

## ABSTRACT

HILGENBERG, Heidi A. The effects of a season of intercollegiate basketball on various fitness measures of women players. M.S. in Adult Fitness and Cardiac Rehabilitation, December, 1988. 60 p.p. (Dr. Philip K. Wilson)

This study examined the effects of a season of intercollegiate basketball on various fitness measures of women players. Weight, body composition, aerobic fitness, peak anaerobic power, and vertical jump height were analyzed through the use of five separate tests. These five tests were administered before and after the playing season to 11 members of the University of Wisconsin - La Crosse Women's Basketball Team. The preseason tests were conducted before regular team practice began, while the postseason tests were completed two weeks following the last competitive game. A dependent t - test revealed only one significant difference,  $p < .05$ , in this study. The significant difference was a reduction in body fat percentage.

THE EFFECTS OF A SEASON OF INTERCOLLEGIATE BASKETBALL ON  
VARIOUS FITNESS MEASURES OF WOMEN PLAYERS

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A Thesis Presented  
to  
The Graduate Faculty  
University of Wisconsin - La Crosse

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In Partial Fullfillment  
of the Requirements for the  
Master of Science Degree

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by  
Heidi Ann Hilgenberg

December, 1988

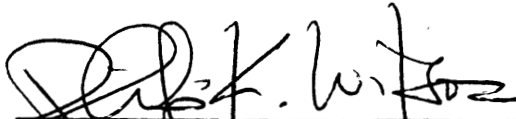
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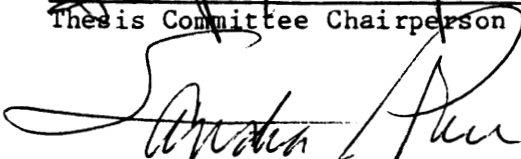
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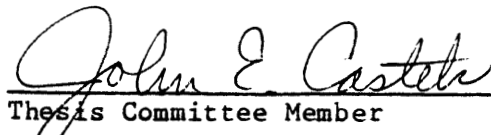
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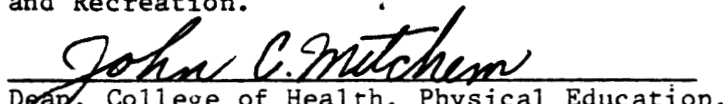
  
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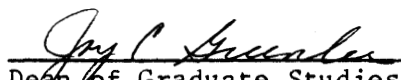
  
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CHAPTER I  
INTRODUCTION

Background

The popularity of women's basketball has grown tremendously in recent years. College women play in highly competitive divisions for a chance to participate in national championships. Women's games are now televised on many stations across the country and around the world. The more skillful players have the opportunity to try out for amateur teams that compete in sporting events around the world, such as the Olympics and the Pan-American Games. Women in Europe have opportunities to play professionally in some countries.

In the United States, high school basketball for girls has become widespread. Many schools have varsity, as well as junior varsity, sophomore, and freshman teams. The high school teams compete in different districts in order to qualify for a place in the state championships. Some of these girls play in order to compete for college athletic scholarships. Many female players begin competing at an early age through different programs sponsored by recreation departments in their cities. Women attend skill development camps and play with their male counterparts on playgrounds and home courts everywhere.

Women all over the world are playing basketball for fun, fitness, and competition. Many companies sponsor tournaments to offer the recreational teams an opportunity to compete for fun and prizes.

Colleges offer classes and intramural programs so their female and male students can play for fun. Basketball is fast becoming a sport popular with men and women of all ages, both as players and as spectators.

This study was conducted to measure any physiological changes in female basketball players associated with a season of competitive basketball. The study was also done to assist the head coach evaluate her training program. The first two physiological characteristics studied were pre- and postseason aerobic fitness, using a maximal oxygen consumption test (Butts, 1983) and pre- and postseason anaerobic fitness, using a Wingate cycle ergometer test as described by Tharp, Johnson, and Thorland (1984). The second two physiological parameters measured were pre- and postseason body composition, using the hydrostatic weighing method (Fox and Mathews, 1981) and pre- and postseason vertical jump height, using the Sargent Jump Test (McArdle, Katch, & Katch, 1981). In the anaerobic fitness testing, there is no guarantee that only the anaerobic energy systems were tested because the anaerobic systems do not function independently of the aerobic energy system (Fox and Mathews, 1981).

#### Statement of the Problem

The problem of this research was to determine changes in the pre- and postseason mean values of certain physiological measures for the University of Wisconsin - La Crosse women's basketball team.

### Need for the Study

Due to the increase in competitiveness among women's basketball teams, there is a need for those playing to be in the best possible physical condition. It was felt that a comparison between pre- and postseason fitness levels could aid the coach in assessing the players' preseason conditioning, as well as in determining a plan for maintaining fitness during the playing season. This is important, especially for those members of the team who do not start regularly.

### Purpose

The primary purpose of this study was to determine significant changes in anaerobic fitness, aerobic fitness, vertical jump height, and body composition for the members of the 1987 - '88 University of Wisconsin - La Crosse Women's basketball team due to the competitive playing season. The secondary purpose of this study was to assist the head coach in evaluating her conditioning program's for effectiveness during the preseason and the playing season.

### Hypotheses

For statistical purposes, all the hypotheses are stated as null hypotheses. They were accepted or rejected at the .05 level of significance. The six null hypotheses were as follows:

1. There would be no significant differences between the pre- and postseason values for total body weight,

2. There would be no significant differences between the pre- and postseason values for body fat percentage,

3. There would be no significant differences between the pre- and postseason values for lean body mass,

4. There would be no significant differences between the pre- and postseason values for maximal oxygen consumption,

5. There would be no significant differences between the pre- and postseason values for anaerobic power,

6. There would be no significant differences between the pre- and postseason values for vertical jump height.

#### Assumptions

There were two assumptions in this study:

1. It was assumed that all participants exerted maximal effort during all tests performed,

2. It was assumed that all tests measured the physical parameter they were designed to test.

#### Limitations

There were four limitations to this study:

1. No control group was used to determine if changes found were due to the competitive season,

2. It was impossible to determine if all the players had conditioned to the same extent in the off season or during the playing season,

3. It was impossible to control the outside activities of the players which might have affected their physical condition,

4. There was the possibility of human or machine error during the administration of the tests.

#### Definition of Terms

The following terms were used in this paper :

Adenosine Triphosphate (ATP) : A complex chemical compound formed with the energy released from food and stored in all cells, particularly the muscles. The only way a cell can perform its function is with the energy released when this compound is broken down (Fox and Mathews, 1981).

Aerobic : In the presence of oxygen (Fox and Mathews, 1981).

Anaerobic Work : The highest work performed during any five second period. This is thought to be related to the alactic phosphogen component of anaerobic energy release (Tharp, et al., 1984).

Anaerobic Power : The total work performed during the entire thirty second period. This is thought to reflect the glycolytic (lactic) component as well as the alactic component of energy release (Tharp, et al., 1984).

Basketball Player : A player on either the women's freshman or varsity team during the 1987-'88 competitive season at the University of Wisconsin-La Crosse.

Body Composition : The lean body mass plus the weight of the body fat. The essential fat is the minimal amount of fat required for body functions, while the nonessential fat is extra fat stored in the adipose cells of the body (Brooks and Fahey, 1985).

Hydrostatic Weighing : A method of determining body composition through the determination of body volume. A person is completely submerged in water and their weight is recorded. This method enables the researcher to measure the density of the body and its percentage of fat and lean muscle mass through a series of equations (Brooks and Fahey, 1985).

Lean Body Mass : The weight of the body's nonfat components, including skeleton, water, muscle, connective tissue, organ tissue, and teeth (Fox and Mathews, 1981).

Maximal Oxygen Consumption (max  $\dot{V}O_2$ ) : The maximal rate at which oxygen can be consumed per minute; the power or capacity of the oxygen (aerobic) system. This physical parameter was tested using the treadmill in this study (Fox and Mathews, 1981).

Residual Volume (RV) : The volume of air remaining in the lungs after a maximal expiration (Fox and Mathews, 1981).

Vital Capacity (VC) : The maximal volume of air forcefully expired from the lungs after a maximal inspiration (Fox and Mathews, 1981).

## CHAPTER II

### REVIEW OF RELATED LITERATURE

#### Introduction

Through the review of related literature this researcher found only a few references specific to the sport of women's basketball. Only one study conducted by McArdle, Magel, and Kyvallos (1971) compared the effects of a competitive season of basketball on fitness parameters and it was done sixteen years ago. This report studied six members of the team from Queens College. Although little literature was found specific to women's basketball and the physiological parameters of aerobic fitness, anaerobic work and capacity, body composition, and vertical jumping ability, many articles and books were found that dealt with these topics individually.

The first section will consist of information regarding the physical characteristics of women basketball players, while the second section will review lung volume measurements. The third section will examine different aspects of body composition and its importance to basketball, and the fourth section will contain information on the different metabolic processes. The fifth section will inspect the need for the vertical jump and its importance in basketball. Finally, the summary will recapitulate the information of the above sections.

### Physical Characteristics of Women Basketball Players

Vaccaro, Clarke, and Wrenn (1979) found the mean height (172.97 cm) and weight (68.28 kg) of the female basketball players in their study were both greater than those of previous studies (Alexander, 1976; McArdle, et al., 1971; Sinning, 1973; Sinning and Adrian, 1968). Since 1979, Walsh, Heyward, and Schau (1984) tested forty - nine National Collegiate Athletic Association Division I women basketball players from four different teams. They found an even greater mean height (176.49 cm), but less mean weight than the aforementioned study by Vaccaro, et al. (1979). As for body shape, Morrow, Hosler, and Nelson (1980) found that the women players they tested generally had longer arms and were generally stronger in both upper and lower body strength when compared to sedentary women or intercollegiate female volleyball players. It would seem from a review of the literature that height is an advantage in the game of women's basketball.

### Lung Volume Measurements

Vital capacity refers to the volume of air that can be expelled forcefully from the lungs after a maximal inspiration, while residual volume describes the amount of air remaining in the lungs after a maximal expiration (Fox and Mathews, 1981). These volumes together are considered to represent total lung volume (Brooks and Fahey, 1985). These volumes are important in the determination of body composition because allowances must be made for residual volume in the lungs when the individual is being weighed under water (Sloan and Bredell, 1973).

Residual volume is the lung volume used in hydrostatic weighing because it is the volume least affected by hydrostatic pressure (Smith and Bishop, 1987).

Vital capacity can be measured directly using a spirometer, but residual volume cannot (McArdle, et al., 1981). Wilmore (1969) found that a closed - circuit oxygen dilution method was as effective for measuring pulmonary residual volume as an open - circuit method. Sloan and Bredell (1973) stated that a closed - circuit took less time and no correction was needed for nitrogen in the air. In 1980, Wilmore, Vodak, Parr, Girandola, and Billing commented that the closed - circuit approach to residual volume determination using the dilution principle had the most reliable results and was the most efficient method relative to the time needed to duplicate the maneuver. The closed - circuit dilution method as specified by Wilmore (1969) was used in this research.

#### Body Composition

Body composition is important to athletes because it affects athletic performance (McArdle, et al., 1981). Various sports have different metabolic requirements and result in differing amounts of lean body mass and fat (Brooks and Fahey, 1985). The first section will discuss various ways of measuring and predicting body composition, while the second section will examine women athletes and the effects of body composition.

## Methods of Measurement

Body composition: refers to the relative amounts of fat and lean body tissue that make up one's person (Getchell, 1983). There are many ways of assessing this physical fitness index and they fall into the categories of direct and indirect, according to McArdle, et al. (1981). The direct method involves the use of chemicals to break the body down into its different components (McArdle, et al., 1981). For obvious reasons, direct body composition is impossible to do with live subjects, so that leaves only the indirect methods. These procedures include height and weight charts, hydrostatic weighing, skinfold measurements, body circumference and bone diameters, and electrical impedance (Fox and Mathews, 1981; Pollack and Jackson, 1984).

Height and weight charts: are one of the most widely used methods for assessing body composition. The problems with these charts are twofold; first, they are not as accurate as other methods, such as skinfold measurement or underwater weighing, and second they do not differentiate between fat weight and lean body mass (Pollock and Jackson, 1984). Lean body mass refers to the fat free weight that still includes the essential amount of lipid (fat) necessary for life sustaining physiological processes, such as neural transmission and cell membrane functioning (Buskirk and Mendez, 1984).

Hydrostatic weighing: is considered to be the more accurate way of measuring body composition and has become the standard by which all other indirect methods are derived (Brooks and Fahey, 1985). There are problems with hydrostatic weighing due to difficulties measuring the

subject's residual volume and misreading the scale; however, it still tends to be more accurate than other methods (Buskirk and Mendez, 1984). Hydrodensitometry involves costly equipment and is not readily available or practical to use when assessing the general public (Pollock and Jackson, 1984).

Skinfold measurements: are probably the most "popular" method for body composition assessment because the procedure is inexpensive after the initial purchase of calipers and easily learned with practice (Brooks and Fahey, 1985). This method can also be done quickly and performed on a large number of people in a relatively short time (McArdle, et al. 1981). The rationale for doing skinfold measurements comes from the fact that almost one - half of the fat in the body lies deposited in the adipose tissue directly beneath the skin, (McArdle, et al. 1981). Pollock, Schmidt, and Jackson (1980) stated that the proportion of subcutaneous fat to internal fat tends to be a one to one ratio in young adults, but decreases with age. These types of measurements are subject to severe limitations that can result from tester inexperience, inappropriate equation use and other types of measurement error which can drastically reduce this type of method's reliability (Fox and Mathews, 1981).

Body circumferences and bone diameters: are other types of anthropometric measures that are used to determine body composition. These types of measurements were first presented by Behnke and use a reference man and woman as a standard, according to Brooks and Fahey (1985). Sometimes, they are inappropriate for use with female athletes because most women athletes are not representative of the general

population and it also takes experience to obtain the correct, reproducible measurements needed for accuracy (Brooks and Fahey, 1985). The biggest problem, according to Behnke and Wilmore (1974), is the difficulty in obtaining reproducible results.

Electrical impedance: is a more expensive and less reliable method for determining body composition. This is a relatively new method and though it promises to be useful in the future when improvements have been made, it is not accurate presently (Pollock and Jackson, 1984). Other more complicated and expensive methods include computer assisted tomography (CAT scans), potassium - 40 counting, and nuclear magnetic resonance (Lohman, 1984).

#### Women, Body Composition, and Athletics

Body composition is important to athletes because excess fat is an added burden during any type of physical movement and because of this burden it is an important concern to everyone, especially athletes (Buskirk and Mendez, 1984). Brooks and Fahey (1985) feel that the variability in the amount of body fat seems to depend on the sport and its metabolic requirements, as well as, the disadvantage of carrying the extra weight of excess fat. Body composition and size seem to be the greatest limiting factor between male and female athletes (Fox and Mathews, 1981).

While physically fit women often see a decrease in the amount of body fat and an increase in lean body mass, women still have seven to ten percent more essential fat than men due to their sex (Getchell, 1983; Pollock, et al. 1980). According to Fox and Mathews (1981) women,

in general, are three to four inches shorter than men and are twenty to thirty pounds lighter. According to the same source (Fox and Mathews, 1981), the differences in body composition between men and women are great as women, while weighing less overall, carry ten to fifteen pounds more fat weight and forty to forty - five pounds less lean body tissue. This difference in body composition can be both good and bad for the female athlete. In swimming events, the greater amount of body fat is advantageous because it increases buoyancy and reduces the body drag, which results in less energy expenditure per distance unit swum (Fox and Mathews, 1981). In running events, it is just the opposite because the extra fat adds extra weight without adding any energy sources (Wells, 1986). It seems, from a review of the literature, that the greater amount of sex - related body fat carried by women can be limiting to women who participate in land based sports and a bonus to those who participate in swimming events.

Women basketball players tend to have a lower percentage of body fat than sedentary women, but a higher percentage than other athletes, such as runners. Vaccarro, et al. (1979) reported a mean percent fat for their basketball players of 20.78% . In 1984, Walsh, et al. found the players in their study to have a mean value of 19.21% . This differs from other athletes, such as runners who may carry less or swimmers who may carry more (McArdle, et al., 1982; Butts, 1983).

#### Metabolic Processes

Metabolic processes are those processes in the body that produce energy (McArdle, et al. 1981). They are divided into two categories,

anaerobic and aerobic metabolism. Anaerobic metabolism consists of two processes that produce energy without using oxygen, while aerobic metabolism requires oxygen in order to produce energy through a series of chemical reactions (Fox and Mathews, 1981). Discussion in this section concern the following : aerobic fitness and maximal oxygen consumption, women and maximal oxygen consumption, aerobic fitness and female basketball players, and anaerobic metabolism and its function in basketball.

#### Aerobic Fitness and Maximal Oxygen Consumption

Maximal oxygen consumption ( $\text{max VO}_2$ ), as defined by Astrand and Rodahl (1986), describes the highest oxygen uptake of an individual during physical activity while breathing at sea level. According to McArdle, et al. (1981), the attainment of this physical parameter involves the integration of many body systems; namely, the cardiovascular, ventilatory, and the neuromuscular. These same scientists (McArdle, et al. 1981) also felt that a person's aerobic capacity is one of the more important factors for determining a human's ability to participate in high intensity physical exercise or work for longer than four or five minutes and that  $\text{max VO}_2$  provides a quantitative measure of a person's physical capacity for aerobic energy transfer. Fox and Mathews (1981) stated aerobic energy is produced by a series of complex chemical reactions involving oxygen and is, by far, the greatest producer of adenosine triphosphate (ATP), which is the basic energy source for the working cell and only through the breakdown of this compound can the cells perform their function.

Knuttgen (1978) proposed that the use of aerobic power in athletics is based on the availability of muscle cells capable of high oxidative energy release and an adequate supply of oxygen for use during this process. During extended activity of sufficient intensity, oxygen consumption reaches a plateau and stays stable throughout the remaining exercise period; this plateau is considered, by McArdle, et al. (1981), to reflect a balance between the energy needed by the working muscles and the production rate of ATP and represents an individual's capacity for the aerobic resynthesis of ATP. Fox and Mathews (1981) consider maximal oxygen consumption to be the best indication of a person's aerobic capacity and fitness. In 1981, McArdle, et al. commented that an improved capacity for energy transfer, be it aerobic or anaerobic, has a direct positive correlation to improved exercise performance.

Maximal oxygen consumption represents the maximal transport of oxygen in the blood from the lungs to the working tissues (Brooks and Fahey, 1985). Presently there are two theories on how aerobic capacity is limited physiologically. The first is that aerobic capacity is limited by oxygen transport (i.e. cardiac output and arterial oxygen content) from the lung to the working tissue (Rowell, 1974). The second is biochemical and relates to the working cell's ability to use the oxygen once it arrives (Holloszy and Booth, 1976). According to Brooks and Fahey (1985), the ability of a cell's mitochondria to use oxygen, especially a trained muscle cell, far exceeds the ability of the blood to supply it through circulation. While these two factors may limit the aerobic capacity, Knuttgen (1978) credits the blood supply of glycogen and fats to be the limitation on aerobic exercise and endurance. This

seems reasonable as endurance athletes generally perform their events at a percentage of their max  $VO_2$  and not their maximum which would soon deplete all available energy sources, according to Brancazio (1984).

#### Women and Maximal Oxygen Consumption

Wells (1986) found that the highest recorded values for maximal oxygen consumption were recorded for distance runners, alpine and nordic skiers, rowers, and bicyclists; while the lowest values were seen in gymnasts, as well as volleyball and basketball players. Between the sexes, aerobic capacity values for trained women versus trained men are generally fifteen to twenty - five percent lower for women (Fox and Mathews, 1981). The differences are usually attributed to differences in body composition and size, as well as hemoglobin content (McArdle, et al. 1981). According to the previous source (McArdle, et al. 1981), men generally have a higher max  $VO_2$  than women because they have a greater amount of active tissue mass to produce energy and ten to fourteen percent greater concentration of hemoglobin, the iron containing protein pigment in the blood that carries the oxygen from the lungs. Puhl (1986) found that a larger amount of muscle mass (i.e. active tissue) has a positive effect on endurance and oxygen consumption. Brooks and Fahey (1985) attribute the difference in oxygen consumption to women having smaller heart sizes, less blood volume, and thus less overall cardiac output, but reported that physical activity and sports participation affect and benefit both women and men equally.

### Aerobic Fitness In Female Basketball Players

This section will deal with max  $VO_2$  and why it is important to women's basketball. It will also provide previous findings reported for women basketball players, as well as female athletes in other sports.

Berg (1984) felt that basketball with its four quarters of play and alternating period of strenuous activity periods and constant movement with periods of low intensity could be classified as an activity largely dependent on aerobic metabolism. Parnat, Viru, Savi, and Nurmekivi (1975) stated that the importance of aerobic fitness increases as the duration of the event increases. This does seem to come into play because women have been playing on a full court since 1973. In their 1979 study of women players, Vaccaro, Clarke, and Wrenn theorized that the greater interest in women's basketball would place more importance on the players' physical conditioning and skill level than ever before in the history of the sport. This, in turn, would increase the importance of aerobic capacity. Astrand and Rodahl (1977) felt the ability of the individual to perform physical work (i.e. endurance) depended on the body's ability to supply the energy needed. Events, such as basketball, that last longer than four or five minutes depend on aerobic metabolism, according to Fox and Mathews (1981)

According to Vaccaro, Wrenn, and Clarke (1980), aerobic fitness can help decrease the amount of fatigue often experienced in the critical late stages of a game. It may also help to reduce the number of injuries. Parr, Wilmore, Hoover, Bachman, and Kerlan (1978) reported that fewer injuries were reported when players were less fatigued.

There have been a number of studies done in the last twenty years concerning women, basketball, and oxygen consumption (Conger and Macnab, 1967; Sinning and Adrian, 1968; McArdle, et al. 1971; Sinning, 1973; Plowman, 1974; Vaccaro, et al. 1979). The results of these studies varied from a low of 35.75 ml/kg/min (McArdle, et al. 1971) to a high of 49.63 ml/kg/min (Vaccaro, et al. 1979). Regardless of the time of the study, basketball players have been shown to have much lower max  $\text{VO}_2$  values than other collegiate athletes. Kollias, Bartlett, Oja, and Shearburn (1978) found cross country runners to have an average of 59.5 ml/kg/min., while Butts (1983) found an average of 50.5 ml/kg/min. Kovaleski, Parr, Hornak, and Roitman (1980) found that volleyball players even had higher max  $\text{VO}_2$  values than any of the female basketball teams studied. The average found for volleyball players by Kovaleski, et al. (1980) was 56.0 ml/kg/min.

#### Anaerobic Energy and Basketball

Anaerobic energy is the energy source used primarily during sporting events lasting thirty seconds to three minutes (Puhl, 1986). Plowman (1974) found that high intensity events lasting two minutes or less received fifty to eighty - five percent of the energy required through anaerobic sources. According to Tharp, et al. (1984), the amount of anaerobic energy available, like that of aerobic metabolism, is dependent on age, weight, lean body tissue, and body size.

Anaerobic energy is the type of energy produced when the oxygen supply to the working muscles is insufficient (Getchell, 1983). There are two anaerobic energy systems. The first is the adenosine

triphosphate - phosphocreatine system which provides enough energy, through the breaking of phosphate bonds, for a few seconds work (McArdle, et al., 1981). The second system of anaerobic energy production is glycolysis which consists of a series of reactions involving the incomplete breakdown of glucose into lactic acid (Fox and Mathews, 1981).

According to Wells (1986), there exists little published data for anaerobic tests because standards have not been set and the different tests are not widely used. A limitation to the standardization of anaerobic tests, including the Wingate test used in this study, is that the results are based on overall body weight and do not take the amount of active tissue into account (Vandewall, Peres, Heller, and Monod, 1985). Fortunately, the interest in anaerobic testing is increasing in the scientific community due to the realization that many sporting events and everyday tasks require anaerobic energy production instead of that synthesized by aerobic metabolism (Tharp, et al., 1984). This same idea was proposed earlier in 1977 by Katch, Weltman, Martin, and Gray who stated that more sporting events and individual athletic performances involve anaerobic energy production than aerobic metabolism.

Wells (1986) felt that anaerobic capacity and power are important in events that require jumping, throwing, and sprinting. Basketball encompasses all of these activities. Astrand and Rodahl (1977) stated, that while the anaerobic energy systems are important as the strenuousness of the task increases, the aerobic and anaerobic systems are never completely independent of one another. Sports, such as

basketball and soccer which require full sprints, constant movement, and last longer than two or three minutes, depend on a combination of aerobic and anaerobic fitness (Fox and Mathews, 1981).

### The Vertical Jump and Basketball

The vertical jump is an important movement in many sporting events, such as basketball and volleyball. It is also one of the oldest tests in physical education, originally named Sargent's Physical Test of Man, can be a measure of how a force can combine with the greatest muscle contraction velocity to project the body upwards to the greatest height possible (Smith, 1960). Brown, Mayhew, and Boleach (1986) proposed that basketball players are more efficient at the vertical jump because it is a necessary skill in the game. This skill would be an important element for basketball players when they attempt to block shots, retrieve rebound, or shoot jump or lay - up shots. Brown, et al. (1986) reported that a player's performance in basketball was greatly improved when they are able to jump higher and quicker than their opponents.

### Summary

In a 1979 study, Vaccaro, et al. found that the women basketball players studied were taller than any studied previously (Alexander, 1976; McArdle, et al. 1971; Sinning, 1973; Sinning and Adrian, 1968). In 1984, Walsh, et al. found that her subjects were taller and lighter than any of the aforementioned subjects studied. Morrow, et al. (1980) found that women basketball players tested were stronger in both upper

and lower body strength than either sedentary women or intercollegiate women volleyball players.

Vital capacity and residual volume are lung volumes that are combined to represent total lung capacity (Fox and Mathews, 1981; Brooks and Fahey, 1985). Residual volume is important in the determination of body composition because allowances must be made for this volume when using the hydrostatic weighing method and it is also the volume least affected by hydrostatic pressure (Sloan and Bredell, 1973; Smith and Bishop, 1987). Vital capacity determination is done in the process of determining residual volume (Wilmore, 1969). Vital capacity can be determined directly, but residual volume cannot be determined by direct methods (McArdle, et al., 1981). Residual volume can be found using either open or closed - circuit breathing method (Wilmore, 1969). The closed - circuit dilution method was found to be as reliable and more efficient than the open - circuit method (Sloan and Bredell, 1973; Wilmore, et al., 1980).

Body composition is composed of fat free weight and fat weight and there are many ways to measure this fitness index, both directly and indirectly (Getchell, 1983; McArdle, et al. 1981; Fox and Mathews, 1981; Pollock and Jackson, 1984; Lohman, 1984). Height and weight charts, hydrostatic weighing, skinfold measurements, bone circumferences and body diameters are all methods for determining body composition (Brooks and Fahey, 1985; Buskirk and Mendez, 1984; Pollock and Jackson, 1984; Fox and Mathews, 1981; Pollock, et al. 1980; McArdle, et al. 1980; Behnke and Wilmore, 1974). Some more recent and complicated methods are

electrical impedance, potassium - 40 counting, CAT scans, and nuclear magnetic resonance (Lohman, 1984).

Body composition is important to athletes and the percentage of body fat for athletes varies from sport to sport, while body composition and size appear to be the limiting factors between male and female athletes (Brooks and Fahey, 1985; Buskirk and Mendez, 1984; Fox and Mathews, 1981). Physically fit females have more lean tissue and less body fat than sedentary females, but still have seven to ten percent more sex - specific fat than males do (Getchell, 1983; Pollock, et al. 1980). Women are generally three to four inches shorter than men, twenty to thirty pounds lighter, but carry ten to fifteen more pounds of fat and forty to forty - five less pounds of lean body tissue (Fox and Mathews, 1981). This extra fat is advantageous in swimming events and a burden in land activities (Fox and Mathews, 1981; Wells, 1986).

Maximal oxygen consumption ( $\max \text{VO}_2$ ) describes the highest oxygen amount an individual can use during physical activity and this measurement provides a quantitative measure of a person's capacity for aerobic metabolism (Astrand and Rodahl, 1986; McArdle, et al. 1981). Aerobic metabolism is accomplished through a series of complex chemical reactions, provides a greater amount of ATP than any of the other metabolic processes, and is based on the amount of muscle cells capable of high oxidative energy release and adequate oxygen supply (Fox and Mathews, 1981; Knuttgen, 1978). There are two theories of how aerobic metabolism is limited. One theory is aerobic metabolism is limited by cardiac output; the second proposes that it is limited by the the cell's ability to use the oxygen available (Rowell, 1974; Hollozy and Booth,

1976). According to Knuttgen (1978), the overall limiting factor to aerobic endurance is the supply of glycogen and fats in the blood. Endurance athletes generally perform at a percentage of their max  $VO_2$  to avoid depleting all available energy sources (Broncazio, 1984).

The highest recorded max  $VO_2$  values for women are from distance runners and other endurance athletes, while the lowest values for athletes are recorded for basketball players and gymnasts (Wells, 1986). Women generally have a max  $VO_2$  fifteen to twenty - five percent less than a comparatively trained male and the differences between the sexes are attributed to body size, composition, and hemoglobin content of the blood (McArdle, et al. 1981; Brooks and Fahey, 1985). A larger amount of active tissue has a positive effect on endurance and maximal oxygen consumption (Puhl, 1986). Physical activity and sports participation affects and benefits both sexes equally (Brooks and Fahey, 1985).

Basketball is considered to be an aerobic event and the need for endurance increases as the length of the event increases (Berg, 1984; Parnat, et al. 1975; Astrand and Rodahl, 1977; Fox and Mathews, 1981). Vaccaro, et al. (1979) felt that the greater interest in women's basketball would increase the need for the players to be more skilled and in better physical condition than ever in the history of the sport. Women basketball players are in better condition now than ever before, but continue to have lower values for maximal oxygen consumption than other women athletes (Vaccaro, et al. 1979; Kollias, et al. 1978, Kovalski, et al. 1980). Aerobic fitness may also help decrease fatigue and injuries due to fatigue in later stages of the game (Vaccaro, et al., 1980; Parr, et al., 1978)

Maximal oxygen consumption by basketball players has been studied by many people (Conger and Macnab, 1967; Sinning and Adrian, 1968; McArdle, et al., 1971; Sinning, 1973; Plowman, 1974; Vaccaro, et al., 1979). It has been found, in general, basketball players have lower values for maximal oxygen consumption than female athletes in other sports (Kollias, et al., 1978; Kovaleski, et al., 1980; Butts, 1983).

Anaerobic energy is the energy used during short, intensive events and the anaerobic system supplies fifty to eighty - five percent of the energy required for events lasting two minutes or less (Puhl, 1986; Plowman, 1974). Like aerobic metabolism, anaerobic metabolism depends on body size, composition, weight, and age (Tharp, et al. 1984). Anaerobic energy is produced when the oxygen supply to the working tissue is insufficient (Getchell, 1983). There are two types of anaerobic energy systems, the adenosine triphosphate - phosphocreatine (ATP - PC) and the anaerobic glycolysis system (McArdle, et al. 1981; Fox and Mathews, 1981). There is little published data concerning anaerobic energy and women, but the amount of research is increasing (Wells, 1986; Tharp, et al. 1984; Katch, et al. 1977). Standardization is difficult because of the lack of standard techniques (Vandewall, et al. 1985). Anaerobic power is important to basketball and this importance increases as the strenuousness of the task increases and the duration of the event decreases; such as, in a full court sprint (Wells, 1986; Astrand and Rodahl, 1977; Fox and Mathews, 1981).

Vertical jump is an important component in basketball. Vertical jump measures how a force can be combined with a muscle contraction, was originally developed by D. Sargent, and is one of the oldest

physical fitness tests (Smith, 1960). Brown, et al. (1986) felt that a player's performance is greatly improved when a player is skilled in this movement. Vertical jumping can be considered an activity requiring anaerobic metabolism because of its short duration.

## CHAPTER III

### METHODS

#### Introduction

The primary purpose of this study was to determine if any changes occurred in each player's aerobic fitness, anaerobic fitness, vertical jumping ability, and body composition due to a season of competitive basketball. The secondary purpose of this study was to help this team's head coach evaluate her players' fitness before and after the playing season. It was hypothesized that no significant changes would be found by the researcher.

The procedures for this study are presented in the following order: 1. subject selection; 2. general procedures; 3. determination of body composition; 4. lung volume measurements; 5. peak anaerobic power determination; and 6. vertical jump testing. The pretesting took place a week before the start of team tryouts and a month before the beginning of the competitive season. The postseason testing was done two weeks following the last game.

#### Subject Selection

The subjects for this study were the members of the 1987 - '88 freshman and varsity women's basketball teams from the University of Wisconsin - La Crosse. The coach was contacted personally by the researcher and permission was obtained to use her team for the study.

A letter of proposal (Appendix A) was also submitted to her describing the study. The subjects were briefed on the researcher's intent and purpose for the study. Each person was required to sign an informed consent form (Appendix B).

#### General Procedures

The subjects were informed of the purpose of the study at an organizational meeting on September 3, 1987. They were informed about the types of tests that would be conducted at this time. They were also assured that their participation in this study would in no way affect the final selection of team members, as the preseason testing was completed before final team selection and all player hopefuls were tested.

The Human Performance Laboratory at the University of Wisconsin - La Crosse was reserved for the first two weekends of October. The laboratory was also reserved the last two weeks in March for postseason testing when the season was completed. The postseason testing was completed in March, 1988. Each subject then selected a time to be pretested at a second organizational meeting held on Oct. 1, 1987. The first weekend each subject was tested to determine her aerobic capacity and her vertical jumping ability. The second weekend each subject was tested to determine her anaerobic fitness and her body composition. Each subject was given individual instruction for each test before the procedure was begun in both verbal and written form (Appendices C, D, E, F, and G).

### Determination of Body Composition

Each individual was instructed to fast at least four hours prior to her test period. Upon her arrival to the lab, each was instructed to expel any bodily waste possible and to change into her bathing suit. Once this process was completed, each individual was given the instruction sheets for body composition and anaerobic power testing (Appendices E, F, and G) and an informed consent form (Appendix B) to read and sign. Once the subject had completed reading and signing the sheets, each individual was weighed on a double beam scale and the weight was recorded to the closest .25 pound.

### Hydrostatic Weighing Technique

Every subject was weighed in a water tank specially designed for underwater weighing. Each participant was instructed to shower and expel any bodily waste possible. Then, each individual was instructed to climb into the tank and sit on both of the bottom bars of the weighing apparatus in the tank. This apparatus was hung on a Chatillon hanging scale. Next, she was told to remove any air bubbles between her skin and her suit. She was told to exhale as much air as possible before submerging her head under water and instructed to continue expelling air once her head was submerged and to stay as motionless as possible while under water. The subject was signaled to resurface when the investigator knocked on the side of the tank. This procedure was repeated until the researcher had three similar values.

The common value for body weight under water was then recorded as MX. The weight of the empty apparatus was recorded with the subject in the tank and it was recorded as MY. The temperature of the water and the density at that temperature were also recorded. The formula used was derived by Buskirk (cited in Fox and Mathews, 1981). It is as follows:

$$\text{Body Density} = \frac{\text{Body Mass in Air}}{([\text{mass in air} - \text{mass in water}] / \text{water density}) - \text{RV} - .1\text{L}}$$

The percent body fat equation was derived by Brozek, Grande, Anderson, and Keyes (cited in Fox and Mathews, 1981). It is as follows:

$$\% \text{ Fat} = [ (4.570 / \text{body density}) - 4.142 ] \times 100$$

#### Lung Volume Measurements

For this study, several lung volumes were measured. Vital capacity was measured to determine the maximal amount of air in the lungs after a maximal inhalation and expiration. Residual volume was done to calculate the amount of air remaining in the lungs after a maximal exhalation. These two procedures were done to estimate the total lung capacity for use in estimating body composition (Wilmore, 1969).

#### Vital Capacity

Every subject's vital capacity (VC) was measured, according to Wilmore (1969), using a Collins 9 - liter Vitalometer. Each subject was instructed to take a maximal inspiration, place her lips securely on the cardboard mouthpiece, and exhale as rapidly, deeply, and long as

possible without removing her lips from the tube. This procedure was repeated two times and each value was recorded. Verbal encouragement was supplied throughout both tests.

#### Residual Volume Testing

The residual volume (RV) was tested using a method prescribed by Wilmore (1969). The closed - circuit oxygen dilution method was performed on a Med - Science 505 Nitralizer nitrogen gas meter with a Collins 6 - liter Vitalometer used to determine the bag volume. The RV was determined in two phases.

In the first phase, the subject was fitted with a nose clip and placed her mouth on the cardboard mouthpiece and instructed not to remove her lips during the test. The breathing valve was turned for ambient air. Once the subject took four or five normal inspirations, she inhaled and exhaled as deeply as possible, as instructed by the investigator. Once a maximal expiration was indicated, the valve was turned so that the subject was breathing through the spirometer circuit. The nitrogen present at the end of the first maximum expiration was recorded as the initial nitrogen concentration (Ni).

The second phase began when the subject was instructed to inhale and exhale at about 70% of her vital capacity. Approximately one breath every four seconds until the the breathing bag was nearly empty. During this period, the range of the nitrogen values decreased until equilibrium was reached. Once this state of equilibrium was reached (usually 5-7 breaths), the subject was instructed to inhale and exhale

as fully as possible and then remove her lips from the tube. The percentage of nitrogen present at the the point of equilibrium was recorded as  $N_e$ . Finally, the nitrogen concentration at the end of the last maximal expiration was recorded as the final alveolar nitrogen concentration ( $N_f$ ). This procedure was repeated twice with each subject.

The RV was calculated using a modified formula from Wilmore (1969):

$$RV = [ (\text{bag volume} \times N_e) / (N_i - N_f) ] - [ 0.085 \times \text{BTPS} ]$$

BTPS stands for body temperature and pressure saturated with water vapor. This number is a correction factor used to account for the changes of a gas once it enters the body.

The two values were added together and divided by two to get the mean value. This mean was then used in all future calculations calling for a residual volume value.

#### Maximal Oxygen Consumption Testing

In order to evaluate the changes in aerobic fitness over the competitive season, maximal oxygen consumption tests were performed on each individual during the preseason and postseason. The Butts' protocol (1983) was used in order to elicit a maximal measurement of aerobic fitness. The reliability of this method was established using high school cross - country girls and found to be .96 .

Each subject was monitored for heart rate response at the beginning of every minute during the test. The heart rate was monitored for the last fifteen second period and then multiplied by four. Heart

rate was monitored using a single lead electrocardiogram. The electrodes were placed under the clavicle on the right side, and under the last rib of both the left and right sides. Prior to applying the electrode, each area was cleaned using alcohol and an abrasive pad to remove oil and dead skin cells. This was done to provide better conduction between the body and the electrode. Each subject was monitored using the Burdick M 200 Heart Rate Monitor. The heart rate strips were obtained using an EK 8 Electrocardiograph which is part of the Burdick M 200. Each electrode was then fitted with a conduction wire which was plugged into the cord of the Burdick M 200.

Once the subject was prepared, she stood on the motionless treadmill and was fitted with a Rudolph Head Support #2726 which connected with a Rudolph Valve # 2700. This valve was fitted with a Collins rubber mouthpiece. This mouthpiece fit tightly into the mouth, located between the subject's lips and teeth and provided rubber pieces to bite. The right side of the valve was fitted into a flexible rubber hose which connected the subject to the Beckman Metabolic Cart by way of the air collection bell. Each subject was also provided with a nose clip to put in place before the test began.

The Beckman Metabolic Measurement Cart consisted of a Beckman Transducer Control Module, a Beckman Oxygen Analyzer OM II, and a Beckman Medical Gas Analyzer LB - 2. The Beckman was turned on one hour prior to the first subject's arrival. It was then calibrated for temperature and barometric pressure, as well as oxygen and carbon dioxide levels. These values were obtained from the connected oxygen tank. The oxygen tank was set for a thousand milliliters of pressure.

Before the beginning of the test, the subject's weight was entered into the Beckman computer and converted to kilograms.

The Butts' protocol (1983) was developed to test cross-country high school runners. Each subject was given a five minute, five mile per hour warm - up run at zero percent grade. After the five minute warm-up period, the speed was increased to six miles per hour and the grade was increased to two and one-half percent. The grade was then increased two and one-half percent every two minutes until the final grade of ten percent was reached after the eleventh minute. The speed remained at six miles per hour until after the thirteenth minute, the speed was then increased one-half mile per hour every two minutes until the twentieth minute. A strip was received from the Beckman Metabolic Cart every minute which supplied the investigator with information concerning ventilation, oxygen usage, and carbon dioxide expelled. The test was considered to be a valid maximal effort when the respiratory exchange quotient reached or surpassed unity.

#### Anaerobic Power and Capacity Determination

Anaerobic fitness was measured using a modified Monarck bicycle ergometer and the Wingate Anaerobic Test (WAnT) protocol (Tharp, et al., 1984). The seat height of the bicycle was positioned to each subject's satisfaction, and her feet were strapped in using toe clips with straps to prevent the feet from slipping off the pedals.

Each subject read the written instruction form (Appendix G), and was weighed. She was then given verbal instructions once seated on the ergometer. Each subject was given a two minute warm-up pedalling

against a load of one-half kilogram and then a two minute rest period. Each subject was told to pedal as fast as possible from the start of the test, and to attempt to continue the maximum speed possible throughout the thirty second test period. At the starting command of "Go", each subject began pedalling as fast as possible against the low resistance. The resistance was then increased to the predetermined level within two to three seconds. The resistance was determined relative to body weight: 0.075 kilograms per kilogram of body weight. When this level of resistance was reached, a stopwatch was started and the number of pedal revolutions was recorded for thirty seconds. Revolutions were recorded through a magnetic switch triggered by the right pedal crank. The signal was then run through a voltage box built by J. Tesch and P. Homstadt of the University of Wisconsin-LaCrosse and converted to an electrical signal. This signal was recorded using a Fisher Recordall Series 5000. The paper speed of one-half centimeter per second was used to allow each revolution to be clearly defined. At the end of the thirty second test period, each subject pedalled the bicycle and then walked around the laboratory for two to three minutes to prevent dizziness or muscle soreness.

The anaerobic work performed was calculated using the following formula from Tharp, et al. (1984):

$$\text{Work} = \frac{\text{kilogram load} \times \text{number of pedal revolutions}}{1^{\text{st}} \text{ 5 second} \times 6}$$

$$.102 \text{ watts/kgm/sec}$$

### Vertical Jump Testing

Each subject was also tested for vertical jumping ability. This was done by marking off the distance from the floor up to the wall in centimeters. The top half of the wall was colored blue. Each subject chalked her dominant hand. The standing reach height was measured by having the subject stand with her dominant side next to the wall, heels together flat on the floor, and reach as high as possible and touch the wall. Each subject was allowed a one-step, two footed takeoff. They were also allowed to move their arms any way that was comfortable. Each subject was allowed three trials. The greatest height from the floor of the three trials was recorded. The total jumping height was the highest height in centimeters from the floor reached with the dominant hand. The vertical jumping distance in centimeters is the difference between the total jumping distance and the height of the dominant hand.

### Statistics

The pre- and postseason values for each parameter measured were compared using a dependent t-test. The level of significance was set at .05 .

CHAPTER IV  
RESULTS AND DISCUSSION

Introduction

Eleven members of the University of Wisconsin - La Crosse Women's Basketball Team were studied for changes in various fitness parameters due to a season of competitive basketball. These players were tested before team practices began and within two weeks of their last game.

During each testing period, the individuals were tested on two separate days. The first day of testing consisted of trials for vertical jumping ability and maximal oxygen consumption measurement on a treadmill. The second testing period was used to determine total body weight, body composition, and anaerobic power. The five fitness elements tested, the methods used, and the scoring units are listed in Table 1.

Table 1

Fitness Parameter / Method Used / Score

<u>Fitness Parameter</u>	<u>Method Used</u>	<u>Score</u>
Weight	Scale Weight	kilograms
Body Composition	Hydrostatic Weighing	percent fat
Aerobic Fitness	Maximal Oxygen Consumption	ml/kg/min
Peak Anaerobic Power	Wingate Anaerobic Test	watts
<u>Vertical Jump</u>	<u>One - Step Jump</u>	<u>centimeters</u>

The statistical analysis consisted of a dependent t - test to compare

the preseason and postseason scores. The level of significance was set as  $p < .05$ .

### Results

#### Total Body Weight

Each subject was weighed on a triple beam medical scale and the weight was recorded to the nearest quarter of a pound. The weight in pounds was then converted to kilograms using the conversion factor of 2.2 kilograms per pound. Both preseason and postseason weights were measured on the same scale.

The means, standard deviations, and t - test value for both weights are displayed in Table 2. There was no significant difference between the weights obtained.

Table 2

#### Total Body Weight (kg)

Means, Standard Deviations, and t - test Value

<u>Test</u>	<u>Mean</u>	<u>Standard Deviation</u>	<u>t - value</u>
Preseason	63.49	7.00	0.62
Postseason	63.10	6.07	

Pre- and postseason raw scores and means are shown in Figure 1.

#### Body Composition : Percent Fat and Lean Body Mass

Hydrostatic weighing was used to determine the team members percent body fat and lean body mass before and after the playing season.

The pre- and postseason means, standard deviations, and t - test results are recorded in Table 3 for percent body fat. The critical value indicates that there was a significant change for the mean fat percentage.

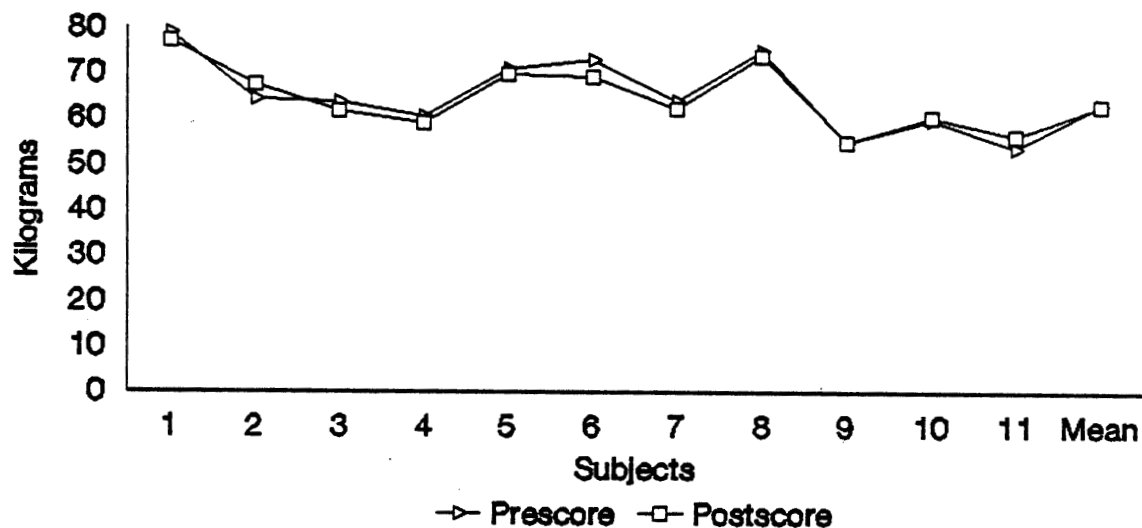


Figure 1: Weight Raw Scores and Means

Table 3

Body Fat Percentage

Means, Standard Deviations, and t - test Value

Test	Mean	Standard Deviation	t - value
Preseason	19.75	3.75	
Postseason	18.49	2.81	2.23*

\*  $p < .05$

The graph in Figure 2 presents each individual's fat percentage, as well as the team's mean scores, for the beginning and end of the season. Table 4 shows the pre- and postseason means, standard deviations, and t - test comparison for lean body mass.

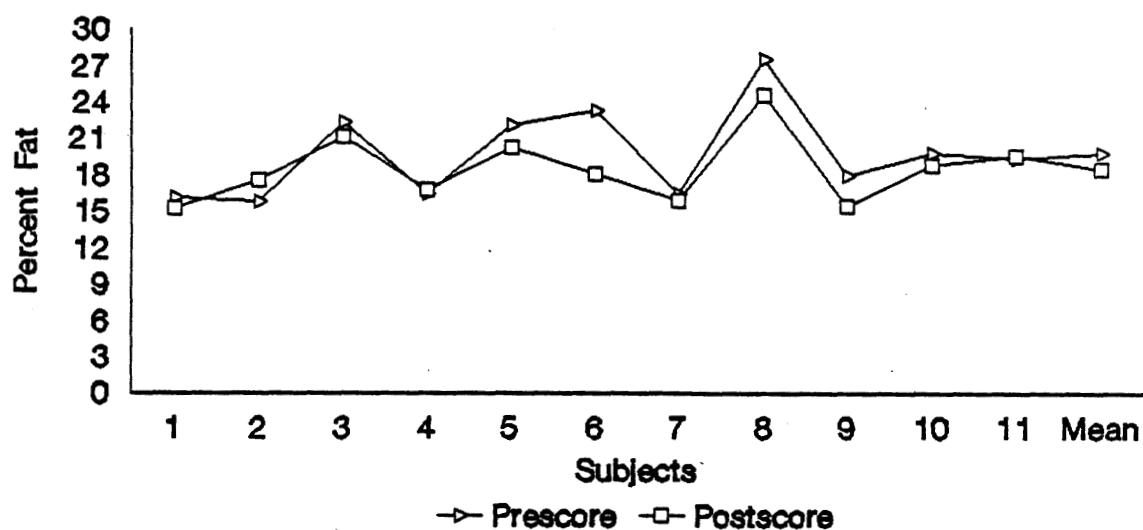


Figure 2: Percent Fat  
Raw Scores and Means

Table 4

Lean Body Mass (kg)

Means, Standard Deviations, and t - test Value

Test	Mean	Standard Deviation	t - value
Preseason	50.62	4.27	
Postseason	51.20	4.06	- 1.65

Figure 3 gives a visual presentation of each player's pre- and postseason amount of lean body mass and the team mean.

### Aerobic Fitness

For this fitness measure, the subjects were instructed to run as long as possible on a motorized treadmill. Their expired air was collected and analyzed for oxygen and carbon dioxide content to determine oxygen usage.

The mean scores, standard deviations, and t - test results are for the pre - and postseason trials are exhibited in Table 5. There was no significant change in aerobic fitness as a result of the competitive season.

Table 5

Maximal Oxygen Consumption ( ml/kg/min )

Means, Standard Deviations, and t - test Value

<u>Test</u>	<u>Mean</u>	<u>Standard Deviation</u>	<u>t - value</u>
Preseason	53.89	4.98	
Postseason	53.69	3.28	0.21

The raw scores and group means are presented in Figure 4.

### Peak Anaerobic Fitness

In order to measure this physical parameter, team members pedalled a cycle ergometer against seven and a half percent of their total body weight for thirty seconds. Peak power output was determined from equations developed for this particular test using the revolutions in the first five seconds.

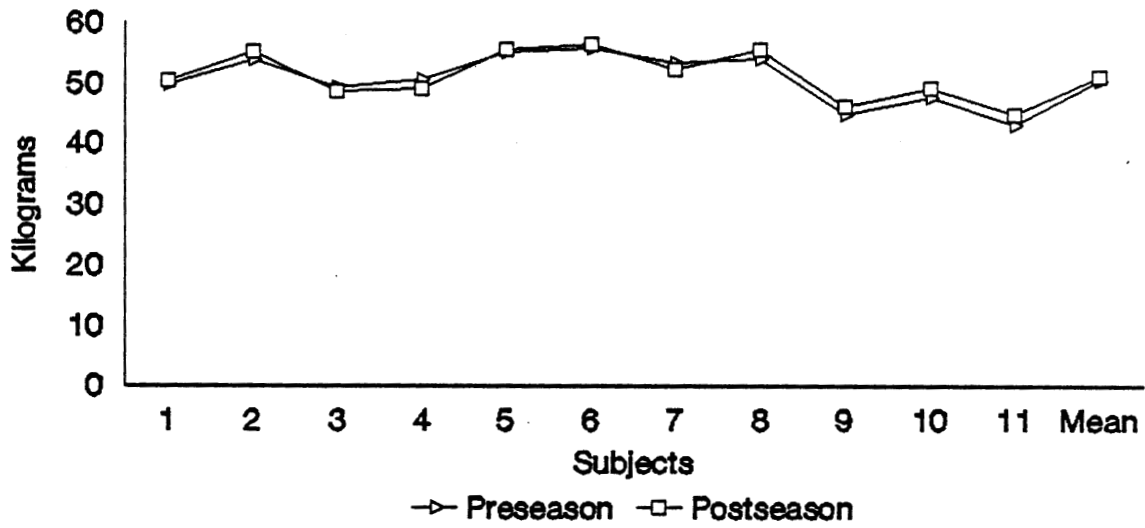


Figure 3: Lean Body Mass  
Raw Scores and Means

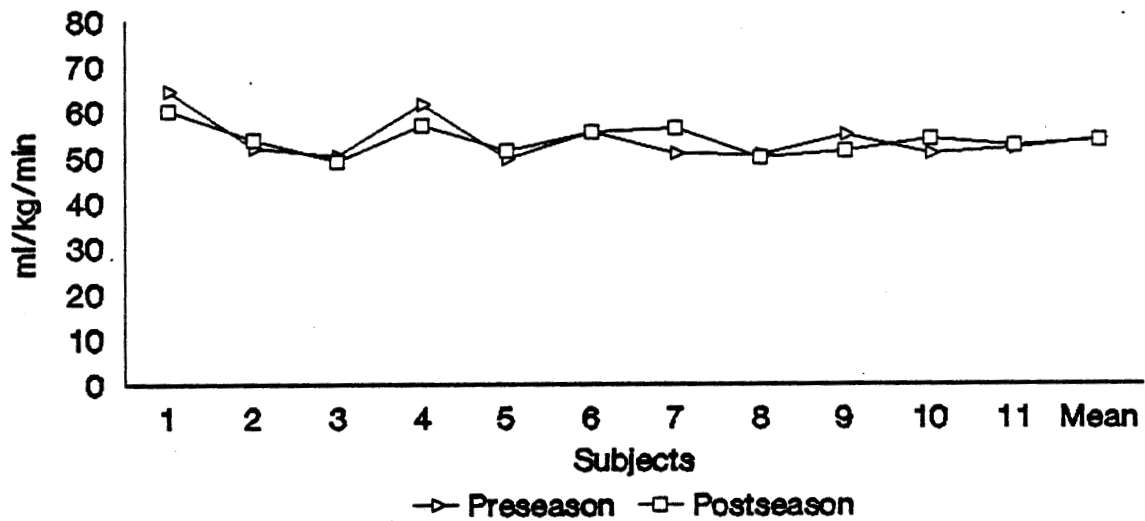


Figure 4: Maximal Oxygen Consumption  
Raw Scores and Means

The means, standard deviations, and  $t$  - test results are presented in Table 6 for both the pre- and postseason tests. There was no

statistically significant difference, but there was an increase in power after the playing season.

Table 6

## Peak Anaerobic Power (watts)

Means, Standard Deviations, and t - test Value

Test	Mean	Standard Deviation	t - value
Preseason	618.58	104.70	
Postseason	651.51	97.02	- 2.05

The raw scores and team means are shown in Figure 5.

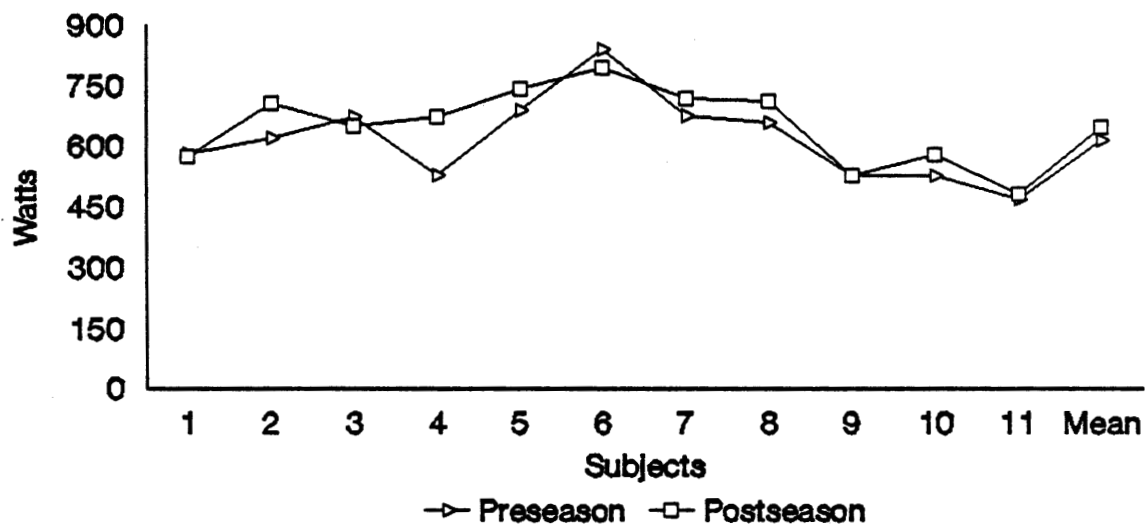


Figure 5: Peak Anaerobic Power  
Raw Scores and Means

### Vertical Jump Height

Each person on the team performed a one - step vertical jump. The testing consisted of a single step vertical jump performed three times.

Table 7  
Vertical Jump Height (centimeters)  
Means, Standard Deviations, and t - test Value

<u>Test</u>	<u>Mean</u>	<u>Standard Deviation</u>	<u>t - value</u>
Preseason	46.16	4.96	
Postseason	45.86	4.26	0.20

The means, standard deviations, and t - test result for the pre- and postseason jumps are recorded in Table 7. There was no significant difference reported in vertical jump heights as a result of the competitive season.

The raw scores and team means for the pre- and postseason are displayed in Figure 6.

### Discussion

#### Body Weight

The mean weight decreased very slightly over the course of the competitive season. Changes in lean body mass and body fat percentage may account for the small decrease in total body weight. As lean muscle mass was increased fat weight may have been lessened or redistributed due to the regular activity and use of certain areas of the body. The players in this study weighed less overall (63.30 kg) than those players studied by Vaccaro, et al. (1979) or Walsh, et al., (1984) who reported weights of 68.28 and 66.82 kilograms, respectively.

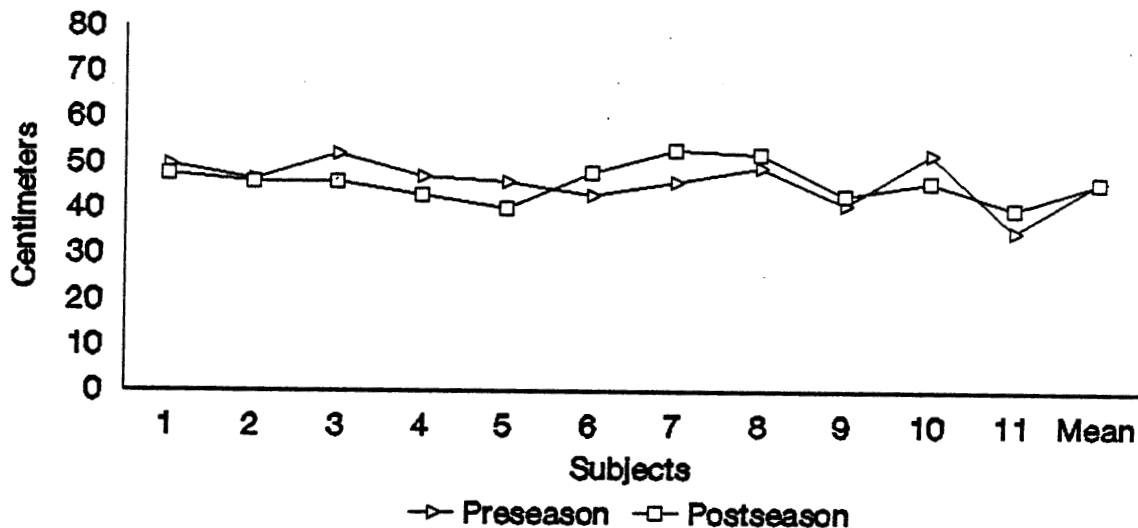


Figure 6: Vertical Jump  
Raw Scores and Means

#### Body Composition

There was no significant difference between the amount of lean body mass present before the season and that at the end. The mean for total lean body mass did increase from beginning to end, however. A possible reason for the increase in the mean for lean body mass may be due to the weight training program followed by the team. Another contributing factor may have been the regular periods of practice and game play performed by these athletes. Both of these situations could have added or maintained lean body mass without increasing it significantly.

The percentage of body fat decreased over the course of the season; but, as shown in Table 2, the total body weight decreased only slightly. It is possible that once regular practice began consisting of regular sprinting and endurance running, as well as skill drills and weight

lifting, the players lost fat weight while gaining lean body mass. As was demonstrated in Table 4, there was an increase in lean body mass though it was not significant. It is possible that some players lost only fat weight without gaining any lean mass, while some may have lost lean body weight. In the end, this may have balanced out to make the drop in fat percentage significant, but not the increase in lean body mass. These two factors combined may explain the stability of total body weight. The subjects used in this study had a mean percentage of body fat (19.12%) slightly less than either of the means for the studies cited in Chapter II. Vaccaro, et al. (1979) reported a mean for body fat percentage of 20.78%, while Walsh, et al. (1984) determined the mean fat percentage of their players to be 19.21% .

#### Aerobic Fitness

Maximal oxygen consumption is a measurement of aerobic fitness. While some emphasis in the preseason practice was devoted to sprint and endurance training, most practices consisted of drills designed to develop skill and maintain physical conditioning rather than produce aerobic training. Once the playing season started, team practices centered around scrimmaging and competitive games. This team played in 38 games, completing the season with a 30 - 8 record in Division III play. It is thought that the lack of endurance training coupled with the regular periods of practice and play maintained the initial level of aerobic fitness without increasing it.

The mean for maximal oxygen consumption found for this study was much greater than those reported in Chapter II. The season mean was

determined to be 53.79 ml/kg/min. McArdle, et al. (1971) found their mean to be 35.75 ml/kg/min, while Vaccaro, et al. (1979) reported a mean of 49.63 ml/kg/min. The mean obtained for this team of basketball players was lower than that obtained by Kollias, et al. (1978) for cross-country runners (59.5 ml/kg/min), as well as the mean recorded for volleyball players in 1980 by Kovalski, et al. of 56.0 ml/kg/min. The mean for maximal oxygen consumption indicates that this team had a well established aerobic training base at the beginning of practices that was maintained throughout the competitive season.

#### Anaerobic Power

This study showed an increase in anaerobic power after the completion of the competitive season. This increase, while not statistically significant, may be due to an increase in anaerobic energy substrates developed throughout the season of play and practice. Basketball consists of many short sprints from one end of the court to the other followed by periods of little or no movement. These alternating period of activity and inactivity continued over extended periods of time combine to make basketball primarily an anaerobic sport with aerobic components. The game itself closely imitates anaerobic interval training. Over the course of the season, this could explain the increase in power shown by this study.

#### Vertical Jump

The vertical jump is a important skill in the game of basketball. It can be used to block shots, shoot, or to rebound missed shots. In this

study, the mean vertical jump height decreased over the course of the season. It may be possible that lack of emphasis on this specific movement during practice and games resulted in this decrease. It may be possible to increase vertical jumping ability by incorporating drills specific to this skill into team practices. A decrease in vertical jump height was also not expected due to the increase in peak anaerobic power. According to McArdle, et al. (1982) the Wingate Test and the vertical jump both use anaerobic power sources from the thigh region and should correlate fairly well. It would be expected that if one increased, so would the other. This was not the case in this study. It is possible that team members did not exert maximal effort for the test.

## CHAPTER V

### SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

#### Summary

The purpose of this study was to evaluate the effects of a season of women's competitive intercollegiate basketball on various fitness parameters. A secondary purpose was to assist the head coach in evaluating the preseason conditioning plan, as well as fitness maintenance throughout the playing season. The subjects were eleven members of the 1987 - '88 women's basketball team from the University of Wisconsin - La Crosse.

Each of the eleven players performed four tests designed to measure various fitness aspects. The parameters measured were aerobic fitness, peak anaerobic power, body composition, and vertical jump height. Aerobic endurance was evaluated using a maximal treadmill run while measuring oxygen uptake. Peak anaerobic power was determined using the Wingate Anaerobic Test on a cycle ergometer. Body composition was evaluated through the use of hydrostatic weighing. Finally, vertical jump height was found using a modified Sargent's jump. These tests were performed once during preseason tryouts and once two weeks following the last competitive game.

The data analysis was performed on the VAX SPXX computer system at the University of Wisconsin - La Crosse. A dependent t - test was used

to evaluate and compare the preseason and postseason results. The level of significance was preset at  $p < .05$ .

### Conclusions

1. There was no significant change between preseason and postseason mean total body weight and the null hypothesis was accepted.
2. There was a significant decrease in the percentage of body fat between the beginning of the basketball season and the end of the season. Due to the significant reduction in body fat, the null hypothesis was rejected.
3. There was no significant change in lean body mass as a result of the competitive season of basketball. The null hypothesis relating to the lack of change in lean body weight was accepted.
4. There was no significant gain or decrease in maximal oxygen consumption after the competitive basketball season. Because there was no significant change in aerobic fitness, the null hypothesis was accepted.
5. There was an increase in peak anaerobic power, but it did not prove to be significant. This nonsignificance resulted in the acceptance of the null hypothesis.
6. There was no significant increase or decrease in vertical jump height over the course of the playing season; therefore the null hypothesis was accepted.

### Recommendations

Some recommendations for further studies are as follows:

1. All team starters should be tested in further studies, if possible.

Due to injuries to two starters and the lack of cooperation of another, the entire team was not tested in the postseason trials. Their data was not used. This may have affected the results of this experiment in a negative manner.

2. A study could be conducted comparing the men's and women's basketball teams, providing both teams followed the same training program and played the same number of games during the season. Comparisons could be made between the preseason fitness levels or between the effects of the competitive season on men and women.
3. A control group of nonathletes who did not participate in any conditioning or recreational sports could be used to compare the effects of nonparticipation to that of a season of competitive sports.
4. Players who played a majority of the time, based on minutes played could be compared to those who played less time.
5. The college team could be compared to a high school team to compare the differences, if any, between the fitness demands of collegiate and high school basketball.
6. Team members of several different sports could be compared for fitness levels and any changes in fitness resulting from a competitive season. Some sports that could be compared are basketball, softball, volleyball, track, and swimming.

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APPENDIX A

September 2, 1987

Ms. Terrie Sheridan  
Women's Basketball Coach  
University of Wisconsin - La Crosse  
La Crosse, Wisconsin 54601

Dear Coach Sheridan,

As was previously discussed, I would like to test your 1987 - '88 women's basketball teams for my master's thesis. This testing would be done before and after the the coming season. I would then compare the differences in the players' fitness levels.

I am planning on having the players perform four different tests. The first test would consist of a treadmill run to determine their aerobic fitness. The second test would be a Wingate Power Test, which tests for peak anaerobic power. The third test would be a test for vertical jump, while the final test would involve the determination of body composition through the use of hydrostatic weighing.

The first series of tests will be performed in October, while the second round will be administered following the playing season. If you have any questions, please feel free to contact me at home. My number is . Thank you for your cooperation.

Sincerely,

Heidi Ann Hilgenberg

APPENDIX B

Informed Consent

I, \_\_\_\_\_, volunteer to participate in four different physical tests to measure my fitness level. I understand these tests to be a maximal treadmill test, an underwater weighing test, the Wingate Anaerobic Cycle Test, and a vertical jump test.

I understand that the treadmill test requires maximal effort. I also understand that I can terminate the test anytime I wish. As with any exercise, there may be adverse feelings (i.e. irregular heart beat, dizziness, etc.). If any of these feelings occur, the test will be terminated immediately. I realize that I will feel tired at the end of the test.

I understand that to be underwater weighed, my residual volume must be determined. Then my weight will be determined with my body completely submerged and my lungs must be emptied of air as completely as possible. I understand the possible risks of working in a water environment (i.e. infection, accidents or possible drowning).

I understand the thirty second Wingate test will be very hard on my legs due to the requirement of the protocol that I pedal against a resistance of 0.075 kilogram of weight for every kilogram of body weight. My legs may be fatigued at the end of the thirty second period. I understand that, as with the maximal treadmill test, I may experience adverse feelings (fatigue, dizziness, etc.), and I may terminate the test if these things occur to the extent that I feel too great. I also understand that I am required to exert maximal effort during this test.

I understand the vertical jump consists of a one step two-footed jump, touching the highest point possible with my dominant hand. I realize this test will be done three times.

I understand each of these tests will be done two times; once preseason and once postseason.

To my knowledge, I do not possess any disabilities or physical limitations, especially heart conditions, which would excuse me from participation in the above program. I am also, to my knowledge, not infected with any disease which would be transmittable in a water environment.

I have read the above statements and I understand them. Any questions I thought of have been asked and answered fully. I understand the potential risks and their implications. I am also aware that there are no guarantees or assurances of any kind made to me by the University of Wisconsin-LaCrosse, the faculty, employees or anyone acting on behalf of the University. I also understand that the results of these tests have nothing to do with my chance of selection to the UW-L women's basketball team.

\_\_\_\_\_  
Signature

\_\_\_\_\_  
Date

\_\_\_\_\_  
Witness

\_\_\_\_\_  
Date

APPENDIX C

### Treadmill Instructions

As instructed, you will be asked to perform a maximal oxygen consumption test. The directions are as follows:

1. Straddle the belt and place your hands on the railing.
2. When the treadmill starts, place one foot on the belt to get a feel for the speed and begin walking when you feel comfortable.
3. The electrodes will give us your heart rate and the mouthpiece will let us collect your exhale air. You will also wear a noseclip. Please keep your lips sealed as tightly as possible.
4. Because this test requires maximal effort, please run for as long as you possibly can. We will provide you with verbal encouragement throughout the test.
5. When you can no longer continue straddle the belt and hold onto the railing. The treadmill speed and grade will be reduced and the headset removed so you can walk comfortably while cooling down.
6. If you have any sick feelings during the test, please signal to us and straddle the belt.
7. We will also periodically show you this chart (hold up RPE chart) and ask you to indicate how hard you are working. Six represents easy exercise and twenty represents the hardest work you've ever done. Just point to the number that indicates your feeling.
8. You will be informed before every speed and grade increase. The warm-up period lasts for five minutes, and the different stages last two minutes each.

Please do your best and we appreciate your participation and cooperation.

Sincerely,

Kathy Brown - Miner    Heidi Ann Hilgenberg

APPENDIX D

Vertical Jump Instructions

- 1) Stand sideways with your heels together.
- 2) Reach with your dominant hand as high as possible next to the meter tape.
- 3) Take a one - step approach towards the meter tape and a two - footed takeoff.
- 4) Swing both arms upward and touch the wall at greatest height possible with the chalked hand.

This procedure will be performed three times.

APPENDIX E

### Pulmonary Measurement Instructions

#### Vital Capacity

- 1) Place noseclip on nose.
- 2) Inhale as deeply as possible.
- 3) Place your mouth on the mouthpiece making a tight seal and exhale as much air as you can.

This procedure will be repeated twice.

#### Residual Volume

- 1) Place noseclip on nose.
- 2) Place your mouth around the mouthpiece creating a tight seal.
- 3) Take two normal breaths and then inhale deeply.
- 4) Exhale as long and hard as you can, when all the air you can expel is out hold up your finger.
- 5) Breathe as rapidly and deeply as you can until you are instructed to stop.

This procedure will be done until two consistent values are obtained. These values are necessary to determine your body composition.

APPENDIX F

Underwater Weighing Instructions

- 1) Rinse off body, hair, and swimsuit with soap and water in shower.
- 2) Carefully climb into tank and submerge up to your neck without touching the weighing apparatus.
- 3) Sit on weighing chair and remove air bubbles from skin and swimsuit.
- 4) Place noseclip on nose and grasp bars of the chair and place your feet on the bottom bar.
- 5) Exhale as much air as possible and submerge the rest of your body under the water. Continue exhaling while you are under water.
- 6) Remain as still as possible while under water.
- 7) Stay submerged until you are told to resurface or you cannot stay under any longer.

This procedure will be repeated until three identical values have been recorded.

In addition:

- 1) Avoid vigorous activity prior to the test.
- 2) Avoid alcohol and coffee 24 hour prior to the test.
- 3) Avoid eating 8 hours before the test.

APPENDIX G

Anaerobic Power Test Instructions

1. Adjust seat height for your comfort.
2. Insert feet into the toe clips and tighten straps.
3. Pedal lightly for two minutes to warm - up.
4. Rest for two minutes.
5. A specified weight will be added to the weight basket.
6. Pedal as fast as you can, then the weight will be added to the flywheel.
7. Keep pedalling as hard as you can throughout the test. Verbal encouragement will be given.

This procedure will be completed once.

In addition:

1. Avoid vigorous activity 5 hours prior to testing.
2. Avoid alcohol and coffee 24 hours prior to testing.