary iron. Female endurance runners were found to absorb 29 percent of radioactive iron versus the 70 percent absorbed by the non-exercising controls. These lower absorption rates may be a reflection of athletes' ability to excrete iron at an increased rate over their sedentary counterparts, through increased sweating, increased fecal loss, hematuria or menstruation.

Through the culmination of causes, female endurance runners find themselves at a higher risk for iron-deficiency than their non-exercising counterparts. (Parr, 1984)

According to Scrimshaw (1985), as iron deficiency develops, the first of the three stages is defined by a decline in serum ferritin. The second stage is a decrease in circulating iron, characterized by a decline in serum iron and a rise in the capacity of transferrin to bind additional iron, expressed as percent transferrin saturation. The third stage is a reduction in the production of essential iron compounds, such as enzymes and hemoglobin. Recent clinical studies have found that compounds affecting the brain, immunological competence and work performance may

all be affected before circulating hemoglobin is reduced. Symptoms of iron deficiency include headache, fatigue, heartburn, changes in appetite, vasomotor disturbances, muscular cramping, and dyspnea (Clement, 1984).

Fairbanks and Beutler (1980) state that iron deficiency is the most prevalent nutritional deficiency in this country. An estimated 50 percent of pre-menopausal women are iron deficient in the United States. (Parr, 1984) Female endurance runners present a greater risk due to their iron balance difficulties. An estimated 80 percent are iron deficient according to bone marrow studies and serum ferritin levels. (Steencamp, et.al.,1986) This has precipitated new health issues for women which need to be dealt with as the running phenomena continues to expand. A large portion of runners are in their child bearing years, and many plan pregnancy without regard to their nutritional status. This investigation was an attempt to study women runners who may be at high risk for anemia as they enter pregnancy.

Pregnancy is a condition which naturally places extra demands on iron reserves due to the demand of the fetus, placenta and maternal circulating blood volume. Anemia in pregnancy is well understood; hemodilution occurs during the first and second trimesters, causing a fall in hemoglobin concentration in normal pregnancies. A negative iron balance throughout pregnancy may cause iron deficiency

anemia in the latter half of pregnancy from fetal requirements which take precedence over maternal needs to expand the red blood cell mass. Women who enter pregnancy with a negative iron balance will most likely become anemic as they progress through their pregnancy unless vigorous iron therapy is initiated. (Bentley, 1985) Women at high risk for iron deficiencies are those who have had multiple pregnancies or prolonged breastfeeding without adequate repletion of iron stores (Bentley, 1985). The development of iron deficiency during pregnancy may be detected by frequently monitoring hemoglobin concentrations. Values falling below 11.0g/dl should be regarded as abnormal - (normal non-pregnant female 12.0-15.0g/dl). (Bentley, 1985; Williams, 1985)

Usually, there is no risk to the fetus from maternal iron deficiency due to the ability to draw on the maternal stores for growth needs before maternal demands are met. Studies have shown a minimal effect on the fetus from iron deficiency unless maternal stores drop dangerously low. (Pritchard, MacDonald, Gant, 1985) However, iron-deficient mothers may have increased symptoms of discomfort in the pregnancy state and may be started on vigorous treatments of oral iron supplements which may lead to gastrointestinal distress.

The purpose of this study was to investigate female endurance runners for stage three anemia. Hematological

values were viewed to determine if a significant difference occurred between pregnant endurance runners and a control population of pregnant non-exercisers in their first trimester of pregnancy. None of the participants took oral iron supplements prior to laboratory testing and only first trimester results were viewed before iron supplementation was started.

The Statement of the Problem

This research investigated first trimester hemoglobin, hematocrit, red blood cell count, mean cell volume and mean cell hemoglobin in a group of pregnant endurance runners and a control group of pregnant non-exercisers. Also, this study identified subjects in one or both groups as having hemoglobin levels less than 11.0gm/dl which may indicate iron-deficiency anemia.

The Research Hypotheses

- 1) There is a statistically significant difference in hemoglobin levels between pregnant endurance runners and pregnant non-exercisers.
- 2) There is a statistically significant difference in hematocrit levels between pregnant endurance runners and pregnant non-exercisers.
- 3) There is a statistically significant difference in red blood counts between pregnant endurance runners and pregnant non-exercisers.

4) There is a statistically significant difference in mean cell hemoglobin concentrations between pregnant endurance runners and pregnant non-exercisers.

5) There is a statistically significant difference in mean cell volume between pregnant endurance runners and pregnant non-exercisers.

6) A greater proportion of pregnant endurance runners will have hemoglobin levels below 11.0gm/dl than proportion of pregnant non-exercisers with hemoglobin levels less than 11.0gm/dl.

Level of Significance

The level of significance chosen for this study to accept or reject these hypotheses was the .05 level.

Importance of the Study

The importance of this study was to determine if female endurance runners are more prone to anemia as they enter pregnancy due to the fact they are more prone to iron deficiency because of their training. This study has limited external validity, but may show implications for further research in the areas of endurance running and nutrition for female athletes in childbearing years.

Delimitations

1. The subjects for the study were limited to pregnant women from the Missoula, Montana area plus three subjects

St. Paul, Minnesota.

2. All subjects reported not taking iron supplements or multi- vitamins before becoming pregnant.
3. The control group consisted of pregnant women who reported no regular physical activities or less intense activities described as walking three to four days per week, less than thirty minutes per session.
4. Endurance runners were defined as women who ran between 10-50 miles per week.
5. All participants were pregnant for the first time, except for three from the runner's group. However, these three women had not delivered within 24 months prior to the studies laboratory results. None had breastfed within the last eighteen months.
6. All participants filled out a survey which requested personal information about the type of routine exercise in which they participate, the frequency and duration. (See Appendix A)
7. The study was limited to eighteen pregnant runners and eighteen pregnant controls.
8. Participants personally obtained their own laboratory results on pre-natal visits by having a staff member in the office of the obstetrician fill in the second section of the survey. (See Appendix A) (Hemoglobin, hematocrit, and red blood count are routinely done on the first visit to an obstetrician for baseline data.)

The Limitations

1. There was no assessment of diets performed to determine if dietary iron consumption was standardized between groups. An assumption is made that the diets of the participants are similar to those discussed in Chapter Two.
2. All laboratory drawings were done at various periods during their first trimester instead of a fixed schedule. Hemodilution can begin at six to eight weeks into pregnancy. Ideally, laboratory testing should begin before this time. However, the majority of tests were completed approximately eight weeks into the pregnancy.
3. There was not a standardized laboratory or testing instrument used for this investigation. Participants received their own test results as reported from their physician's office.
4. The physical fitness component is self-reported.
5. No serum ferritin levels were obtained because this test is not routinely administered during pregnancy.

Definition of Terms

Hemoglobin (HGB) is the oxygen-carrying pigment of the red blood cells and is reported in grams per deciliter, or gm/dl. The normal hemoglobin for adult females is 12.0 to 15.0gm/dl. (Tilkian, et. al., 1979)

Hematocrit (HCT) is the volume of packed red blood

cells found in 100ml and is expressed as a percentage. For example, a value of 46 percent means that there are 46ml of red blood cells per 100ml of blood. A normal hematocrit for females is from 38 percent to 47 percent. (Tilkian, et. al., 1979) This value is critical in determining hemodilution in hemoglobin concentration.

Red Blood Cells (RBC) (erythrocytes) are formed in the red bone marrow. Red blood cells contain complex compound of hemoglobin which is made up of heme, a pigmented compound containing iron and globin, a colorless protein. Hemoglobin binds with oxygen, and the thus red blood cells' primary function is to transport oxygen. The red blood cell count represents the number of red blood cells in one microliter of whole blood. The normal red blood cell count for women is 4.2 to 5.4×10^6 . (Tilkian, et. al., 1979)

Mean Cell Hemoglobin (MCH) is the hemoglobin content of each individual red blood cell and is calculated by dividing the hemoglobin by the red blood cell count. The normal is 27 to 31 picograms (pg). (Tilkian, et.al., 1979)

Mean Cell Volume (MCV) describes the individual red cells in terms of cell size. The normal is 82 to 98 microcubic millimeters per red cell (cu microns). (Tilkian, et. al., 1979)

Iron Deficiency Anemia is evidenced by a hypochromic microcytic anemia. A borderline low hematocrit and hemoglobin should suggest the possibility of iron deficiency

anemia. A more finite diagnosis can be made by checking serum iron level and iron binding capacity. Additionally, serum ferritin level correlate well with total body iron stores, which obviate the need for bone marrow studies. (Tilkian, et. al.,1979) Due to the scope of this study, laboratory values which are routinely drawn during the prenatal visits will be used.

Sports Anemia is defined as a reduced hemoglobin level due to the destruction or loss of red blood cells without the repletion of these cells or a dilutional anemia which may reduce hemoglobin counts from an increase in plasma volume. This is an adaption to regular exercise. The body conserves salt and water to increase plasma volume. During exercise the plasma is driven into the tissues and fluid is lost through sweat. After exercise, the plasma volume is built up again. This may not be a true anemia because the red cell mass will remain normal. The increase in blood volume induced by aerobic conditioning is a critical factor in improving performance and promoting a resistance to fatigue.

Anemia may be diagnosed in female athletes with hemoglobin levels below 11 gm/dl when hemodilution may be a consideration. However, absolute values are not consistent with all researchers. Pate (1983) has stated that hemoglobin concentrations for women should be well above 12 gm/dl for optimal performance. Many factors need to be

considered before the diagnosis of anemia is made in both the female athlete and pregnancy.

CHAPTER II

REVIEW OF THE LITERATURE

The iron status of female athletes has been under investigation for the last several years. Many investigators have attempted to identify and explain iron deficiencies and its impact on the body, in both training and pregnant states. This review is a discussion of the recent investigations, information and controversy pertaining to iron deficiency and anemia in female endurance runners and pregnancy.

Iron Deficiency and Anemia

Iron is a finely balanced essential mineral to the body, and is needed in most systems for proper functioning. According to Scrimshaw (1985), and Clement and Sawchuck (1984), about 70 percent of body iron is classified as essential or functional and is contained in the hemoglobin, myoglobin and respiratory enzymes. Hemoglobin accounts for about 85 percent, and myoglobin accounts for about 4 percent of the total; and the additional iron is present in a large number of enzymes including cytochromes, flavoproteins, and other mitochondrial iron compounds involved in the oxidative production of cellular energy. Thus the function of any tissue or organ, including the brain, may be affected by iron deficiency states. The remaining 30 percent of iron is classified as storage iron and serves as reserve for any

iron imbalances which may occur.

Iron may be depleted from the body due to an imbalance between intake and the body's needs and ability to utilize and absorb essential iron. The process of depletion is complex and is described in stages of events. According to Parr, et. al.(1984), stage one iron deficiency is the depletion of iron stores in the liver, spleen and bone marrow. Bone marrow studies are the most accurate methods to determine iron deficiency. However, serum ferritin levels correlate highly with bone marrow aspirations, and thus are used more routinely due to the ease and comfort for the subject (Wishnitzer, 1983). Low serum ferritin level will be the first indication of low body stores of iron. The normal mean value for women is 25 to 59 ng/100ml of blood, Approximately 10 ng/100ml equals 100 mg of stored iron. Women are commonly reported to have stores between 250 mg to 590 mg of iron. (Parr, et.al., 1984)

According to Parr, et.al. (1984), once iron stores are depleted, serum ferritin measurements do not reflect more advanced degrees of iron shortage. During the second stage of iron deficiency, serum iron levels decrease and total iron-binding capacity increases. This stage is usually diagnosed by testing serum iron levels (mean values for women are 55 to 185 mcg/100ml), and total iron binding capacity (mean values for women are 250 to 420 mcg/100ml). Transferrin also has an increased affinity to bind with iron

and is expressed as transferrin saturation percent (mean values are 20 to 45 percent).

Stage three iron deficiency anemia is the last stage of iron deficiency and is defined as hemoglobin concentrations below 12 gm/dl for adult females (Scrimshaw, 1985). This measurement is used because as iron deficiency progresses, hemoglobin synthesis decreases due to the lack of iron. The degree of iron deficiency anemia can be further evaluated by observing other hematological parameters. Hematocrit and hemoglobin both found below normal, would rule out a hemodilutional effect. Red blood cell count is usually found within normal range.

The size of the red blood cells is an important criteria for distinguishing between iron deficiency anemia and other causes of anemia. Iron deficiency anemia is evidenced by microcytic, hypochromic red blood cells. That is, the cells will be smaller than normal and will have less pigment or hemoglobin content. This may be determined by mean cell volume which determines the average red blood cell size, and the mean cell hemoglobin which averages the cell hemoglobin content. (Scrimshaw, 1985).

Causes of Iron Deficiency

Recent investigations have focused on iron deficiency in female endurance athletes, particularly runners, because they are at greatest risk for iron imbalances. There are several suspected factors which influence iron balance.

According to Clement and Sawchuck (1984), and Pate (1981), there are pathological and exercise-related factors which influence iron deficiency.

Pathological factors are conditions which cause an abnormal amount of blood loss. These conditions may result in an acute blood loss or a chronic loss which diminishes iron reserves and may cause anemia (Clement and Sawchuk, 1984). Regular blood donors often have depleted iron stores and daily iron requirements may increase three to four fold with periodical donations of 500ml of blood (Bothwell, 1981). Blood loss can also occur through the gastrointestinal tract. Chronic aspirin use and stress may cause gastritis or colitis which may cause the intestine to bleed. (Williams, 1985) Bothwell and Charlton (1981) report that a prolonged daily loss of only a few milliliters of blood will inevitably lead to the depletion of iron and possibly anemia. Another important consideration for premenopausal women is heavy menstrual bleeding. (Bothwell and Charlton, 1981) Women vary on monthly menstrual losses, but normal losses are approximately 20 to 60 mls of blood per cycle. (Parr, Bachman and Moss, 1984; Williams, 1985)

Other factors which affect iron deficiency are exercise related. There are general hematological adaptations to exercise which are exaggerated in endurance athletes. Endurance runners have been found to have lower hemoglobin values than their sedentary counterparts. According to Pate (1981)

and Eichen (1986), this phenomenon is called "sports anemia", but may not be considered a true anemia. Hemoglobin is reduced due to a hemodilution or an increase in plasma volume without a proportional increase in red blood cell mass. This is a physical adaptations to regular endurance exercise and is considered to be a critical factor in improving performance and resisting fatigue. This usually occurs in initial training or with increased endurance training.

Eichen (1986) describes the process of sports anemia as the body's attempt to conserve salt and water to increase plasma volume. During exercise, plasma volume decreases as plasma is driven into the tissues to facilitate an increase in sweating. Once exercise has stopped, plasma volume is regained through an increased release of renin, aldosterone, and vasopressin, and an increased synthesis of serum albumin. An increased plasma volume is a sustained response in training for regular exercisers. The enhanced volume aids the athlete by increasing cardiac stroke volume and improving the efficiency of sweating.

Eichen (1986) also proposed that the degree of dilutional anemia correlates with the amount of exercise performed. Guidelines are given to determine an expected amount of hemodilution with exercise. Plasma volumes should increase approximately 5 percent from a moderate jogging program, 10 percent from military basic training, 15 percent

from a 20-day running road race, and 20 percent from the regimen of an elite distance runner. Thus to account for hemodilution, hemoglobin levels for female runners under 11gm/dl can be considered anemic. Running in altitudes may bring this standard slightly upward.

Other factors which may influence iron deficiency are a female athlete's inability to consume adequate amounts of iron. Clement and Asmundson (1982) indicated that female athletes have increased demands for iron which are rarely met in the average Western diet. Clement and Asmundson (1982) performed a seven day dietary analysis on 17 female endurance runners and found an average iron intake of 12.5 mg/day, which is well below the recommended daily intake of 18mg. These women were also found to have a mean hemoglobin of 13.3 gm/dl which is within the normal range, but 82 percent exhibited plasma ferritin levels less than 30ng/100-ml which is indicative of stage one iron deficiency. Perron and Endres (1985) studied 48-hour dietary records of 31 female athletes in high school and found that 69 percent had iron intakes less than 67 percent of the recommended daily requirements.

Women are at greater risk for inadequate intakes of iron because the average Western diet contains only 5 to 6mg of iron per 1000 kcal. (Clement and Sawchuck, 1984) The average caloric intake for premenopausal women is between 2100 to 2400 calories per day. Approximately 10 percent of

dietary iron is absorbed through the digestive tract and one could expect women to retain 1.26-1.44 mg of iron. This falls short of the 1.8 mg/day needed to maintain iron balance. (Williams, 1985) Caloric intakes below 2000kcal are often associated with inadequate available iron. According to Bothwell and Charlton (1981), female athletes are at special risk of iron deficiency due to an already increased requirement from menstruation.

Another exercise related factor to iron deficiency may be the phenomenon of hemolysis during exercise, and running in particular. Running is thought to produce a high incidence of mechanical trauma to red blood cells from footstrike and bladder and kidney jarring, causing hemolysis and excretion of hemoglobin through the urine, or hemoglobinuria and hematuria. (Pate, 1981; Clement and Sawchuck, 1984; Eichen, 1986; and Steenkamp, et. al., 1986) However, Steenkamp, et. al. (1986) studied six female marathon runners pre- and post-marathon and found no trace of red blood cell fragmentation or hemoglobinuria. According to Eichen (1986), hemolysis may be reduced with air cushioned shoes and by maintaining an ideal body weight for running, which helps to reduce the traumatic footstrike to red blood cells. Thus, many factors may play a role for the individual runner to determine the impact of hemolysis on iron stores.

Iron absorption difficulties may also contribute to

iron deficiencies. A study by Clement in 1983 (Clement and Sawchuck, 1984), indicated that female endurance runners may have a lower iron absorption ability than non-exercising females. The average absorption of radioactive iron was 29 percent versus 70 percent absorption in the non-exercising females. The low absorption rate is not completely understood, and further investigation in this area is needed. However, Clement (Clement and Sawchuck, 1984) speculated that these athletes may eliminate iron faster than their sedentary counterparts. Iron absorption has been shown to vary with diet, iron stores and the rate of erythropoiesis. (Parr, Bachman, and Moss, 1984) Total body iron is estimated to be between 2 and 6 gm or an average of 35 mg per kg of body weight. Normal daily losses of 0.5 to 1.0 mg occur through sweating, fecal loss, hair, skin and urine. Female athletes menstrual flow may contribute an additional loss of 8 to 38 mg per period. (Parr, Bachman, and Moss, 1984)

Athletes have also been shown to have a greater need for iron early in training. This is due to an increased uptake of iron in the muscle for building new tissue, and a greater need for plasma iron, and for hemoglobin production to correct hemolysis. (Parr, Bachman, and Moss, 1984)

Prevalence of Iron Deficiency and Female Athletes

The study of iron deficiencies in female athletes has been cause for debate over the last ten years. Several

investigators have attempted to identify and predict female athletes at risk for developing iron deficiencies from training. The following is a discussion of recent research and their findings.

One of the first studies performed in this area was by Wirth, et. al. (1977). These researchers studied the hemoglobin, hematocrit and serum iron levels of 17 college-age women before and after 10 weeks of training on a bicycle ergometer. While aerobic capacity increased by 11 percent over a group of eight controls, none of the hematological values changed significantly.

In 1980, Hunding, Jordal, and Paulev (1981) performed an investigation to evaluate iron deficiencies in 113 joggers and competitive runners in Copenhagen, Denmark. The mean running distance was approximately 12 miles per week. Only one woman had frank anemia, while thirteen were suspected of latent anemia because of increased iron binding capacities and hemoglobin less than 13gm/dl. This study is not conclusive enough to extrapolate to all female runners, but the results have posed many questions for further investigation.

The next significant investigation was done by Clement and Asmundson (1982). These researchers studied the dietary intakes and hematological values of 17 college-age women who ran approximately six miles per day. The average intake of daily iron was 12.5 mg (per dietary recall), which was well

below the recommended 18 mg. Eighty two percent of the women were found to have subnormal ferritin levels, which contribute to the risk for iron deficiency, but none of the women showed latent anemia. The mean hemoglobin was 13.3 gm/dl.

Parr, Bachman, and Moss (1984) studied 29 female athletes and 8 controls for iron deficiency. All athletes were found to have stage one iron deficiency, that is they had less than optimal ferritin levels. Eleven of the athletes were from the track team, however, endurance running was not specified as their mode of exercise.

Brown, et. al., (1985) compared the iron statuses of 32 female high school track athletes with 31 controls. There was no significant difference between hemoglobin and serum ferritin, but both groups were in low-normal ranges. However, the athletes' transferrin saturation was found to be lower than the controls. A note should be made in regard to special findings from this study. Thirty seven of the subjects were black and all black subjects were significantly lower in all of these values. This may have a sociometric value which is not clearly documented with athletes studies.

Pate, et. al., (1986), recently studied a large population of 126 habitual adult female runners and 87 sedentary females. The runners were found to be significantly lower ($p < .05$) than the reference group in hemoglobin,

hematocrit, serum ferritin, red blood cell count, mean cell hemoglobin and total iron binding capacity. Iron depleted and iron deficient states were significantly more prevalent in the habitual runners when compared to their sedentary counterparts. However, anemia was rare in both groups.

Pregnancy and Anemia

Anemia occurs commonly in association with pregnancy, but is rarely a serious complication with proper identification and treatment. Anemia can be caused by a number of conditions, such as chronic blood loss, metabolic disorders, genetic defects or nutritional deficiencies. Bentley (1985) reports that the most common cause of anemia during pregnancy is due to iron deficiency. This is due to an imbalance from excessive demands for iron which cannot be met by dietary means during pregnancy.

According to Pritchard, MacDonald and Gant (1985), women enter pregnancy with an inadequate amount of stored iron to meet the demands of pregnancy. The total iron content of normal healthy women is in the range of 2.0 to 2.5 g. The iron requirements of a normal pregnancy totals about 1.0 g. About 300 mg are transferred to the fetus and placenta, and about 200 mg are lost through normal routes of excretion, i.e. gastrointestinal, urine and skin. Also, there is an average increase in the total volume of circulating red blood cells of about 450 ml, which utilizes about 500 mg of iron, if available (1 ml of RBC contains 1.1 mg

of iron).

Iron demands are greatest during the latter half of pregnancy and increases daily intake requirements to 6 to 7 mg/day during this period. (Pritchard, MacDonald, and Gant, 1985; Goodwin, 1976) An earlier discussion noted that only 10 percent of dietary iron is absorbed through the digestive tract. (Williams, 1985) However, during pregnancy there is a 20 percent increase in ability to absorb dietary iron. Bentley (1985) believes most women's iron stores and diets are inadequate to meet these demands, and maternal red blood cell mass will not increase unless exogenous iron is made available in adequate amounts. If exogenous iron is not made available, maternal hemoglobin and hematocrit will become below normal. However, hemoglobin concentration in the fetus will remain uncompromised because of the placenta's ability to draw on maternal stores.

Thus, anemia is not a normal feature in the first trimester of pregnancy and hemoglobin values should remain stable for the first 16 weeks, unless maternal iron stores are depleted. (Bentley, 1985) According to Pritchard, MacDonald and Gant (1985), anemia exists in early pregnancy if hemoglobin levels fall below 11.0 gm/dl for women at lower altitudes. Later in pregnancy, a distinction must be made between iron deficiency anemia and a hemodilutional effect which may appear as anemia. Hemoglobin and hematocrit concentrations should be observed together to

account for a dilutional effect.

Hemodilution is normal in pregnancy and is a functional adaption to meet the increased needs of the fetus and the mother. (Pritchard, MacDonald, and Gant, 1985) The increased circulating volume serves to meet the demands of the enlarged uterus and its hypertrophied vascular system. Enhanced maternal blood volumes also act to protect the mother and fetus from the effect of impeding venous return while mother is in supine and erect position. Finally, the increased volume is a safeguard for the mother which protects her from deleterious effects of blood loss at delivery.

Pritchard, MacDonald, and Gant, (1985) explain this pattern as follows. The maternal blood volume begins to increase during the first trimester, and expands most rapidly during the second trimester and then plateaus during the last several weeks of pregnancy. The increased blood volume comes from both an increase in plasma and red blood cells. The initial rise is from the plasma volume, which is followed by an increase in circulating red blood cells. If iron intake is inadequate and iron stores are depleted, red blood cell production may be compromised and an iron deficiency anemia results.

Bentley (1985) believes that women who have inadequate iron stores at the start of pregnancy will have iron depletion as the demands of the fetus advance unless iron

supplements are given. Foulkes and Goldie (1982) performed a study which found that 87 percent of women who had serum ferritin levels less than 50 ng/l at the first trimester became anemic later in later pregnancy unless iron supplements were given. Thus, women who have lower serum ferritin may be at risk for anemia. Also, women with lower hemoglobin values between 11 to 12 gm/dl and hematocrit levels in a low range may be suspect for iron deficiency. (Bentley, 1985; Pritchard, MacDonald and Gant, 1985; Goodwin, Godden and Chance, 1976)

Iron supplements are routinely started after the first prenatal visit to prevent iron deficiency anemia in latter pregnancy, but reseachers are now questioning the need for prophylactic supplements in early pregnancy. (Bentley, 1985) Studies have shown that subjects who benefit from iron therapy are those that are found to be iron-depleted. These investigators suggest further determinants are needed to identify high risk individuals, rather than using standard iron therapy for all pregnancies. (Hemminki and Starfield, 1978; Bentley, 1985) Bentley (1985) recommends starting supplementation in women with ferritin levels less than 50 ng/l or hemoglobin levels that are abnormal in early pregnancy.

Iron supplements are often aversive in large amounts because of gastrointestinal side effects. According to Ivey and Elmer (1982), iron supplements may cause gastric

irritation, nausea and diarrhea. The other extreme is its constipating effect. All of these symptoms may exacerbate early symptoms in pregnancy and make physical activities uncomfortable.

Effects of Iron Deficiency and Anemia

There is a difference of opinion concerning the significance and effect iron deficiency has on the female athlete. Research has shown conflicts results and the implications for athletes. The following is a discussion of various research and opinions of the effects of iron deficiency and anemia for female and pregnant athletes.

Iron is the main component of hemoglobin in red blood cells, myoglobin in muscle tissue, and the cytochrome enzyme complex in the mitochondria. Thus, the function of iron is to promote oxygen transport into the cell and within the cell. (Williams, 1985) The major concern of iron deficiency is a progression to iron deficiency anemia which will impair physical activity. The extent of the impact on performance is unclear. According to Williams (1985), there is a debate whether or not iron deficiency without anemia will impair physical performance. However, Williams states iron deficiency is more likely to impact endurance athletes over their sedentary counterparts. Endurance athletes need adequate body iron stores for efficient oxygen transport. Poor iron stores impair oxygen transportation in the blood

and tissues which reduce the ability to generate Adenosine triphosphate by aerobic synthesis. This may greatly impair physical performance in the endurance athlete.

Poor iron status will effect hemoglobin concentrations in various magnitudes, but the degree at which performance is effected is not completely understood. Pate (1983) states that normal clinical values of hemoglobin concentration may not be optimal for endurance athletic performance and female athletes should have hemoglobin concentrations well above 12 gm/dl. This concept has risen from new research which demonstrates an increase in aerobic power in athletes who have participated in "blood doping". This is a process to increase hemoglobin levels by removal and subsequent reinfusion of blood before a performance. Pate (1983) recommends suboptimal hemoglobin level should be defined as concentrations below the mean for the normal population. Lutter (1985) notes that pregnant women should have hemoglobin concentrations greater than 14 gm/dl because hemoglobin levels usually stay high until the latter stages of iron deficiency. This may act as a safeguard against the development of anemia, but serum ferritin levels should be measured along with hemoglobin levels.

Maximum performance may not be the only physiological compromise of iron deficiency, with or without anemia, but it may be a limiting factor for pregnant women who wish to continue running during their pregnancy. According to

O'Neil, Hynak-Hankinson, and Gorman (1986), a deficiency of iron stores may result in weakness, fatigue, pallor, dyspnea with exertion, palpitations, and prolonged restoration of cardiorespiratory function to pre-exercise levels.

Scrimshaw (1985) reports functional consequences affecting the immunological system in iron deficient adults. Diarrheal and respiratory diseases have been more common in adults with iron deficiency. Iron deficiency has also been associated with an increase in the frequency of chronic mucotaneous candidiasis and recurrent herpes. Obviously, these conditions impair both athletic and pregnancy states.

The increased iron demands of pregnancy may pose a new problem for female endurance athletes due to their inability to meet the demands through their diets alone. A reduction of maternal hemoglobin is the most obvious sign of iron deficiency, but a variety of non-hematological effects may be recognized in iron deficiency. (Bentley, 1985) According to Pritchard, MacDonald, and Gant (1985), a hemoglobin level less than 9.0 gm/dl is the minimum level for safety, at 6.5 gm/dl, the mother's life may be endangered. Maternal effects may be an intolerance of blood loss at delivery, a predisposition to infection, and in severe cases, dysfunctional labor.

Anemia in the newborn is rarely a problem due to placental enlargement. This is a compensatory response to

protect the fetus from anoxia when maternal iron stores are depleted. (Bentley, 1985) However, late abortion and pre-term labor may occur as a result of severe maternal anemia. This has become an infrequent phenomenon due to the advent of widespread iron supplementation during pregnancy. Pritchard, MacDonald, and Gant (1985) state that pregnant women generally benefit from 60 to 100mg of iron per day if there is no overt anemia and also believe that since iron requirements are slight during the first four months of pregnancy, it is not necessary to provide supplements at that time. Withholding iron supplements during the first trimester avoids the risk of further aggravating nausea and vomiting which is common in early pregnancy. Bentley (1985) also agrees with this mode of therapy, but cautions to examine the serum ferritin along with the hemoglobin levels. Bentley concludes that in early pregnancy, women with serum ferritin level less than 50 ng/l are candidates for iron supplementation.

Conclusion

Female endurance runners have been documented as high risk individuals for iron deficiency due to their increased needs for training and their inadequate dietary intakes. This poses a new health concern for female runners in their childbearing years and also for obstetricians and gynecologists who are health educators to these women.

CHAPTER III

RESEARCH PROCEDURES

The purpose of this study was to determine whether there was a statistically significant difference in the hemoglobin concentrations between a group of pregnant endurance runners and a group of pregnant sedentary controls. A second purpose was to identify participants with hemoglobin values less than 11 gm/dl. The following is a description of the research procedures used for the data collection.

Selection of Subjects

The subjects of this study were 36 adult pregnant women, ranging in age from 22-39. Participants were obtained by soliciting the Missoula community via LaMaze classes and by word-of-mouth. All participants were requested to fill out a questionnaire about their exercise habits and then requested to have their physician fill out their first trimester laboratory values.

Scope of Subjects

Eighteen of the participants were categorized into the experimental group based on criterion of physical activity immediately prior to pregnancy. Exercise habits were to include endurance running as defined by Lutter (1985).

Moderate endurance running may be described as running between 10-50 miles per week. Three of the participants were running between 10 to 12 miles per week, and two participant were training for marathons which put their mileage in excess of 25 miles per week. The rest of the runners group fell somewhere in between in terms of running mileage.

Four of the runners group delivered before the data was collected. However, each of the four had delivered within one year of the data collection to ensure accuracy in recall.

The control group was selected on the basis of reporting no regular or low intensity endurance activities prior to pregnancy. Three control members reported they participated in regular walking programs. However, their programs consisted of less than 30 minutes of walking, three to four days per week.

All participants from both groups reported not taking vitamin supplements with iron prior to pregnancy, the only dietary control used in this investigation. Several studies and reports from the 1970's indicate that most females in the United States fail to receive enough dietary iron (Williams, 1985). The Ten State National Nutrition Survey and the Nutrition Examination Survey both reported a general deficiency of iron in the American diet, particularly in females after the onset of puberty. Also, Buetler (1980)

noted that iron deficiency is the most common deficiency of a nutrient and iron-deficiency anemia is a major medical and public health problem. Thus, for the purpose of this study, both groups are considered to be at risk of iron deficiency due to inadequate dietary iron.

Data Collection Instrument

A two part questionnaire was designed to quantify participant's exercise patterns and hematological laboratory values. The questionnaire included a cover letter which included directions on how to fill out the questionnaire. A self-addressed stamped envelope was supplied to ensure ease in the return of the data. Appendix A includes the survey in its entirety.

The first part of the questionnaire consisted of a one page survey requesting personal information about the subjects exercise patterns and demographic information. The participants were asked to give their names only if they were interested in the results of the investigation. Subjects were then asked to give their expected due dates of delivery, so that it would be more reasonable to approximate the timing of the laboratory values relative to the expected gestation. The participants were also asked to list their ages for the purpose of assuring participants over the age of eighteen.

The following is a list of the questions and the

rationale for each.

1. Did you take any vitamin supplements with iron before you became pregnant? If yes, please list the type and frequency taken.

This was asked as a control for dietary iron. The participants were asked to list the supplements they were taking in order to determine if the supplements inadvertently contained iron without the participants knowledge.

2. Did you participate in any regular exercise before you became pregnant? Yes No (If no, please skip Questions 3-7)

This question was asked to identify control participants and let them know they were finished with the survey.

3. What type of exercise did you participate in?

Aerobics

Bicycling

Swimming

Walking

Running/Jogging

Other (Please list)

This question was asked to identify any extraneous exercise which may invalidate participation in the exercise group.

4. How many days per week did you exercise? _____ Days/Week

This question helped to quantify the frequency of exercise. Participants to be included in the exercise group were to

exercise more than three days per week.

5. How long were your exercise sessions? _____ Minutes

This question quantified duration of exercise sessions.

Participants in the exercise group were required to have sessions longer than 30 minutes in duration.

6. If you participated in running or jogging, estimate your mileage per week. _____ Miles/Week

This question was used to account for training variances within participants.

7. Have you continued to exercise during your pregnancy?
Yes No If yes, indicate any modifications in your exercise program from pre-pregnancy and approximate which month you changed.

This question was used for the investigator's interest and for future reference.

8. Other comments you may wish to add:

This question provided an opportunity for participants to offer any other comments about their exercise and pregnancy.

Part two of the questionnaire was to be filled out by the participants physician at their next prenatal visit.

This part requested the following information:

1. State patients Expected Delivery Date. _____

2. State Estimated date of Conception. _____

These questions were asked to validate that the laboratory values were taken in the first trimester of pregnancy.

3. First Trimester Laboratory Results: DATE DRAWN _____

This was to ensure that the results were from the first trimester.

- (1) Hemoglobin _____ gm/dl
- (2) Hematocrit _____ %
- (3) Red Blood Cells _____ RBC/ml
- (4) Mean Cell Volume -----Cu microns
- (5) Mean Cell Hemoglobin _____ %
- (6) Mean Cell Hemoglobin Concentration _____ %

If available:

- (7) Serum Ferritin _____ mcg/dl
- (8) Serum Iron _____ mcg/dl
- (9) Serum Iron-Binding Capacity _____ mcg/dl

Treatment of the Data

The data was categorized by defining the mean and

standard deviation for each variable previously described. A one-tailed t-test was used to compare the variables between the control and endurance runners groups.

CHAPTER IV

ANALYSIS OF THE RESULTS

Data from this study were analyzed using descriptive statistics. Means and standard deviations analysis was performed on demographic information. Laboratory values were collected within the first 13 weeks of pregnancy for both groups, with a mean collection period of 8 weeks.

The average age for the endurance runners group was 30.3 years, with a range of 24-34 years. The average age for the control group was 28.4 years, with a range from 22-39 years.

The endurance running group was comprised of pregnant subjects who ran an average of 26 miles per week, with a range from 10 to 50 miles per week. The control subjects reported no regular physical activities except for four subjects who reported walking 20-30 minutes per session, three to four times per week.

Analysis of the Data

A one-tailed t -test for independent samples was used for each of the dependent variables. Table 1 lists the mean laboratory values, normal values, and standard deviations for each of the dependent variables for both groups.

None of the hematological values derived in this study indicate a statistical significance at the .05 level. No hemoglobin values were found below 11 gm/dl in either the endurance running group or the control group.

TABLE 1
MEAN LABORATORY VALUES AND STANDARD DEVIATIONS
IN PREGNANT ENDURANCE RUNNERS AND PREGNANT CONTROLS

	Normal Range for Females	Endurance Runners (n=17) Mean \pm SD	Controls (n=17) Mean \pm SD
Hemoglobin (gm/dl)	12.0-16.0	13.5 \pm 0.6	13.3 \pm 1.0
Hematocrit (%)	38-47	39.7 \pm 2.1	38.8 \pm 2.9
Red Blood Cell Count ($\times 10^6$ /ml)	4.2-5.4	4.4 \pm 0.3	4.4 \pm 0.4
Mean Cell Volume (cu microns)	82-98	90.1 \pm 2.8	89.0 \pm 3.8
Mean Cell Hemoglobin (picograms)	27-31	30.6 \pm 1.3	30.6 \pm 1.6
Mean Cell Hemoglobin Concentration (%)	32-36	34.3 \pm 1.1	34.4 \pm 0.7

The following is a discussion of the statistical analysis of the hypothesis proposed for each of the hematological values between the two groups.

Mean hemoglobin values were slightly less in the control group versus the runners group and a t -value of -0.7745 was reported with a one tailed probability of 0.2258. Hematocrit values were also less in the control group and a t -value of -1.0229 was reported with a one tailed probability of 0.1575. Red Blood Cell counts were slightly higher in the endurance runners and a t -value of -0.3556 was reported with a one tailed probability of 0.3623. Mean Cell Volume levels were higher for the runners group and a t -value of -0.9149 with a one tailed probability of 0.1900 was reported. Mean cell hemoglobin levels were slightly higher for the runners group and a t -value of 0.1658 was reported with a one tailed probability level of 0.4318. Finally, Mean Cell Hemoglobin Concentration was higher in the runner group and a t -value of 0.4685 was reported with a one tailed probability level of 0.3237 was reported.

Figures 1 through 3 were added to demonstrate trends in hemoglobin and hematocrit concentrations among and between group members. Figure 1 is a graphic display of hemoglobin levels between the pregnant endurance runners and the control group. This notes the trend of hemoglobin distribution between the two groups. Figure 2 is a graph depicting the hemoglobin concentrations in pregnant

endurance runners as it correlates to weekly running mileage. Figure 3 is a graphic distribution of hematocrit concentrations between the pregnant endurance runners and pregnant controls.

Figure 1
Hemoglobin Values of Runners and Controls

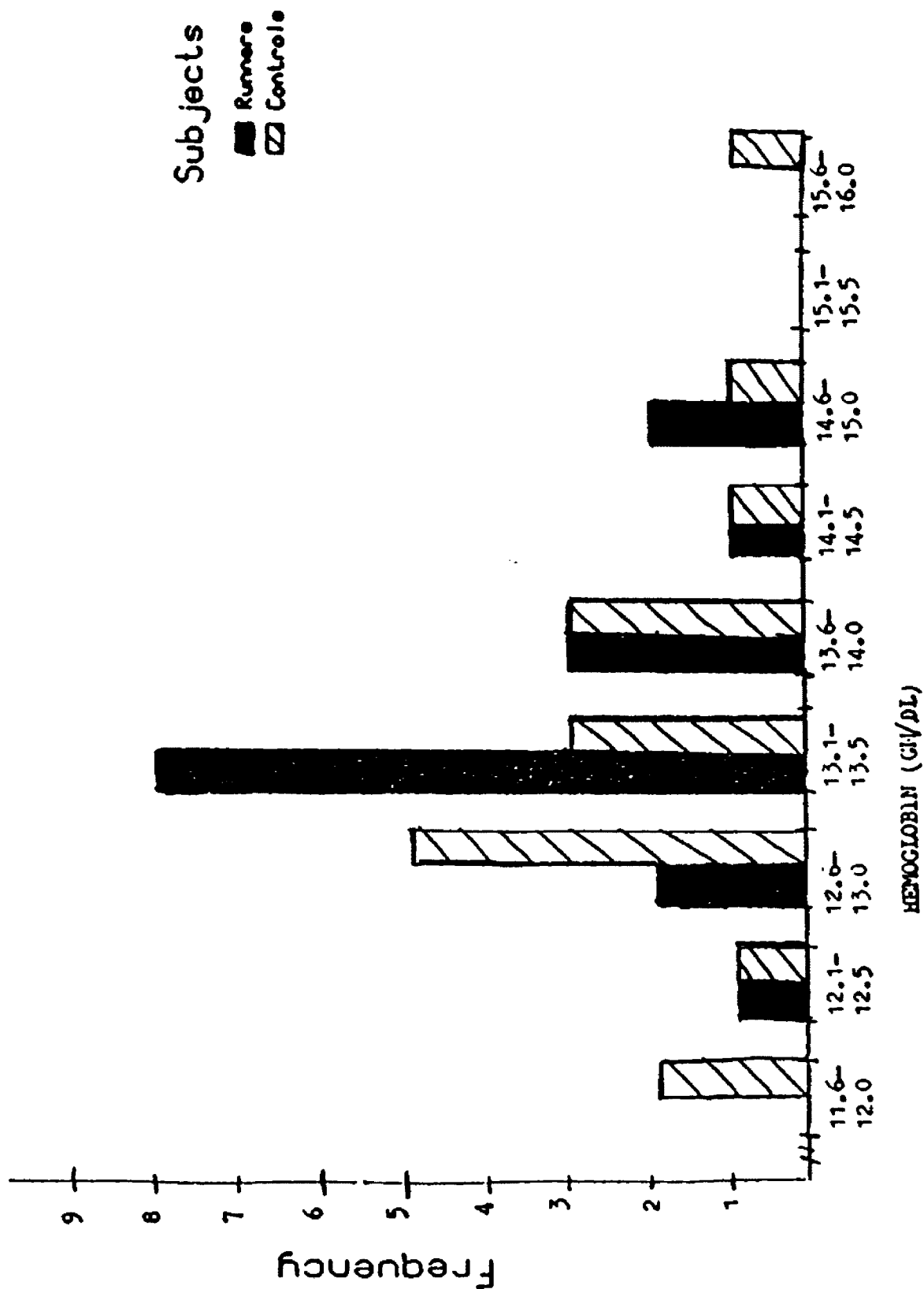


Figure 2 - Comparison of Hemoglobin Values (g/dl) and Miles Run Per Week

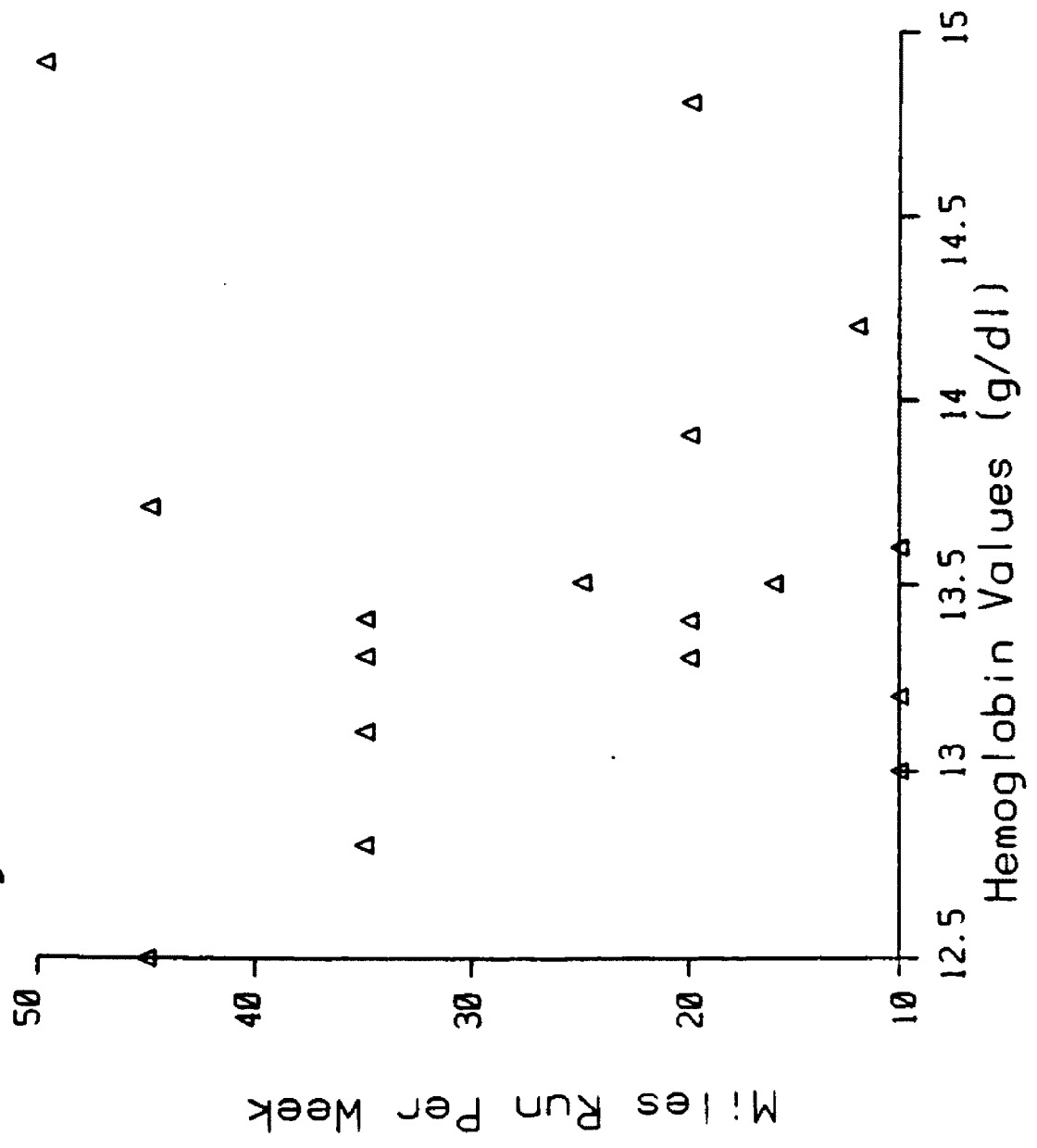
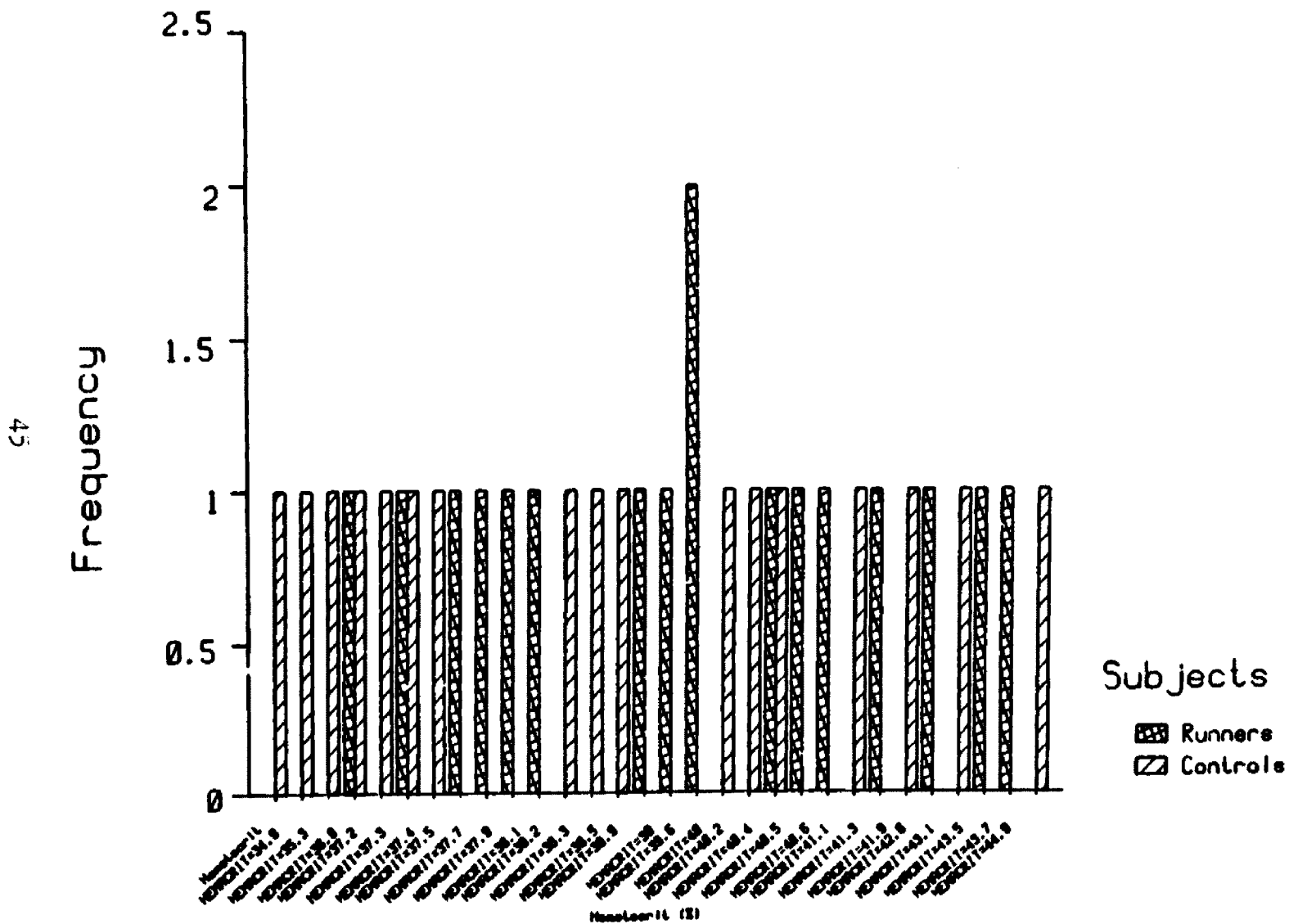


Figure 3
Hematocrit Values of Runners and Controls



CHAPTER V

DISCUSSION, CONCLUSION, RECOMMENDATIONS AND SUMMARY

This chapter will discuss the results of this study, as well as the implications for use and recommendations for future study.

DISCUSSION

The activity of endurance running in female athletes has been associated with reduced iron stores which places these athletes at risk for iron deficiency anemia. Pregnancy is also a condition which is known to deplete iron stores in females. This study identified a group of pregnant endurance runners and compared first trimester hematological values against a group of relatively sedentary pregnant females. The independent variable of running showed no additional effect on the hematological values. There was no statistical difference in first trimester hematological values between the two groups.

Hemoglobin values indicate the amount of the oxygen-carrying pigment in the red blood cell, and is reported in grams/dl of blood. The normal range for females is 12.0-16.0 gm/dl. The mean values for both groups were within the normal range, although both groups mean values were in the lower half of the range. There was no statistically significant difference between the two groups at the 0.05 level. Mean hemoglobin values were lower in the control group which disputes the hypothesis that the hemoglobin

values would be lower in the running group. None of the members in either of the groups showed hemoglobin values below 11.0 gm/dl. However, two members of the control had values less than 12.0 gm/dl, which is clinically significant given their first trimester status. Hemoglobin values should not drop below 12.0 gm/dl during pregnancy and the two values can be considered abnormal.

Hemoglobin trends were identified and a more stable occurrence of hemoglobin values in the running group compared to the control groups. Hemoglobin values fell mostly between 13.0 to 14.0 for the runners group, and conversely, hemoglobin values were more diverse for the control group. Both groups demonstrated diverse values among members.

Hematocrit values are the volume of packed red blood cells found in 1 dl or 100 ml of blood. Values are reported in terms of percentages and normal values for females range from 38 to 47 percent. This is a very accurate means of determining the hemodilution or quality of blood volume. Females with an expanded blood volume without a coinciding increase of red blood cells will demonstrate a reduced percentage of red blood cells per 100 ml of blood. Conversely, states of dehydration will demonstrate abnormally high hematocrit along with a high hemoglobin and red blood cell count.

Weekly mileage did not seem to be a determining factor

in hemoglobin values. Hemoglobin values were quite diverse and not dependent on the number of miles per week the participants ran.

Hematocrit concentrations were not found to be statistically different between the two groups at the 0.5 probability level. Mean hematocrit values were lower in the control group than the runners group. Both groups had mean values at the lower end of the scale. A hemodilutional effect may be present for both of the groups at the end of their first trimester.

Hematocrit distributions had less diverse values for the runners group with the majority (n=12) of the group having hematocrit values between 37.1 to 41.0 percent. The control group had findings that were more diverse with a range from 34.1 to 45 percent. These findings may represent significant information in identifying causes for stable hemoglobin and hematocrit values in the runners group. Endurance runners may be predisposed to chronic dehydration from vigorous training and may have findings higher due to a dehydration effect. Two control members with hemoglobin values below normal were also the members with the lowest hematocrit which may indicate a hemodilutional effect which lowers the hemoglobin concentration. (Other hematological indices were within normal ranges which indicates hemodilution for these two participants)

Red blood cell counts represents the number of red

blood cells in one microliter of whole blood. Red blood cell count may be normal in anemia. The normal value for females is from 4.2 to 5.4 x 10⁶ per microliter. Mean values for the two groups were identical with minimal variation for either of the groups. No statistical significance was observed between the two groups at the significance level of 0.05. Both groups values were in the low normal range for this parameter.

Mean cell volume describes the red cells in terms of individual cell size. Smaller than normal cell size is an indication that the cells are microcytic which is part of the anemia process. Microcytic cells indicate that there is abnormal development of the cells and hemoglobin concentration within the cells may be compromised. Normal values are from 82 to 98 cu microns. There was not a statistically significant difference between the two groups at the 0.5 level. Both groups mean values were within the normal range which indicates normal development of their red blood cells. Both groups varied in their values, but only one member in the control group indicated a below normal value.

Mean cell hemoglobin is the hemoglobin content of each individual red blood cell. This value indicates the pigmentation within each cell and whether or not the cells appear hypochromic. The pigmentation of the cell is the other parameter which may identify anemia. Hypochromic,

microcytic red blood cells indicate anemia. The normal range for mean cell hemoglobin is from 27 to 31 picograms (pg). Values were found identical between the two groups and no statistical difference was found at the 0.5 level. No members were found to have suboptimal mean cell hemoglobin values, except for one control member who had the suboptimal mean cell volume as well, all other values for this member were within normal range.

Mean cell hemoglobin concentration is the amount of hemoglobin found in 100 ml of red blood cells. The value is documented as a percentage. Normal values range from 32 to 36 percent. No statistical difference was found between the two groups at the 0.05 level. Mean values were almost identical and none of the members from either groups were below normal.

The results of this study indicate no statistically significant difference in hematological values between pregnant runners and relatively sedentary controls. No members of either groups were found to have anemia as defined previously. However, this study does indicate a large variance in hematological values among members in both groups in the first trimester of pregnancy.

Stage three anemia was not identified in members among the runners group which is consistent with the previous research on iron deficiency in female athletes. This is significant in that female athletes may need to be evaluated

with further hematological values to measure for stage one or two iron deficiency since iron deficiency may not be detected by routine testing. Also, dietary recalls or food frequency surveys may be useful in determining the amount of dietary iron they may be receiving which may aid in determining the need for prescribing exogenous iron.

Bentley (1985) describes a decrease in the phenomena of pregnancy induced anemia in Western cultures over the last twenty years. However, iron therapy during pregnancy has not changed and women are still receiving routine therapy beginning at the first trimester. Prudent physicians may be prophylactically prescribing iron therapy routinely without closely investigating the need for therapy. The physicians involved in the study were all asked to report any further first trimester laboratory values which would indicate stage one or two iron deficiency. None of the physicians responded to this request for further laboratory values. Serum ferritin, serum iron, and/or total iron binding capacity were not submitted on any of the subjects for review.

A minimum of a complete blood count should be routinely done on the initial visits as a baseline assessment with monthly follow up of hemoglobin values to monitor for abnormal responses. Many respondents could not be included in this study because of incomplete data from the physician. Several of the surveys were returned with only hemoglobin

results reported. This indicates that physicians may be treating women on the sole basis of hemoglobin values without the consideration of other parameters needed to determine iron status. These prescribing habits may be unnecessary and even caustic to women in the first trimester with gastrointestinal symptoms. Usually, symptoms represent a limiting factor in oral iron therapy and compliance during the first trimester (Bothwell, Charlton, 1981). Physicians may feel that further testing may be expensive and tedious for the patient. Also, excessive iron therapy has not been found to harm the fetus, but maternal side-effects are found to be dose related. The physician must treat each case individually and consideration should be given to these facts when weighing out the costs of therapy. Further research is needed in this area to determine its importance in prenatal care.

Research in the past which has focused on the iron status of female athletes has investigated college-age athletes, and only recently have researchers begun to look at maturing athletes. The subjects in this study were above college age with a mean age for the runner group of 30.3 years and 28.4 years in the control group. The more stable hematological values may be a reflection of more nutritionally sound eating habits in mature women as they contemplate and enter pregnancy. Female endurance athletes also have higher caloric needs than their sedentary

counterparts which affords them more calories to meet their nutrient requirements. This may explain why hematological values were found higher in the runners group compared to the control group.

The stable values found in this study may also reflect the trend of planned pregnancies in our society. Couples are timing the onset of their families and women are may be more concerned with their physical status before they embark on pregnancy. This may enhance the overall safety of their pregnancy and its outcome, especially with women starting families at ages older than the norm in the American culture.

SUMMARY OF THE RESULTS

1. There was no statistical significant difference in the hemoglobin values between the pregnant endurance runners group and the non-exercise control group.
2. There was no statistically significant difference in hematocrit values between the pregnant endurance runners group and the non-exercising control group.
3. There was no statistically significant difference in red blood cell counts between pregnant endurance runners and the non-exercising control group.
4. There was no statistically significant difference in the mean cell volumes between the pregnant endurance runners and the non exercising control group.
5. There was no statistically significant difference in

mean cell hemoglobin values in the pregnant endurance runners group and the non-exercising control group.

6. None of the members of this study had hemoglobin concentrations less than 11 gm/dl.

The directional hypothesis cannot be accepted due to a lack of statistical significance from the data. Thus the hypothesis tested in this study were rejected.

CONCLUSIONS

In conclusion, endurance running does not appear to be a limiting factor in hematological values in the first trimester of pregnancy. Stage three iron deficiency was not found in any of the subjects of either group. However, values were found diverse in both groups which may indicate a need for further hematological and dietary assessment of iron status for the high risk groups of female athletes. The efficacy of iron supplement use or non-use should be further evaluated in this group of pregnant runners.

RECOMMENDATIONS

Based on the results of this study, the following recommendations are suggested:

1. Female athletes may need further laboratory testing for iron deficiency during pregnancy.
2. Further assessments should include a dietary analysis or food frequency lists and hematological parameters of at least a complete blood count in

the first trimester.

3. Further parameters of serum ferritin, serum iron and total iron-binding capacity should be evaluated in the first trimester of pregnancy in female athletes.
4. Endurance runners need to be evaluated for iron deficiencies in the same capacity as all other women during pregnancy.

The following recommendations for future research are suggested:

1. Replication of this study with a larger sample.
2. Replication of this study using food frequency recalls along with first trimester serum ferritin, serum iron, and total iron binding capacities with a standardized apparatus.
3. Replication of this study with follow up hematological values throughout the pregnancies and with birth outcomes.

SUMMARY

The purpose of this study was to identify hematological values indicative of stage 3 iron deficiency in a group of pregnant endurance runners compared to a group of relatively sedentary pregnant controls in the first trimester of pregnancy. Seventeen pregnant runners participated (mean age = 30.3 yrs, range from 24-34 yrs), with an average

weekly mileage of 26 miles, ranging from 10 to 50 miles, and were compared to seventeen relatively sedentary control subjects (mean age= 28.4, range from 22-39). Hematological values were collected from individual subject's records from their own physician in the first thirteen weeks of pregnancy. Values collected were hemoglobin concentration, hematocrit, red blood cell count, mean cell volume, mean cell hemoglobin, and mean cell hemoglobin concentration. All subjects were evaluated for anemia. Mean group values were compared via t -tests. No significant difference was found between the two group at the statistical level of $p < .05$. Anemia was not present in any of the subjects of this study. These results indicate that endurance runners, as compared with relatively sedentary controls, may not be at an elevated risk for iron deficiency anemia during pregnancy due to increased endurance training.

APPENDIX A

TO ALL PARTICIPANTS:

Please fill in the requested information as completely as possible. Once you have completed this form and your physician's office has completed the second form, mail both forms to me in the attached self-addressed, stamped envelope.

All information obtained here will be held with strict confidentiality and no names will be reprinted for the use of this study.

Thank you for your time and effort. Please contact me if you have any questions filling out the forms or with the mailing.

Carolyn Ryan
450 E. Central Av.
Missoula, Mt. 59801
549-9038

NAME:
ADDRESS:

PHONE:

AGE:
EXPECTED DUE DATE:

1. Did you take any vitamin supplements with iron before you became pregnant? (1) YES (0) NO If yes, list type and frequency taken.

2. Did you participate in any regular exercise before you became pregnant? (1) YES (2) NO (If no, please skip Questions 3-7)

3. What type of exercise did you participate in?

(1) Aerobics (4) Bicycling
(2) Swimming (5) Walking
(3) Running/Jogging (6) Other (Please list) _____

4. How many days per week did you exercise? _____ Days/Week

5. How long were your exercise sessions? _____ Minutes

6. If you participated in running or jogging, estimate your mileage per week. _____ Miles/Week

7. Have you continued to exercise during your pregnancy?
(1) YES (2) NO

If yes, indicate any modifications in your exercise program from pre-pregnancy and approximate which month you changed.

8. Other comments you may wish to add:

If you have any questions while filling out this form or with mailing, please contact me.

Carolyn Ryan Home: 549-9038

Dear Doctor,

Your patient has agreed to participate in a thesis study by the University of Montana's Human Performance Laboratory in consultation with Dr. Robert B. Curry at the Student Health Service. We are studying pregnant women in the Missoula area and requesting the results of the participant's first trimester Complete Blood Count (CBC) and expected delivery date. The CBC results will be used in a study to evaluate potential populations at risk for iron deficient anemia. We are comparing pregnant women who exercised pre-pregnancy to non-exercising pregnant women.

Thank you for your cooperation, please feel free to have an office staff member fill in the information below. If you would like a copy of the results, please sign your name at the bottom of the page.

PATIENT NAME:

1. State patients Expected Delivery Date. _____
2. State Estimated Date of Conception. _____
3. First Trimester Laboratory Results: DATE DRAWN _____
 - (1) Hemoglobin _____ g/dl
 - (2) Hematocrit _____ %
 - (3) Red Blood Cells _____ RBC/ml
 - (4) Mean Cell Volume _____ cu microns
 - (5) Mean Cell Hemoglobin _____ %
 - (6) Mean Cell Hemoglobin _____ %
Concentration
- If available:
 - (7) Serum Ferritin _____ mcg/dl
 - (8) Serum Iron _____ mcg/dl
 - (9) Serum Iron-Binding Capacity _____ mcg/dl

Thank you for your assistance and your time. This study has been approved by the Human Subjects Committee, University of Montana. There will be no use of physicians names in this study. If you have any questions or concerns, please contact me.

Carolyn Ryan
450 E. Central Av.
Missoula, Mt. 59801
549-9038

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