ABSTRACT

PARKER, S.E. Physiologic and performance changes during a season of men's collegiate basketball. MS in Adult Fitness/Cardiac Rehabilitation, December 1999, 36pp. (C. Foster)

This study evaluated select physiologic and performance variables at the beginning and end of an intercollegiate basketball season using 10 members of the University of Wisconsin-La Crosse men's basketball team. The variables included VO_2peak, body composition, vertical jump, and a modified shuttle run. Maximal aerobic power was measured on a motorized treadmill using a modified Bruce protocol. Body composition was evaluated by anthrompometry. Percent fat was estimated from the sum of seven skinfold measurements. Girth measurements were estimated based on limb circumference and skinfold measurement based on the O-scale approach. Vertical jumping ability was evaluated using a jump and reach test with a single step counter movement. Each subject jumped to the highest point on a Vertec and the best of three jumps was recorded to the nearest 0.5 inch. Basketball specific fitness was evaluated using a modified shuttle run. These tests were administered 2 weeks prior to the beginning of the season and again 2 weeks following the last game. A paired t-test ($p < .05$), with a Bonferoni correction for multiple comparisons, revealed significant differences in the modified shuttle run (entire group), sum of 7 skinfolds and percent body fat between the pre- and postseason of play. All other variables revealed no significant differences between the pre- and postseason.

PHYSIOLOGIC AND PERFOMANCE CHANGES DURING A SEASON OF MEN'S COLLEGIATE BASKETBALL

A MANUSCRIPT STYLE THESIS PRESENTED

TO
THE GRADUATE FACULTY

UNIVERSITY OF WISCONSIN-LA CROSSE

IN PARTIAL FULFILLMENT

OF THE REQUIREMENTS FOR THE

MASTER OF SCIENCE DEGREE

BY

SUZANNE E. PARKER

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THESIS FINAL ORAL DEFENSE FORM

Candidate: Suzanne E. Parker

We recommend acceptance of this thesis in partial fulfillment of this candidate's requirements for the degree:

Master of Science-Adult Fitness/Cardiac Rehabilitation

The candidate has successfully completed the thesis final oral defense.

8/5/99
Thesis Committee Chairperson Signature — Date

8-5-99
Thesis Committee Member Signature — Date

8-5-99
Thesis Committee Member Signature — Date

8-5-99
Thesis Committee Member Signature — Date

This thesis is approved by the College of Health, Physical Education, and Recreation.

8-18-99
Associate Dean, College of Health, Physical Education, and Recreation — Date

8-18-99
Director of University Graduate Studies — Date

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Finally, I would like to thank my Mom and Dad for always believing in me. Both of you have taught me so much. Your love and support have really meant the world to me. I could not have done this without you. I love you both very much. This thesis is dedicated to both of you.

TABLE OF CONTENTS

LIST OF TABLES

TABLE PAGE

LIST OF FIGURES

FIGURE PAGE

LIST OF APPENDICES

INTRODUCTION

Basketball has been a popular sport for over a century. Basketball has been played in just about every venue around the world, including grade schools, high schools, colleges, and professionally. Collegiate basketball began within two years of the invention of the game. Researchers have long been interested in studying certain aspects of the game such as aerobic and anaerobic capacity of participants [6].

Basketball, like many other sports, utilizes both aerobic and anaerobic power with frequent changes in intensity. Studying different collegiate and professional teams around the country has helped to develop information regarding the physiology of basketball players. Endurance in basketball players has been a primary focus of testing [16]. The ability for a player to last through an entire game is enhanced by practice sessions and off season training. Practices incorporate running, sprinting, jumping, and repetitive drills for an extended period of time with the intent that cardiovascular endurance and physical performance would be increased. The evaluation of this training has been done using various criteria including maximal oxygen consumption (VO_2peak) [4,5,6,7,11,17,22], vertical jumping ability [1,12,15], body composition [16,20], and basic skills [8,10,18]. This information has aided in the development of fitness programs and modifications to practice sessions [18].

Most of the longitudinal physiologic evaluations of basketball players have been conducted with the female gender [18]. In general, these studies have failed to demonstrate enhancement in VO_2peak or performance related surrogates of VO_2peak [11]. Outside of some cross-sectional descriptive studies [18], there is surprisingly little data regarding longitudinal changes in aerobic parameters in male basketball players.

Hopkins et al. [14] described some of the difficulties inherent in evaluating athletes. They note that real world performance is greatly superior to laboratory evaluation and that functional evaluation may be superior to conventional laboratory evaluation. There are several functional drills which have wide acceptance within the basketball community. Accordingly, it might be reasonable to expect that such functional drills would track changes in basketball specific fitness better than conventional laboratory evaluation.

Thus, there appears to be a need for not only to measure physiological and performance changes in a competitive season of men's basketball but also to clarify the differences reported in previous studies. The first issue to be addressed concerns potential physiological changes that occur during a competitive season of men's basketball and what coaches and players can do to modify practices to benefit from these changes. The second issue is the relevance of basketball performance to changes in laboratory measures of fitness versus functional methods of evaluation.

METHODS

Subjects

The subjects for this study were members of the University of Wisconsin-La Crosse men's basketball team (N = 10). Preseason descriptive characteristics of the subjects are presented in Table 1. All subjects provided written informed consent prior to participation (see Appendix A) and the protocol was approved by the IRB of the University of Wisconsin-La Crosse.

Table 1. Descriptive characteristics of subjects (N = 10)

Variable	Mean ± SD	Range
Age (yr)	20.2 ± 1.5	19 - 23
Height (cm)	191.4 ± 4.9	183 - 198.1
Weight (kg)	89.3 ± 7.8	80.7 – 102
HR max (bpm)	182.4 ± 8.6	164 – 190
Percent Fat (%)	12.8 ± 2.8	9.1 - 17.6

Testing Procedure

Laboratory evaluations were performed on a motorized treadmill using a modified Bruce protocol. The subjects exercised to volitional fatigue. Oxygen uptake was measured using open circuit spirometry. VO_2 peak was defined as the oxygen uptake during the last full minute of exercise. Ventilatory threshold was defined as the point at which lactic acid builds up in the body, which may be increased with an increase in training. The respiratory compensation threshold is the point where extra ventilation is no longer capable of defending pH against an increase in lactate. This leads to an uncontrollable increase in ventilation relative to carbon dioxide output. This is also represented as a percentage of VO_2peak to help determine exercise tolerance, but may remain unchanged with an increase in training. These thresholds are reported as the VO_2 at which ventilation changes occur. The ventilatory and respiratory compensation thresholds were identified using the V-slope technique [2,13] and confirmed by the ventilatory equivalent for oxygen and carbon dioxide [23]. Heart rate was measured using radiotelemetry [19]. Borg's 10-point category ratio scale [3] was used to score both pre- and postseason VO_2peak tests (see Appendix B).

Vertical jumping ability was evaluated using a jump and reach test with a single step counter movement. Each subject jumped to the highest point on a Vertec and the best of three jumps was recorded to the nearest 0.5 inch. Many variables may contribute to the vertical jump performance, such as the strength and power of the musculature surrounding the hip, knee, and ankle joints. Thus leg power may be a good predictor of performance in the game of basketball [1].

Body composition was evaluated by anthropometry. Percent body fat was estimated from the sum of seven skinfold measurements according to Pollock et al. [20]. The circumference of the muscular limbs was estimated based on limb circumference and skinfold measurement based on the O-scale approach [21]. This technique effectively and mathematically eliminates the fat.

Basketball specific fitness was evaluated using modified shuttle run. Briefly, each subject sprinted from sideline to sideline for 1-minute. The number of touches to each sideline was counted and recorded. Following a 1-minute rest the drill was repeated five times (with a 1-minute rest period between each 1-minute of line to line sprinting). The total number of full sideline to sideline lengths was accepted as the score for the athlete. Each subject was evaluated sometime during the 2 weeks before the beginning of the competitive season and sometime during the 2 weeks after last competition of the season.

Statistical Methods

Data were compared using paired t-tests with a Bonferoni correction for multiple comparisons to determine more accurate significance. Outcome measures included pre- versus postmean values for VO_2peak, ventilatory threshold, respiratory compensation threshold, treadmill test duration, vertical jump, percent body fat, calculated fat free mass, muscular limb circumferences (calf, thigh and arm), and performance on the modified shuttle run. It was hypothesized that there would be no significant ($p < 0.05$, with Bonferoni correction) differences in any of the outcome measures.

RESULTS

Ten members of the University of Wisconsin-La Crosse men's basketball team were studied for both physiologic and performance changes from the beginning to the end of a competitive season of basketball. The members involved in the study were tested 2 weeks prior to the beginning of the season and within 2 weeks following their last game. During each testing session, the subject completed a vertical jump and a modified shuttle run. Also included was assessment of body composition and aerobic power.

Body Composition

The mean values for weight, lean body weight, sum of seven skinfolds, and percent fat are displayed in Table 2 and Figure 1. The results showed significance indicating a decrease in total body fat.

Table 2. Body fat measurements

Body Composition	Preseason	Postseason	p – value
Weight (kg)	89.3 ± 7.8	88.0 ± 7.2	0.06
Lean Body Weight (kg)	77.9 ± 6.9	78.1 ± 6.5	0.38
Sum of 7 Skinfolds (mm)	95.7 ± 20.0	85.4 ± 15.3	0.01*
Body Fat Percentage	12.8 ± 2.8	11.3 ± 2.2	0.01*

* This indicates a significant difference

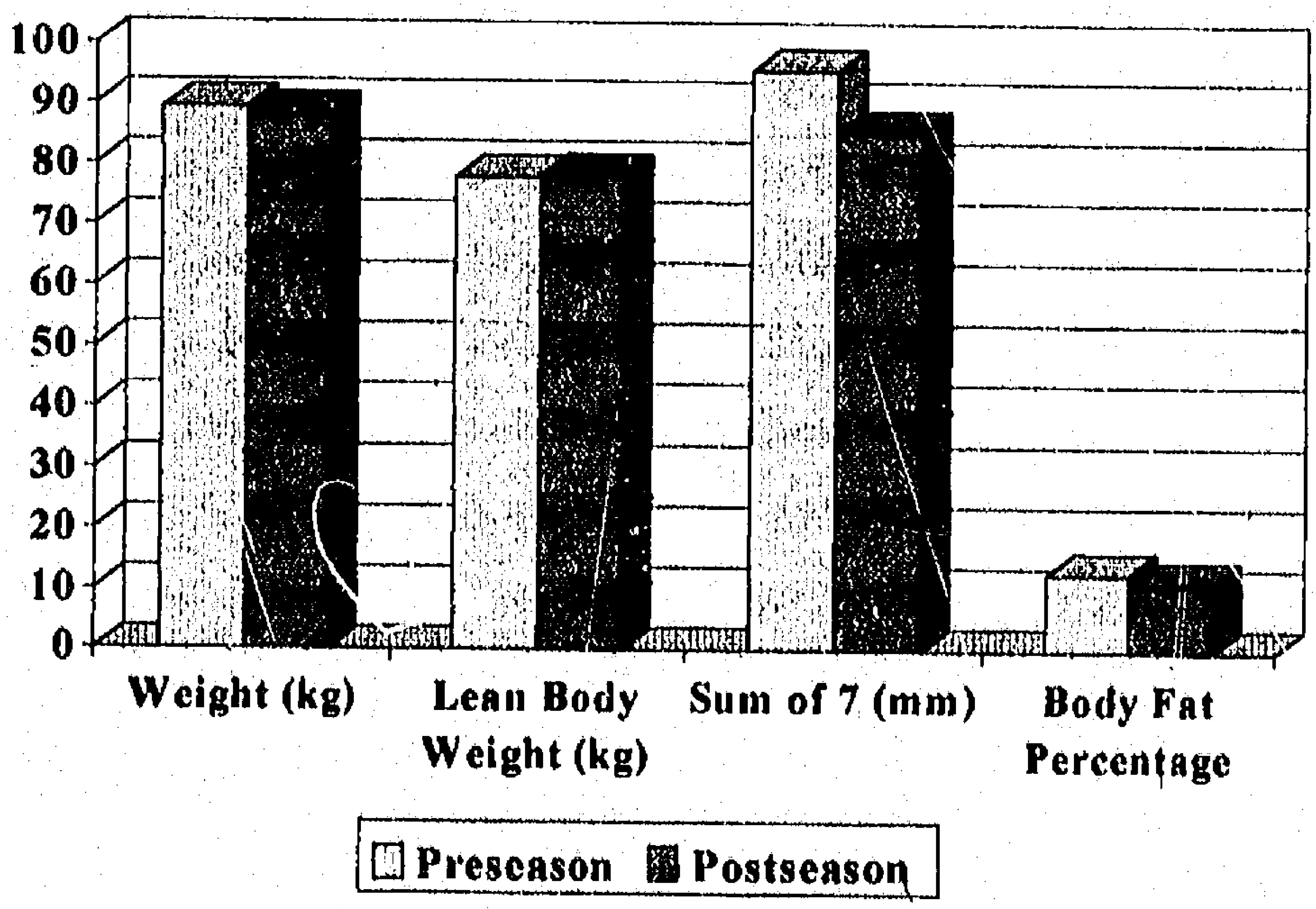

Figure 1. Changes in indices of body composition over the season

Girth Measurements

The mean values for pre- and postseason girth measurements are presented in Table 3 and Figure 2. There was no significant difference in girth between the pre- and postseason.

Table 3. Girth measurements

Girth (cm)	Preseason	Postseason	p – value
Thigh Girth	58.2 ± 2.9	57.4 ± 2.8	0.06
Corrected Thigh Girth	52.8 ± 3.3	52.7 ± 2.7	0.42
Calf Girth	39.7 ± 2.3	39.0 ± 2.5	0.02
Corrected Calf Girth	35.4 ± 2.6	35.4 ± 3.0	0.60
Arm Girth	36.4 ± 1.8	35.8 ± 1.9	0.02
Corrected Arm Girth	31.4 ± 2.3	32.0 ± 2.8	0.05

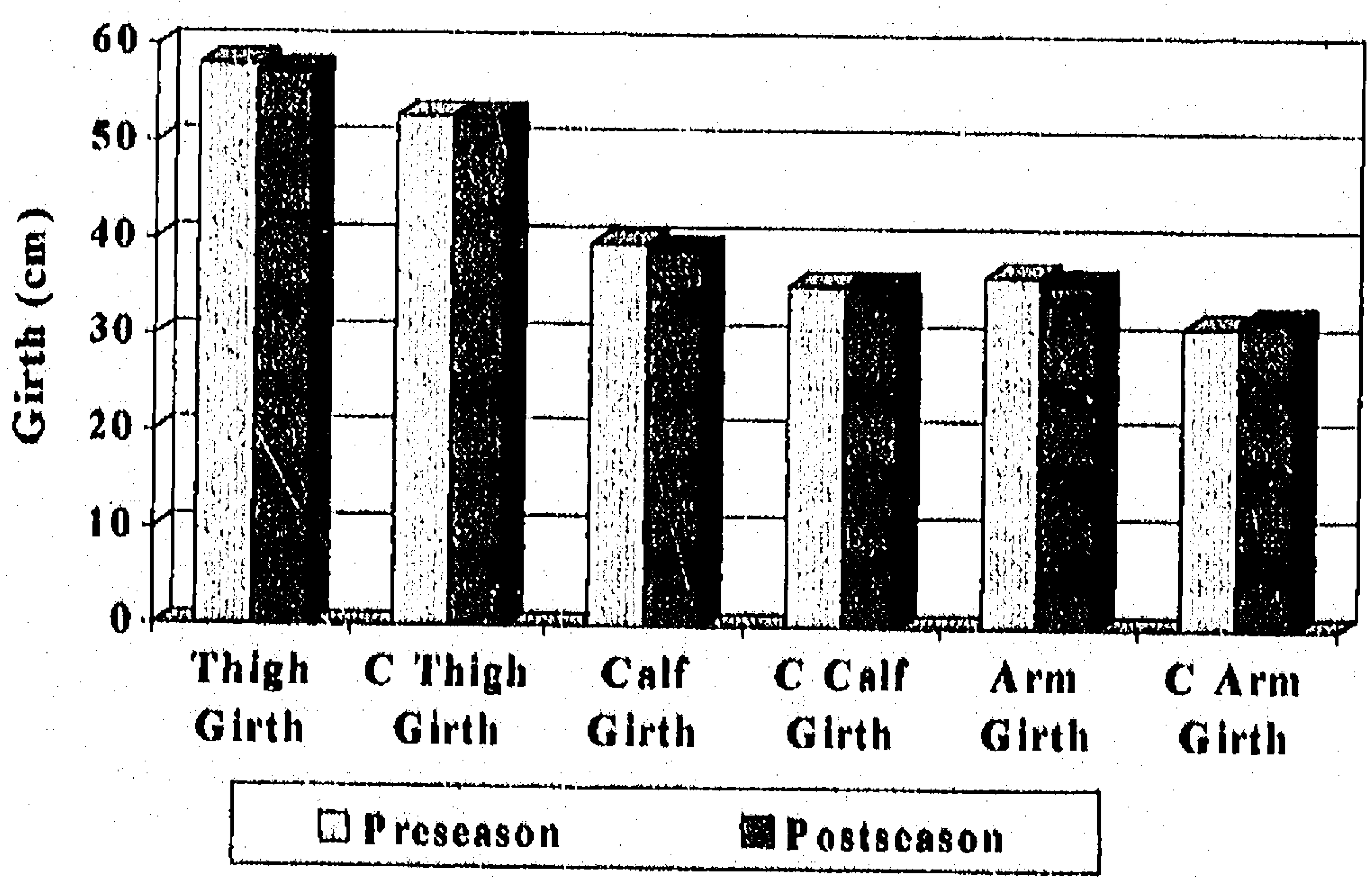

Figure 2. Changes in indices of limb girth over the season (c = corrected)

Aerobic Fitness

The mean values for pre- and postseason aerobic fitness are presented in Table 4 and Figure 3. There were no significant differences between pre- and postseason for any of these measures of aerobic fitness.

Table 4. Exercise measurements

Exercise (L/min)	Preseason	Postseason	p – value
VO_2peak	4.6 ± 0.5	4.5 ± 0.6	0.30
Ventilatory Threshold	3.3 ± 0.5	3.1 ± 0.5	0.02
Respiratory Compensation Threshold	3.7 ± 0.4	3.7 ± 0.5	0.30

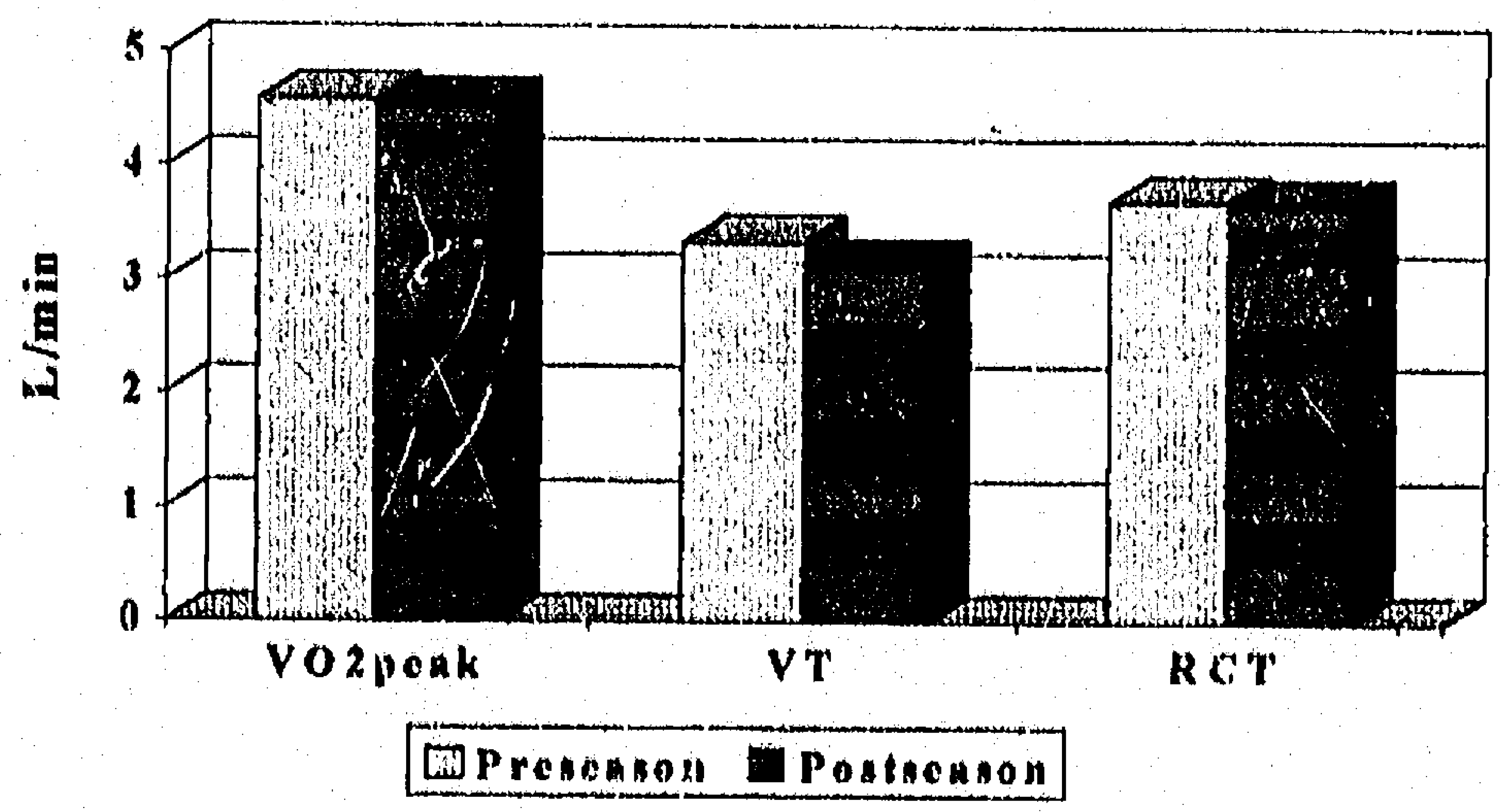

Figure 3. Changes in indices of aerobic fitness over the season

Basketball Specific Fitness

The mean values for the entire group for treadmill time during the VO_2peak test, vertical jump, and modified shuttle run are presented in Table 5 and Figure 4. When the postseason test was administered it was believed that the seniors were not running to their potential in the modified shuttle run. A statistical analysis was done with only the underclassmen. The mean values for the underclassmen for treadmill time during the VO_2peak, vertical jump, and modified shuttle run were obtained to determine true significance. The results are presented in Table 6. The results showed significant differences in the modified shuttle run for the entire group. But when the seniors were taken out no significant changes were noted in any of the variables.

Table 5. Measurements of basketball specific fitness (entire group)

Performance	Preseason	Postseason	p – value
Modified Shuttle Run (reps)	77.2 ± 3.2	71.5 ± 5.7	0.01*
Treadmill Time (min)	16.1 ± 0.9	16.5 ± 1.6	0.13
Vertical Jump (in)	29.6 ± 1.9	28.9 ± 2.4	0.13

* This indicates a significant difference

Table 6. Measurements of basketball specific fitness (without seniors)

Performance	Preseason	Postseason	r – value
Modified Shuttle Run (reps)	78.3 ± 3.2	75.2 ± 4.1	0.08
Treadmill Time (min)	16.2 ± 0.8	17.0 ± 1.5	0.07
Vertical Jump (in)	30.1 ± 1.9	29.8 ± 2.1	0.37

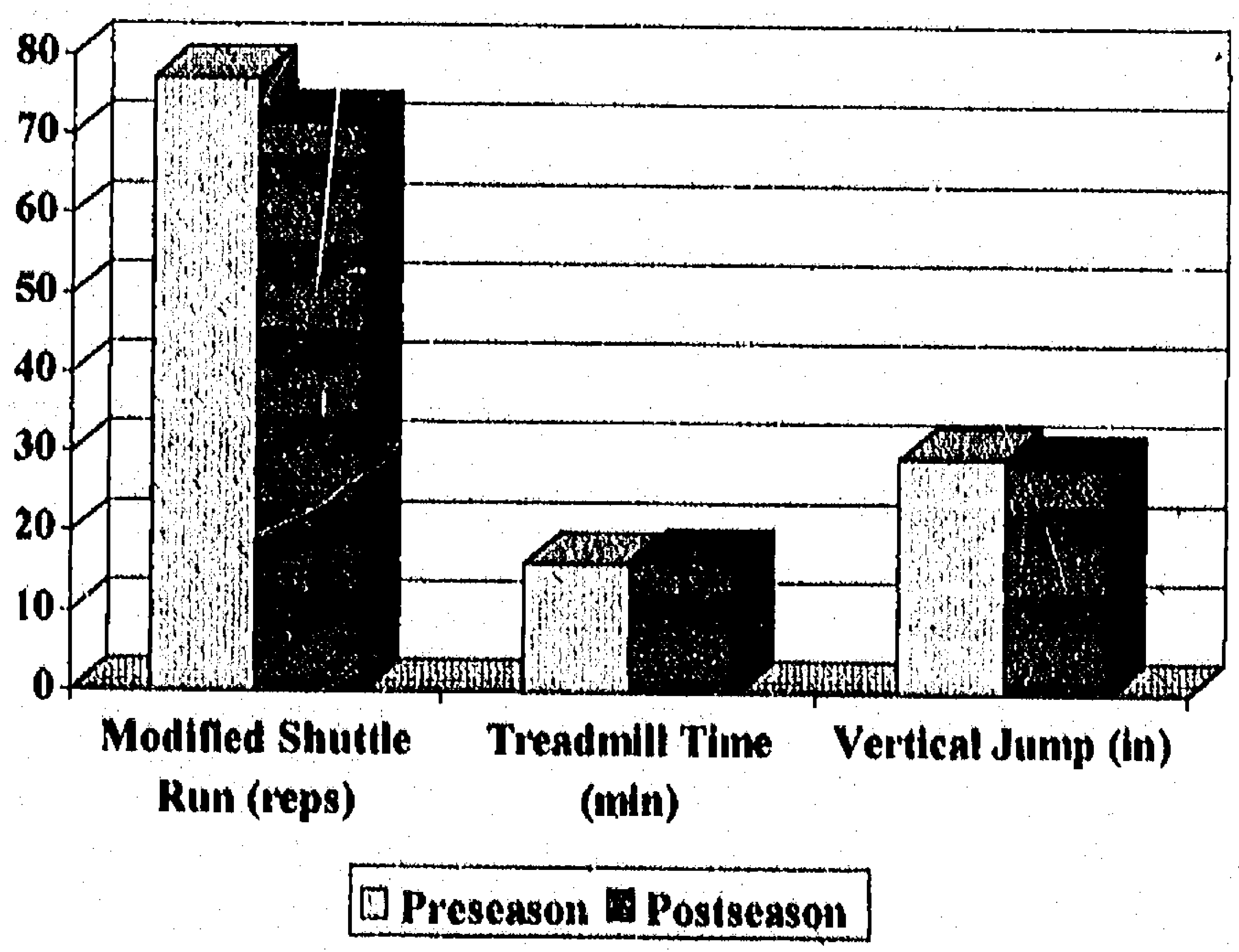

Figure 4. Changes in indices of basketball specific fitness over the season for the entire group

DISCUSSION

This study compared the changes in select physiologic and performance variables from the beginning to the end of a competitive season of men's basketball at the University of Wisconsin-La Crosse. The results indicated significance in some variables between the pre- and postseason of basketball.

Body composition was evaluated by anthropometry. Over the season there was a tendency towards a significant change indicating a slight decrease in total body fat, which may indicate an increase in lean body mass. This may be attributed to regular practice sessions including running and sprinting, as well as functional drills and weight lifting.

The girth measurements showed no significant changes throughout the season (i.e., there were no notable increases or decreases in girth measurements both actual and corrected). Corrected girths were used to mathematically exclude fat and determine if in fact there was a significant difference in muscular girth between the pre- and postseason. The results indicated no change over the season, which may be attributed to training prior to the beginning of the season.

The mean values for indices of aerobic fitness showed no difference between the pre- and postseason of play. This is probably due to preseason conditioning and continuous training throughout the season. Respiratory compensation threshold and ventilatory threshold likewise remained unchanged throughout the season. This may also be attributed to preseason conditioning and continuous training during the season.

Basketball specific fitness was evaluated using the modified shuttle run and vertical jump. The results for the vertical jump remained unchanged in both the entire group and the group excluding the seniors. This also may be due to training prior to the beginning of the season. On the other hand, when the modified shuttle run was measured within both groups, only the entire group showed significant differences. This may be due to the fact that the seniors were less motivated to perform this drill, knowing that they would never have to do it again.

The results indicated significance in some variables between the pre- and postseason of basketball. During the season, it was expected that more variables would show significance. More likely, the reason for this may be due to the players being reasonably well conditioned before the season started thus showing significance in only a few variables during the season as training continued. Several studies have shown that already conditioned athletes demonstrate very little pre- to postseason changes in fitness [9].

During a season of basketball, practices tend to get a little harder as the end of the season approaches and the team is preparing for tournament play. Also, the seniors tended to show decreases between the pre- and postseason. These decreases may have been the result of being tired. The seniors have gone through four years of rigorous basketball and are ready to be done playing.

Therefore, these players could have been very tired and not willing to participate fully in the postseason testing. Any of these factors could have contributed to the results obtained in this study.

Overall, coaches and players can benefit from the results of this study. One way to help coaches modify practices may be to hold less rigorous practices right at the beginning of the season. This may also help researches to identify if more variables show significance over a season of basketball. Also, players may have been very tired at the end of the season due to excessive conditioning. This may have resulted in only minor changes throughout the season.

Another issue that needs to be discussed is how relevant to basketball performance are changes in laboratory measures of fitness versus functional methods of evaluation. The results showed that there were no significant changes in either the VO_2peak or in the functional drills between the pre- and postseason. Laboratory tests and performance on the court are very different aspects of fitness. The laboratory testing involved one day of a 10 to 15 minute run on a motor driven treadmill in a healthy state, whereas performance on the court varied from day to day due to injury and illness. According to Hopkins et al. [14], real world performance is greatly superior to laboratory evaluation. Of course, the comparison of basketball performance and laboratory testing requires more research to have significant relevance.

SUMMARY

The purpose of this study was to evaluate the physiologic and performance changes throughout a competitive season of men's collegiate basketball. The subjects were ten members of the 1998-1999 University of Wisconsin-La Crosse men's basketball team.

Each of the ten subjects completed a set of pre- and postseason tests. These involved aerobic fitness, body composition, vertical jump, and a modified shuttle run. Aerobic fitness was measured on a motorized treadmill using a modified Bruce protocol, where each subject ran to volitional exhaustion during which maximal oxygen uptake was measured. Body composition was evaluated by anthropometry. Percent body fat was measured from the sum of seven skinfold measurements obtained using calipers.

Girth measurements were obtained using a tension regulated tape. Vertical jump was evaluated using a jump and reach test with a single step counter movement. Each subject jumped to the highest point on a Vertec and the best of three jumps was recorded to the nearest 0.5 inch. Finally, basketball specific fitness was evaluated using a modified shuttle run. Each subject was instructed to sprint from sideline to sideline for 1-minute. The number of touches to each sideline was recorded. Each subject repeated this drill five times with 1-minute rest bouts in between sprints. These tests were performed 2 weeks before the season started and 2 weeks immediately following the last game.

The data analysis was performed using paired t-tests to evaluate and compare pre- and postseason results used a level of significance at $p < .05$ with Bonferoni correction for multiple comparisons. Using these data analysis tools significant changes were noted in some variables throughout the pre- and postseason of play. Body fat showed a decrease at the end of the season, as did the modified shuttle run (entire group), indicating a need for longitudinal studies over an entire year or collegiate career to show significance in all variables.

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APPENDIX A

INFORMED CONSENT FORM

INFORMED CONSENT FORM

The University of Wisconsin - La Crosse
La Crosse, Wisconsin

PHYSIOLOGICAL, PERFORMANCE, AND TRAINING RESPONSES DURING A MEN'S BASKETBALL SEASON

(Suzanne E. Parker and Lori L. Gottschall)

I, __________________________, give my informed consent to participate in this study to determine the physiological, performance, and training adaptations that occur over a basketball season. I have been informed that throughout this study my identity and the results of my performance will be kept confidential. I consent to publication of the study results so long as the information is anonymous and that no identification of the individual subjects will be made.

This study will measure my VO_{2max} via a treadmill test, my jumping ability, my basketball specific fitness, my body composition, and my heart rate response during practice and an intersquad game and how I respond to training.

My maximal aerobic power (VO_{2max}) will be determined on a treadmill test which will consist of walking/running to voluntary fatigue on a motor-driven treadmill. Beginning from very easy effort the speed and grade of the treadmill belt will be increased until I become fatigued.

During the exercise testing, I will breathe room air through a scuba type mouthpiece with my nose clamped so that my exhaled air can be collected and analyzed. Although this test will require maximal effort, I have been informed that I can stop the test anytime I wish. I will have several skinfold thickness and girths measured to determine body composition. I will perform a standard vertical jump test and a basketball specific functional fitness test. I will also answer questions regarding my response to daily training sessions and injuries and illness I might experience. The anticipated risk involved in this study is fatigue from laboratory testing. Although severe complications (e.g., cardiac arrest) are theoretically possible, their occurrence in young athletes is very infrequent (<1/10,000 tests).

I have been informed that my heart rate will be monitored with a heart rate monitor which will be strapped to my chest at about heart level. Heart rate response may be measured at various times including laboratory evaluations, practice and an intersquad game. Other than the possible discomfort of the strap, there should be no interference with my ability to play basketball.

All testing sessions will be scheduled at my convenience and will be supervised/conducted by Suzanne Parker and Lori Gottschall, graduate students enrolled in the Adult Fitness/Cardiac Rehabilitation graduate program under the direction of Carl Foster, Ph.D.

To my knowledge, I do not possess any disabilities or physical limitations, especially heart conditions, which would preclude me from participation in this study. I have been informed that muscle fatigue, strains, and sprains may occur. Also, I have been informed there is a chance of serious complications during exercise testing (e.g., heart attack) but the risk of this is low (<1/10,000 tests).

I have read the above statements and understand them. Any questions I might have had have been answered. I have been informed of the potential risks and their implications. I voluntarily consent to participate in this study. I have been informed that I may withdraw at any time without any type of penalty.

Further, I have been informed that neither participation in this study nor the results of these tests will influence my chance of being selected to the 1998-99 UW-La Crosse men's basketball team.

Any concerns or questions that may arise throughout the study may be referred to the primary researchers, Suzanne Parker or Lori Gottschall at (608) 785-3954 or the thesis advisor, Carl Foster, Ph.D. at (608) 785-8687.

NAME: ______________________ DATE: ____________

WITNESS: ____________________ DATE: ____________

WITNESS: ____________________ DATE: ____________

Contact Garth Tymeson, UW-L IRB Chair, if you have questions about the protection of human subjects (608) 785-8155.

APPENDIX B

BORG'S RATING OF PERCEIVED EXERTION CHART

Borg's Rating of Perceived Exertion (Borg, 1982)

0	Rest
1	Very Easy
2	Easy
3	Moderate
4	Somewhat Hard
5	Hard
6	
7	Very Hard
8	
9	
10	Max

APPENDIX C

REVIEW OF LITERATURE

REVIEW OF LITERATURE

The purpose of this study was to determine the physiologic and performance changes from the beginning to the end of a season of competitive basketball. A limited number of studies have been done on the physiological and performance effects of a men's basketball season. Most studies report only women's collegiate basketball with regard to these changes. Many investigators noted the large variety of protocols used for the measurement of aerobic power. Other tests to measure physiologic and performance changes involve vertical jump, body composition, and a modified shuttle run.

Aerobic Power

Prolonged activities such as marathon runs or jogging depend mainly on the aerobic energy system. During a basketball game, aerobic expenditures are utilized when the individuals are in a constant state of motion throughout the entire game. Although the game is not played in continual motion, the players do not sufficiently cool down to resting levels of oxygen intake. Aerobic power is determined through energy expended in practices, scrimmages, and games. Cabrera et al. [5] reported that basketball is a sport that demands a great deal of cardiovascular endurance during competition. Vaccaro et al. [22] reported that basketball players need high levels of endurance as well as skill and technique to be able to perform well in competition. In another study, Coleman et al. [7]

stated that musculoskeletal and cardiorespiratory training enables the participant to be more efficient. These studies indicate that a great deal of cardiovascular endurance is needed to perform well in competition.

Studies on VO_2peak have indicated conflicting results when comparing pre- to postseason values. Some studies show that there is a decrease in VO_2peak, whereas other studies indicate no difference at all between pre- and postseason. A study by Hakkinen [12] stated that no systematic changes occurred in the maximum oxygen uptake during the entire competitive season. These results are compared to results found by Coleman et al. [7] also reported no significant difference in maximal oxygen uptake between the pre- and postseason. In another study VO_2peak was determined three times throughout a season of basketball (pre-, mid-, and post-season). Cabrera et al. [5] found the results of all three tests to be similar: preseason VO_2peak = 46.8 $\pm$ 5.76, midseason VO_2peak = 46.8 $\pm$ 5.40, and postseason VO_2peak = 50.4 $\pm$ 5.68.

In one study, the starters and reserves were studied individually. The results showed no significant change in VO_2peak among the starters but showed significant decrease in VO_2peak among the reserves [6]. In this study, Caterisano et al. [6] stated that the results of previous studies were inconclusive because of the fact that there is such a difference between aerobic power utilized in starters and reserves. The two should not be combined in one study because starters maintain their aerobic power whereas reserves tend to decrease in VO_2peak because of their lack of playing time. The results of this study showed that there was a significant decrease in VO_2peak from pre- to postseason among the reserves (53.8 to 48.6 $ml \cdot kg^{-1} \cdot min^{-1}$) and no significant change among the starters (53.0 to 53.6 $ml \cdot kg^{-1} \cdot min^{-1}$) [6].

Vaccaro et al. [22] divided the basketball team according to specific positions: centers, forwards, and guards. The data showed that the centers had the highest absolute VO_2peak values (5.46 ± .48 L/min), followed by the forwards (5.39 ± .65 L/min), and lastly the guards (4.57 ± .48 L/min). Vaccaro et al. [22] reported that when oxygen uptake was standardized according to body weight, guards (60.61 ± 7.02 $ml \cdot kg^{-1} \cdot min^{-1}$) tended to be physically superior to centers (56.20 ± 1.07 $ml \cdot kg^{-1} \cdot min^{-1}$).

There are numerous studies that determined aerobic capacity with regard to women's basketball. One study compared aerobic capacity, heart rate, and estimated energy cost during a season. McArdle et al. [18] found that there was no statistical significance with regard to VO_2peak in the preseason (35.51 ± 4.1 $ml \cdot kg^{-1} \cdot min^{-1}$) and postseason (35.75 ± 5.6 $ml \cdot kg^{-1} \cdot min^{-1}$).

The Vertical Jump

The vertical jump plays a critical role in many sports, including basketball, volleyball, and the high jump in track and field. Studies by Ashley and Weiss [2], Holcomb et al. [14], and Kraemer et al. [17] have been done concerning vertical jump and performance in sports. A study performed by Ashley et al. [2] measured two different vertical jumps and a variety of musculoskeletal variables.

It was found that all force and power variables related to the jumping performance; however, no correlations were found between the body fat measurement and jumping performance. Many variables contribute to vertical jump performance, such as strength and power of the hip, knee, and ankle muscles. Thus, leg strength may be a good predictor of vertical jumping ability [2].

Holcomb et al. [14] demonstrated the use of plyometric exercises on power and vertical jump. Significant changes in power and vertical jump height between the various plyometric training methods were noted between the pre- and postseason. Kraemer et al. [17] conducted a study to determine whether compression shorts affected the vertical jumping performance in women volleyball players. They found compression shorts increased repetitive vertical jumping ability; however, not for single maximum jump power. Therefore, the use of compression shorts for skilled jumpers may be an advantage for increasing power output over a number of jumps [17]. Throughout the review of research, the vertical jumping ability of basketball players can possibly be enhanced through a variety of measures and is an important element for players who attempt to block shots, retrieve rebounds, or shoot a jump shot.

Components of Body Composition

Many methods have been developed that provide a precise estimation of body composition. In regards to athletes, a low body fat is desirable to enhance physical performance [13]. Measuring and predicting body composition and examining the effects of body composition on male athletes will be discussed.

Body composition refers to the lean body mass plus the weight of the body fat [4]. According to McArdle et al. [18], many methods have been developed and fall either into the direct or indirect assessment of body composition. The direct method involves the chemical analysis of an animal body or human cadaver [18]. As one can tell, using the direct method with human subjects is impossible. This leaves only the indirect method. A variety of indirect procedures are used to measure body composition including hydrostatic weighing, skinfold measurements, girth measurements, and electrical impedance [16,18].

Hydrostatic weighing is considered to be one of the best methods to determine body composition. Although errors are associated with hydrostatic weighing, it is still commonly used [16]. The equipment needed for hydrostatic weighing is quite expensive and very complicated to utilize for both the researcher and the subject. The ACSM guidelines [16] mention problems with hydrostatic weighing including the measurement of residual volume and the differences in bone density among subjects. However, the error in estimating percent body fat was less than 1% in hydrostatic weighing [20].

Skinfold measurements estimate total body fat found in fat deposits directly beneath the skin along with internal fat and body density [18]. This method is used most often when laboratories are not available and requires less expensive equipment and time as compared to hydrostatic weighing. However, the accuracy of skinfold measurement can be affected by certain factors including equipment, technician skill, subject characteristics, and the prediction equations [13]. Brooks and Fahey [4] reported that this technique can produce error even in experienced testers. To increase accuracy in this method, more than one measurement should be taken. Fox et al. [10] reported that the best measurement in males for the skinfold test was a vertical fold in the anterior midline of the thigh and the subscapular skinfold. ACSM [16] found skinfold measurement to be consistent with hydrostatic weighing technique.

Girth measurements were obtained using a tension regulated tape. To help with accuracy, the circumference of the muscular limb was estimated based on limb circumference and skin measurement based on the O-scale approach [21]. As mentioned by McArdle et al. [18], girths can be measured to predict body density and body fat. This measurement allows for a practical and inexpensive method to determine body composition; however, this technique is not as accurate as hydrostatic weighing [16] and skinfold equations of athletic men and women [13]. Heyward and Stolarczyk [13] reported that there does not seem to be any anthropometric equations that are associated to male athletes in general.

Electrical impedance involves passing an electrical current through the body and measuring resistance [24]. This method is less accurate than the previously mentioned methods along with more assumptions of body fat versus lean body mass being made. Evetovich et al. [9] reported that electrical impedance tends to produce large errors in adults and children when compared to hydrostatic weighing. A number of other methods that measure body composition include near infrared interactance (NIR), ultrasound, computed tomography, and magnetic resonance imaging (MRI) [13,18].

Body composition is important in regards to athletes because low body fat is desirable to enhance overall physical performance. Wilmore [24] reported that both athletes and physically active individuals to be leaner than nonactive individuals, regardless of gender. However, in a given sport female athletes have a greater percentage of body fat than do male athletes. Heyward et al. [13] report that the minimum body fat in males should not be lower than 5% body fat, while 12-16% is recommended for female athletes. In the game of basketball, Wilmore [24] reported the average body fat in male athletes to be 7-11% as compared to 20-27% in female basketball players. A low body fat percentage is desired in order to gain maximal physical performance in athletes.

Basketball Specific Fitness

Many measures may be used to evaluate basketball specific fitness. According to Hopkins et al. [15], there are several functional drills that have wide acceptance in the basketball community. Throughout this study, a modified shuttle run was performed by each subject both in the pre- and postseason. This drill is much like that of sprinting and uses mainly the anaerobic energy system. This energy source is used primarily during exercise lasting anywhere from 30 seconds to 3 minutes [19]. Comstock [8] reported that drills are most beneficial when they simulate game situations. This particular drill relates to running up and down the court such as would occur in a game. Many of these drills are utilized to maintain or improve strength, endurance, and form [1]. These drills are also performed to improve anaerobic power thus enabling the player to continually sprint from one end of the court to the next. Wells [23] reported that anaerobic power is an important aspect in the game of basketball in such skills as jumping, throwing, and sprinting. According to Albert [1], one objective of drills is to challenge athletes to go beyond their existing level of fitness. While the anaerobic energy system is an important aspect of the vigorousness of the activity, it does not work independently of the aerobic energy system [3]. Basketball requires full sprints and constant movement utilizing a combination of both energy systems [11].

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