1971

Comparison of five- and six-player basketball for women

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A COMPARISON OF FIVE- AND SIX-PLAYER BASKETBALL
FOR WOMEN

By

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B.A., Idaho State University, 1967

Presented in partial fulfillment of the requirements for the degree of

Master of Science for Teaching

UNIVERSITY OF MONTANA

1971

Approved by:

Chairman, Board of Examiners

Dean, Graduate School

Date Sept 1, 1971

9-2-71

ACKNOWLEDGMENTS

I am indebted to the entire winter quarter 1970 Basketball I class for their participation in this study as subjects and opposing team members. I am deeply appreciative of the numerous assistants who served as pulse takers and distance plotters, referees, timbers, and scorers for the duration of this study. I would also like to acknowledge the patience and encouragement extended by my family and friends.

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Chapter 1

INTRODUCTION

Basketball for women in the United States has been and is now going through an evolutionary process which began with the establishment of the first rules in 1899. In 1936, the original three-court game was changed to the present two-court game with the stationary forward-guard rule. This was later altered to allow one roving player and eventually two. The official game at present includes six players of whom two travel full court and four are restricted to half-court play. However, most countries have been playing under the Federation of International Basketball Association rules which sanction five-player basketball during competition. Plans are in the offing to enter United States teams in the World University Games by the United States Collegiate Sports Council, thereby necessitating the use of the five-player rules (8).

To ease the transition from the six- to the five-player game in the later stages of competition, the Division of Girls' and Womens' Sports and the Amature Athletic Union joint basketball committee has set aside the 1969-1971 basketball seasons for a trial period for five-player basketball (8).

Prior to this move by the DGWS-AAU Committee, many school administrators, teachers, and lay people questioned the inclusion of basketball as an interscholastic activity for girls with respect to their abilities to cope with various physiological demands placed on them by strenuous activity. Undoubtedly they will continue to be concerned as women do have different physiological capacities, though it is generally agreed that women adjust to exercise or work in much the same manner as do men (1, 2). This is supported by Clark (6) who found a significant relationship of adjustment between male and female subjects at varying levels of work regarding initial pulse rate, recovery pulse rate, and recovery under subjective appraisal.

Metheny and others (17) reported a study involving 17 women and 30 men, of whom none was highly trained. The work loads for the study were divided into non-exhaustive (walking 15 minutes at 3.5 miles per hour) and exhaustive work (running at 7 miles per hour on a treadmill with an incline of 8.6 percent). The responses noted between men and women could be compared to the reactions to similar work loads of the often studied fit and unfit men. The eight best women scored as well in the exhaustive work as did the 10 poorest men. However, the women scored lower than did the men in the nonexhaustive work. The authors concluded the 8 top women and the 10 poorest men were equally fit for short bouts of exhausting activity and that the women as a group were less fit for continued moderate work.

Astrand and Rodahl (2) state that during prolonged heavy physical work performance capacity of an individual depends largely upon his ability to take up, transport, and deliver oxygen to the working muscle. This ability to take up, transport, and deliver oxygen is termed the oxygen uptake, oxygen consumption, aerobic capacity, or aerobic power.

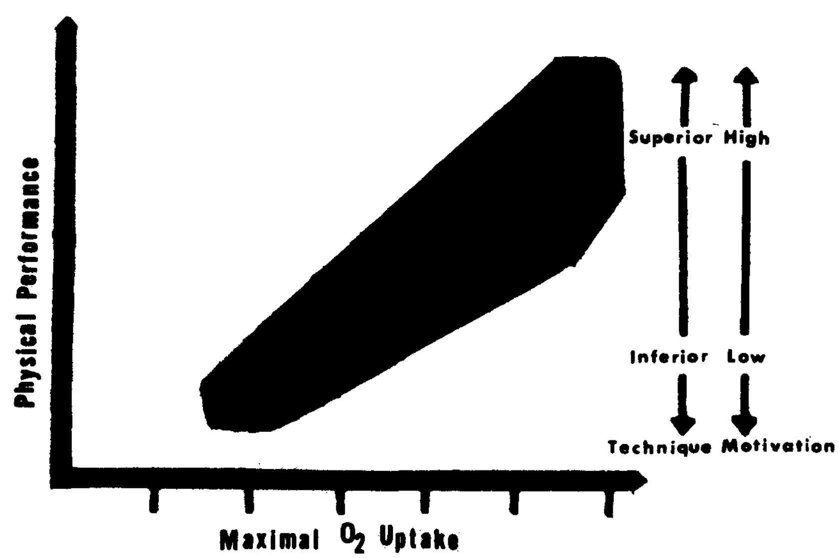

Figure 1

Representation of the Role the Maximal Aerobic Power or Maximal Oxygen Uptake Plays in Performance as Influenced by Technique and Motivation**

**P. O. Astrand and Kaare Rodahl, Textbook of Work Physiology (New York: McGraw-Hill, 1970), p. 310.

It is generally agreed by researchers that women face several physiological disadvantages in this oxygen uptake system. Many of these disadvantages originate from genetic factors, some from hormonal factors, and still others from social custom, habit, or tradition.

Lung volumes in women are approximately 10 percent less than in men of equal age and size (2). As the inspiratory reserve volume, tidal volume, expiratory reserve volume, and residual volume are to be considered, a 10 percent deficit in each would result in 40 percent less total lung capacity for women. As noted by Astrand (2) in a study of fairly well-trained students 25 years of age, the men achieved a total lung capacity of 7.20 liters. The women reached a total lung capacity of 5.40 liters.

The cardiac output should theoretically not be a disadvantage due to a higher maximal heart rate in women, which should compensate for the lower stroke volume found in women (2, 20). However, the cardiac output cannot be fully utilized for oxygen transport in women due to a lower hemoglobin level. Astrand and Rodahl (2) cite the difference in the average hemoglobin level of men and women as 15.8 grams per 100 milliliters of blood and 13.9 grams per 100 milliliters of blood respectively. Each gram of hemoglobin is capable of uniting with 1.34 milliliters of oxygen (2). In the average male, the saturated blood could transport 21.17 milliliters of oxygen per 100 milliliters of blood in addition to the small amount carried in the plasma. In the average female, the saturated blood could carry 18.62 milliliters of oxygen per 100 milliliters of blood.

Another physiological disadvantage found in women is the natural increase in body fat content which begins with puberty (2). Adipose tissue is "metabolically inactive" during the entire oxygen uptake process. However, this inactive fat must be transported during exercise or work and becomes a burden--limiting performance.

Women, after puberty, have an average maximal oxygen uptake of 70 to 75 percent that of men. Related to fat-free body weight the difference declines to 80 or 85 percent when, in fact, the maximal oxygen uptake of women should be higher due to their smaller size (2). Astrand and Rodahl (2) maintain that before puberty no significant sex difference exists in the maximal oxygen uptake capacity.

Illustrating the combined limitations of the oxygen transport capacities of women is a study by Astrand and others (3) involving highly trained subjects. Eleven women and 12 men completed maximal work tests on a bicycle ergometer. The women produced a maximal cardiac output of 18.5 liters per minute with a maximal oxygen uptake of 2.60 liters per minute and a maximal heart rate of 194. The men scored a 24.1 liter per minute average in cardiac output with a maximal oxygen uptake of 4.05 liters per minute and a maximal heart rate of 186.

As the five-player game is a new endeavor, it is important that as much knowledge as possible be gathered concerning special problems girls or women might encounter. The purpose of this paper is to study the heart-rate reactions of six college women to the work loads imposed in five- and six-player basketball.

THE PROBLEM

The problem as defined for this paper will be a comparison of work loads of five- and six-player basketball for college women, as indicated by exercise and recovery heart rates. Distance traveled per minute of play will be computed to further define work load.

DEFINITION OF TERMS

For the purpose of this study the following will be defined as:

Five-player basketball: The game of basketball involving five women on a team, each traveling full court and playing under the 1969-1970 and 1970-1971 experimental DGWS (Division of Girls' and Womens' Sports) rules.

Six-player basketball: The game of basketball involving six women on a team with two roving full court and four stationary, or restricted to half-court play. All activity is governed by the official 1969-1970 and 1970-1971 DGWS rules.

Work load: The intensity of work or the demand upon the operating resources of a system which is usually expressed as footpounds or kilogram-meters of work per minute. It may also be expressed as oxygen requirement or uptake per minute (20).

LIMITATIONS OF THE STUDY

All interpretations of this study should be made in light of the following limitations:

1. The nature of the activity and the time factor involved limited the isolation of many variables.
2. The limited number of subjects were selected from those enrolled in a University of Montana basketball class.
3. Comparison of all individual results may not be made due to the four restricted positions in six-player basketball.

SIGNIFICANCE OF THE STUDY

Most activities and sports for girls and women are modifications of those designed for men, as is the game of basketball with its shift to the five-player game.

Possibly these activities do not lend themselves to the "physiological abilities" of girls and women as presented in the introduction. Sex differences become quite apparent after puberty as physiological functions related to the oxygen uptake system, and, therefore, performance by women seems to peak between the ages of 8 and 10, followed by a sharp decline of approximately 25 percent with another peak at 18 to 20 years (2).

It may be concluded that additional controlled research should be conducted to investigate various physiological reactions of girls and women to specific activities. Armed with additional information, modifications can be made in rules as well as training procedures for girls and women if such changes are indicated.

Chapter 2

SURVEY OF RELATED LITERATURE

Participation in either five- or six-player basketball demands well over one minute of exertion of large muscle groups and would therefore be classified as aerobic or endurance work (2). The importance of the oxygen transport system as discussed in Chapter 1 has been championed by many researchers. A general feeling is present among physiologists that the most efficient test for fitness or physical work capacity is a test for maximal oxygen uptake or maximal aerobic power. The maximal oxygen uptake is reached at a point where the work load can be increased without a concomitant increase in the oxygen uptake. Fatigue would rapidly set in once the anerobic stores were depleted as the body attempted to reach a steady state.

OXYGEN UPTAKE AND WORK LOAD

Many studies have demonstrated a linear relationship between oxygen uptake and an increase in exercise or work--either by intensity or duration. Figure 2 represents this straight-line relationship.

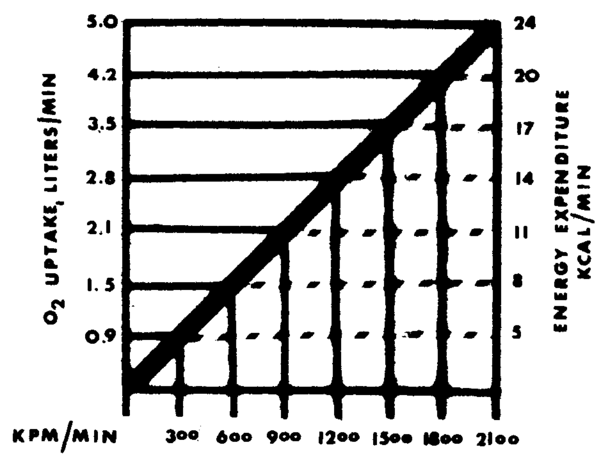

Figure 2

Relationship of Oxygen Uptake to a Given Work Load on a Bicycle Ergometer**

The most exacting test at the present time for measuring oxygen uptake is the gas-analysis method. Expired air is collected in bags (i.e. Douglas Bags) for a specified length of time approximately five minutes after the start of the work test, depending on the beginning load (2). The volume of expired air is measured and analyzed for content. Work tests have been conducted on bicycle ergometers, treadmills, and, with recent equipment modifications, in actual work and exercise situations.

Efforts have been given to devising methods of measuring or accurately predicting maximal oxygen uptake

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**Ibid., p. 364.

by less cumbersome means. This trend has evolved to advance the practical application of knowledge concerning oxygen uptake in areas such as athletics, industry, or heavy manual labor. The majority of the techniques of the predictive methods are based on the adjustments made by the cardiovascular system.

OXYGEN UPTAKE RELATED TO CARDIAC OUTPUT

For the body to achieve a steady state at a specific work level, the cardiovascular system compensates by increasing the amount of oxygen available through an increase in cardiac output. Research has indicated that of the two components of cardiac output, heart rate and stroke volume, the heart rate is most responsible for the linear effect of cardiac output over a period of time. An exception would be the highly trained endurance-type athlete with an extremely high stroke volume and a low heart rate. Figure 3 represents the linear relationship of cardiac output and oxygen uptake at submaximal and maximal levels of work.

Stroke volume is responsible for an early, sharp rise in the cardiac output. An individual reaches his maximal stroke volume at approximately 40 percent of maximal oxygen uptake (3). Astrand and Rodahl (2) cite the individual with a maximal oxygen uptake of 5 liters

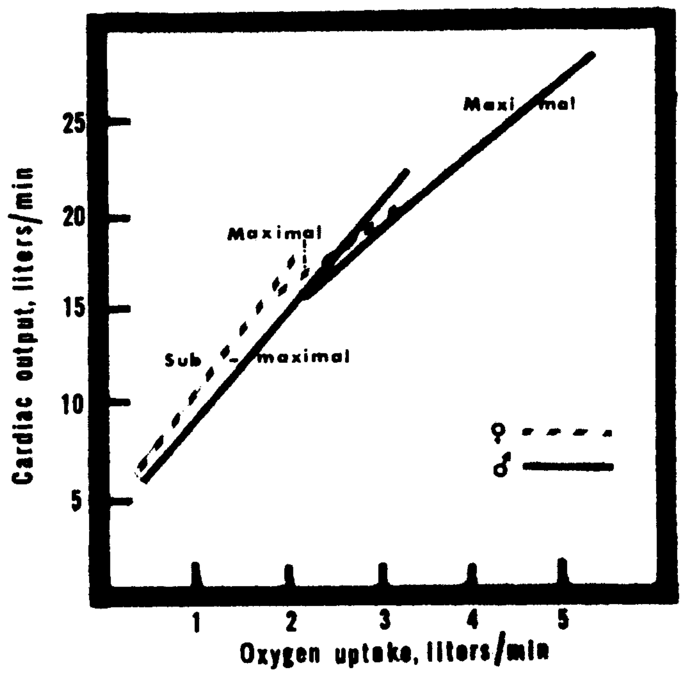

Figure 3

"The Linear Relationship Between Cardiac Output and Oxygen Uptake"**

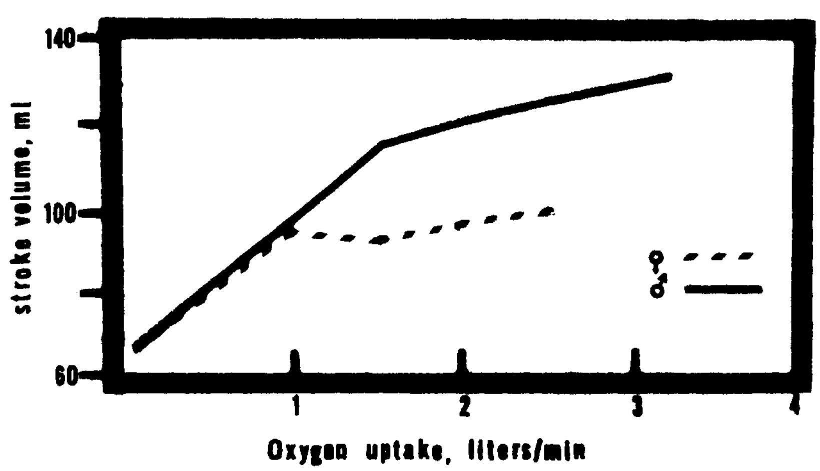

Figure 4

Relationship of Stroke Volume to Oxygen Uptake***

**Ibid., p. 158.

***Ibid., p. 175.

per minute attaining maximal stroke volume at an oxygen uptake of 2 liters per minute. An individual with a maximal oxygen uptake of 3.5 liters per minute reaches maximal stroke volume with an uptake over 1.3 liters per minute. Figure 4 represents the stroke volume curves of 11 women and 12 men whose measurements were the basis for the results in Figure 3 (p. 12). After the early adjustment by stroke volume to exercise, the heart rate assumes the responsibility to maintain the straight-line effect in Figure 5 (p. 14).

HEART RATE INDICATIVE OF WORK LOAD

Heart rate could then theoretically be used as an indicator of the relative strenuousness of exercise or work by reason of the linear function it maintains with oxygen uptake and work load. Much effort has been expended by researchers studying the effects of various work loads on the cardiovascular system. As early as 1932, Prosch (21) determined that the heart rate was a reliable indicator of the strenuousness of exercise or work. A greater increase in pulse rate combined with a longer recovery period resulted from the more exhaustive work loads.

Maxfield and Brouha (13) completed a study involving 7 subjects working 15 minutes on both a Krogh bicycle ergometer at 60 revolutions per minute and a

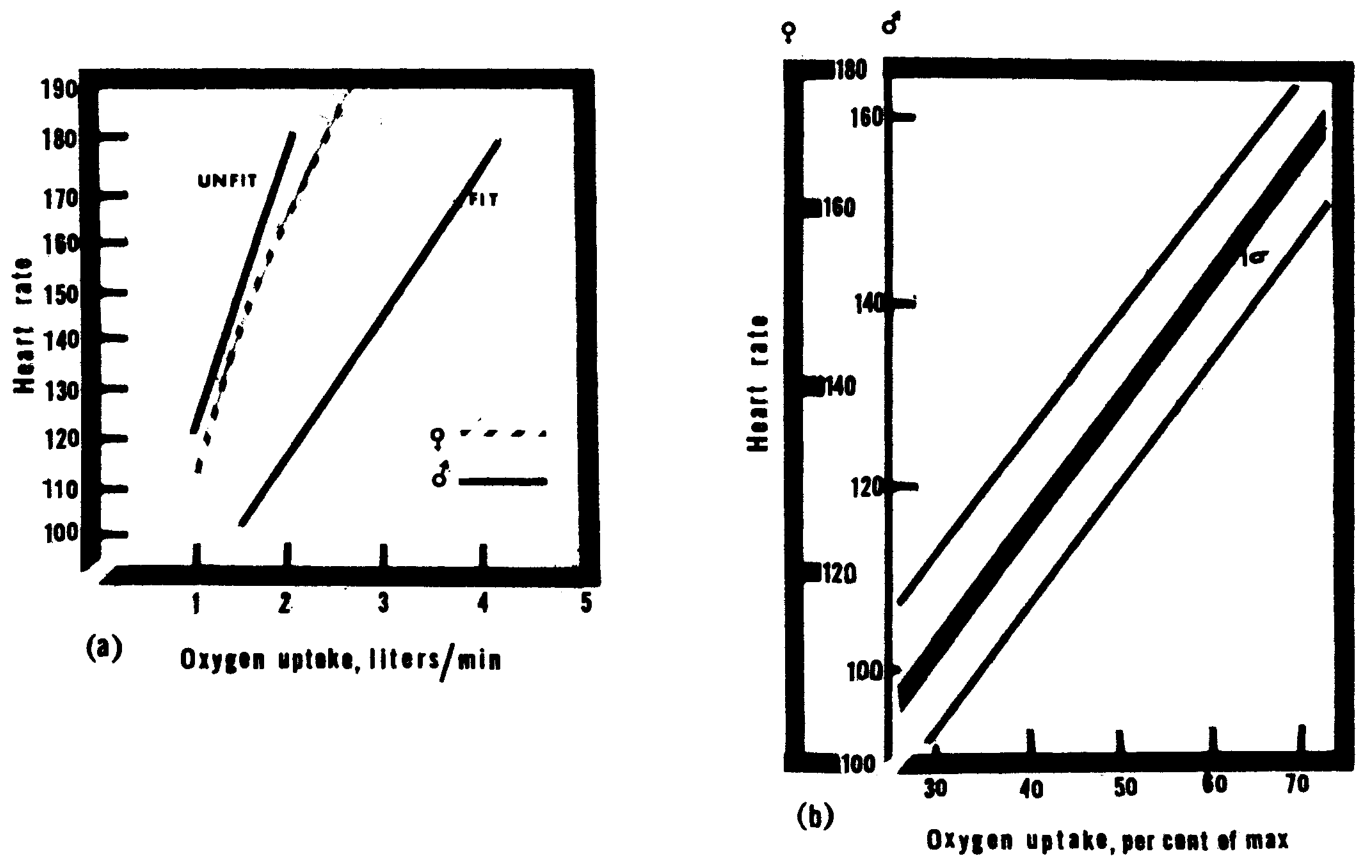

Figure 5

Relationship of Heart Rate to Oxygen Uptake on a Bicycle Ergometer (a)** and Expressed as a Percentage of Maximum (b)***

**Based on Physiology of Exercise notes given by Dr. Brian Sharkey, Health, Physical Education and Recreation Department, University of Montana, November 13, 1969.

***Astrand and Rodahl, p. 175.

treadmill at 3.2 miles per hour. Their paper presented basic evidence of the validity of the use of heart-rate measurements for assessing physiological strain induced by muscular activity. In addition, they found a linear relationship between recovery cost and the total cardiac cost of the exercise in any environment. They presented evidence indicating that when situations prevented the gathering of working heart rates, the heart rates taken the last 30 seconds of recovery minutes one, two, and three, or their averages, could be used to predict the total cardiac cost of the work load.

The majority of the literature reviewed supported Prosch, Maxfield, and Brouha in that the heart rate is the most efficient and feasible means to measure severity of physical strain (1, 5, 6, 10, 13, 14, 20, 25, 26).

CLASSIFICATION OF WORK LOAD

Classification of the severity of work load has long depended on the computation of the energy cost of a task from the oxygen consumed. This energy cost is normally expressed as kilocalories (kcal) of energy expenditure per minute.

Malhotra and others (11) reported a study predicting energy expenditure with the pulse rate. Seven subjects performed on a bicycle ergometer at work loads between 50 and 600 kpm/minute. A linear relationship between the pulse rate and the actual energy expenditure was recorded to the 150-per-minute pulse-rate level. The investigators predicted this relationship would continue to at least 180 beats per minute. They concluded a prediction error of .6 to 7 percent for heart rates beyond 95 which they felt would be adequate to predict the energy expenditure of a task.

A study by Sharkey and others (22) comparing the pulse rate and the ventilatory rate techniques to predict energy expenditure repudiates the accuracy reported with the pulse rate. Their predictions with the pulse rate exceeded the actual measured expenditure of the tasks, in some cases as much as 30 percent.

Simplified classification systems designed for extrapolation from isolated physiological measures have been developed for general use. A system based on the oxygen uptake of a task classifies effort demanding .5 to 1.0 liters of oxygen uptake per minute as light work, with moderate work requiring 1.02 to 2.0 liters of oxygen per minute. The exhaustive category encompasses all work demanding more than 2.0 liters of oxygen uptake per minute (25).

One common method of classification by heart rate includes all work eliciting a heart rate less than 125 beats per minute in the light-work category. The term moderate is applied to work producing a heart rate between 125 and 150 beats per minute, with the label exhaustive attached to all work yielding a heart rate greater than 150 beats per minute (26).

PALPATION METHOD OF OBTAINING PULSE RATE

The latest trend in cardiovascular research has been the use of cardiac telemetry systems to record the electrocardiogram. Although the telemetering of the heart rate would seemingly be more accurate, Skubic and Hilgendorf (23) found a correlation of .909 between the palpation method and cardiac telemetry which closely approximated other research cited in their review. Eight relatively inexperienced pulse checkers were involved with five subjects running the 220, 440, 880, and the mile to obtain the significant figure.

Another factor which would necessarily limit the interpretation of this study is the time factor involved in reaching the participant in a game situation to locate the pulse. As reported in a 1969 study by McArdle and others (14), the percentage of change in heart rate found in a 10-second period, which is the time allocated for the present study, ranged between .5 and 7.7 percent with the light-work category approaching the greater percentage mark. A corrective factor could be calculated and applied to achieve a more accurate pulse count.

BASKETBALL STUDIES

Few studies on the subject of basketball for women are available for review. Hodgson (10) completed a series of studies involving two- and three-court basketball in the 1930s. The respiratory rate and metabolism, pulse rate, systolic and diastolic blood pressure were measured on all subjects. No significant difference was found between the two games in terms of physiological demand. Hodgson noted any differences were due to the skill levels of the subjects.

Skubic and Hodgkins (25) completed a related study involving individual and dual sports. In game situations without a constant work load, they found the average heart rate for the entire game was a good indicator of strenuousness of exercise or work. With two subjects participating for 20 minutes in each activity, the heart rates in tennis and badminton were significantly higher than the individual sports of archery, bowling, and golf. The average heart rates for the entire game situation indicated that badminton was significantly more demanding than tennis.

In a similar study involving the entire competitive situation or game, Armstrong (1) recorded a significantly higher heart-rate response from women subjects in basketball than either badminton or the 600-yard run-walk.

Distance Traveled

Few statistics have been reported on distance traveled in basketball for women. During the controversy over two- and three-court basketball in the late 1930s, Miner and others (19) completed a study of distance traveled and time spent in play, assuming these factors were indirect indications of energy cost. No significance was found as all differences were attributed to the skill levels involved rather than actual game demands. The investigators concluded an error of 1.3 percent in measuring distance traveled by the indirect method of following the subjects' path on a scale-model court and by the direct method of measuring with a tape on the court surface.

Messersmith and others (16) reported a comparative study of distance traveled in mens' basketball and the womens' six-player game. Distances were plotted with an electric-pursuit apparatus. All games were played on a court 40' x 70' in size. In addition, both the men and women played four eight-minute quarters. The men and women were governed by their respective official regulations.

The women averaged between .718 and 1.25 miles per game with a mean of 1.03 miles for the 32 minutes. All results for the men fell between 1.46 and 2.69 miles per game, with a mean of 2.17 miles.

Reduced to feet per minute of play, the women averaged 171.1 feet for 10 games. The men traversed approximately twice the distance of women for the same period of time. These statistics would seemingly indicate that the skill level of the participants as well as their work capacities are important in evaluating distance traveled.

SUMMARY

In reviewing past research this paper will proceed with the basic suppositions that:

1. The system on which most demand is placed in an activity such as basketball is the oxygen-transport system.
2. The heart rate is an efficient and valid measure of physical strain.
3. The pulse rate is a reliable means by which to ascertain the heart rate.
4. Distance traveled in feet per minute will further define the work load, although skill levels, positions involved, and the work capacities of the participants must be considered.

Chapter 3

METHODS AND PROCEDURES

SUBJECTS

Six college women between the ages of 18 and 21 were selected from a University of Montana basketball class winter quarter 1970. The classes met three days of each week for 10 weeks.

A five-minute step test was administered to each subject to obtain a maximal oxygen uptake estimate. The adjusted Astrand and Ryhming nomogram (2) was used in the calculation of the maximal oxygen uptake in Table 1.

Table 1

Physical Characteristics of Subjects

Subject	Age yr.	Height cm	Weight kg	VO_2 ml/kg/min
LC	21	159	49	37.0
CG	19	171	67	42.0
NN	18	171	62	33.0
DS	18	164	76	36.5
TM	18	164	57	50.0
JH	18	159	58	42.0

Each subject was involved in the actual testing program for a period of eight weeks. Prior to this, two weeks were devoted to a general orientation to the study and a review of the basic skills. All subjects ranged slightly above an elementary skill level. The subjects comprised one team with each assuming the same position during the two testing periods for each game. Five-player basketball was conducted the first four weeks, while the six-player games were held the last four weeks of the testing period.

A training effect could possibly have been a factor during the second half of the testing program. Sinning and Adrian (23) reported the results of a training study involving eight varsity basketball team members in 1968. The subjects were involved in 25 practice periods and 7 game situations within a 66-day period. This was equivalent to a 90-minute workout every other day. The mean maximal oxygen uptake increased .26 liters, which was significant. Specific pulmonary and cardiovascular measures, including the heart rate, did not indicate a concurrent increase in efficiency. The mean maximal heart rate declined 2.3 beats per minute, which was not significant. The authors concluded that the training program was not strenuous enough for the subjects to reach their maximal conditioning capacities as indicated by the slight increase in maximal oxygen uptake and the small decrease in the heart rate.

Although no specific measures for training effect were implemented in the present study, the training effect was not expected to play a significant role in the three-day-a-week class program.

METHODS OF TESTING

Step Test

The step test administered to the subjects was adapted for use with the Astrand nomogram in 1953. Following a specific cadence, the subjects stepped onto a bench 33 centimeters high for 5 minutes. A recovery pulse was recorded beginning 15 seconds after exercise to 30 seconds after the test was completed. The exercise pulse rate was calculated with the formula:

Exercise pulse = 51.3 + (.75 x Recovery pulse).

Heart Rate

The subjects were checked for heart-rate response at 13 scheduled intervals over a period of 23 minutes. With a signal from an electric timing device, the subjects assumed a stationary position. The assistants checking and recording the pulse rate were to reach their respective subjects and locate the pulse by way of the carotid artery within 10 seconds. Due to the size of the carotid artery and its location anterior to the sternocleidomastoid muscle, heart-rate response may easily be detected. The pulse rate was counted for 15 seconds and recorded, with the game resuming immediately.

The first reading was taken 15 seconds prior to the jump ball at the start of the game. The second reading was taken for 15 seconds after the first minute of play, with a third reading taken after the fifth minute. The fourth reading was taken 15 seconds prior to the conclusion of one quarter or 8 minutes of official play. The fifth interval was 15 seconds prior to the start of the second quarter. The eighth reading was taken 15 seconds prior to the end of the full 16 minutes of play. Intervals 9 through 13 are recovery rates from the last 15 seconds of each minute, beginning the first minute after play ended and every minute thereafter for 5 minutes. The subjects were seated during the recovery period. Table 2 contains the complete schedule.

Distance Traveled

Distance traveled was plotted by observers located on the sidelines. The path of each subject was traced on a drafting paper overlay on a court drawn to a scale of one inch to eight feet. Lines were placed on the courts to aid the distance plotters. The overlay was changed every two minutes of actual playing time to obtain an estimate of distance traversed per minute of playing time.

Table 2

Schedule and Sample Data Sheet

Subject: ______________________

Date: ______________________

Game: ______________________

Position: ______________________

1.	18.15---18.00	____	x	4	=	______
2.	17.00---16.45	____	x	4	=	______
3.	13.00---12.45	____	x	4	=	______
4.	10.15---10.00	____	x	4	=	______
5.	8.15--- 8.00	____	x	4	=	______
6.	7.00--- 6.45	____	x	4	=	______
7.	3.00--- 2.45	____	x	4	=	______
8.	.15--- .00	____	x	4	=	______
9.	5.00--- 4.45	____	x	4	=	______
10.	4.00--- 3.45	____	x	4	=	______
11.	3.00--- 2.45	____	x	4	=	______
12.	2.00--- 1.45	____	x	4	=	______
13.	1.00--- .45	____	x	4	=	______

Chapter 4

FINDINGS AND DISCUSSION

METHOD OF ANALYSIS

The nature of the six-player game with two subjects roving full court has placed limitations on the analysis of the responses of the individual subjects. For the purpose of this paper, the differences between the grand means $\left(\frac{\Sigma \bar{X}}{N}\right)$ of five-player and six-player basketball will be indicated. In addition, the mean heart rates of the two rovers will be presented in relation to their responses in the five-player game.

FINDINGS

Heart Rate

The comparison of the grand means as team units is presented in Table 3. These results may be compared more readily in the graphic presentation of Figure 6 (p. 28).

Distance Traveled

To further define the amount of work done, the grand means of the distance traveled by the six subjects in both games were computed in feet per minute for the entire 16 minutes of official play. The five-player game yielded an average of 172.9 feet per minute per player as opposed to 127 feet per minute for the six-player game.

Table 3

Grand Means for Heart Rates of Six Subjects

Interval	Five Player	Six Player
1	86	78
2	124	113
3	145	125
4	146	143
5	107	101
6	137	124
7	158	125
8	158	143
9	120	113
10	100	101
11	94	94
12	89	87
13	85	79

Subjects CG and TM

Individual comparison of the results in both games for subjects CG and TM is possible by reason of their positions as rovers in the six-player game. The raw data for the heart rate is listed in Table 4 (p. 29). Graphic presentation of the data is available in Figures 7 and 8, pp. 30 and 31.

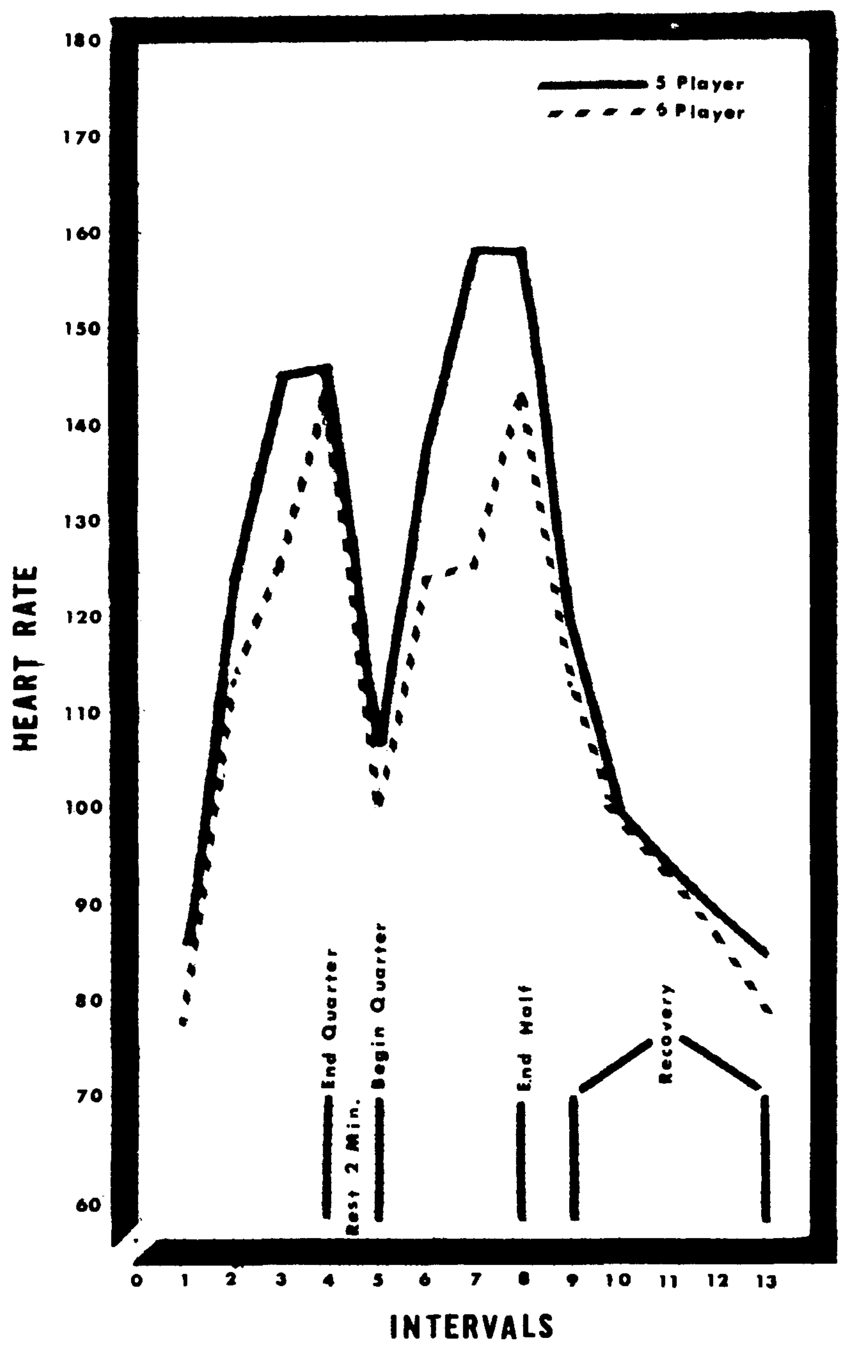

Figure 6

Graphic Analysis of Heart Rates of Six Subjects

In terms of distance traveled, subject CG averaged 162 feet per minute in the five-player game and 154 feet per minute in the six-player game. Subject TM averaged 163 feet per minute in the five-player game as compared to 158 feet per minute in the six-player game.

Table 4

Heart Rates of Subjects CG and TM

	Subject CG		Subject TM	
	Five player	Six player	Five player	Six player
1	90	90	68	64
2	142	134	78	88
3	146	154	120	112
4	154	160	128	130
5	116	112	86	74
6	154	156	114	86
7	170	168	144	92
8	180	164	140	132
9	124	128	118	94
10	109	110	86	78
11	101	94	78	74
12	101	88	74	70
13	96	79	70	65

DISCUSSION

As indicated by the data in Figure 6, the mean heart rate of the subjects in the five-player game increased more rapidly than did their heart rates for the six-player game. The maximal heart rate attained is higher for the five-player game. Astrand and Rodahl (2)

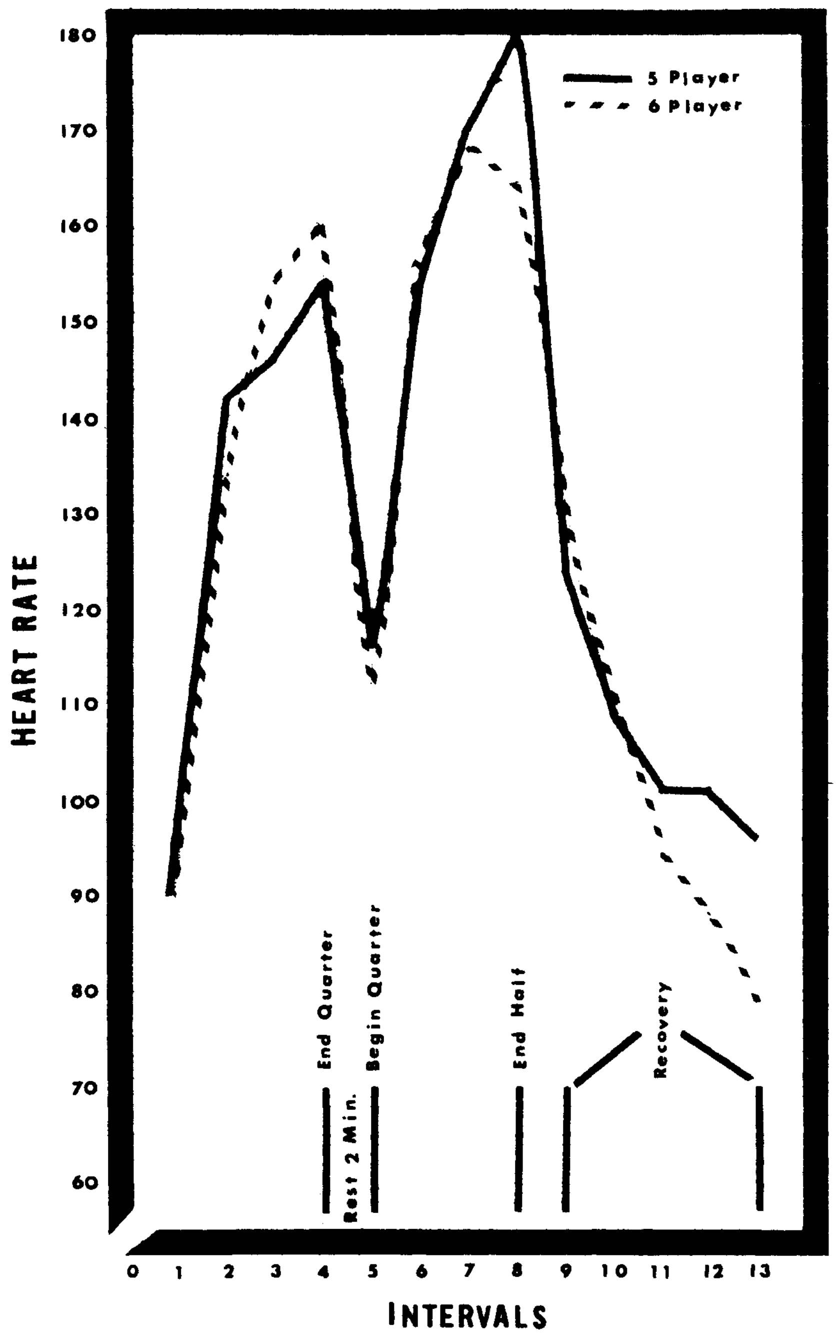

Figure 7

Effect of Five- and Six-Player Basketball
on the Heart Rate of Subject CG

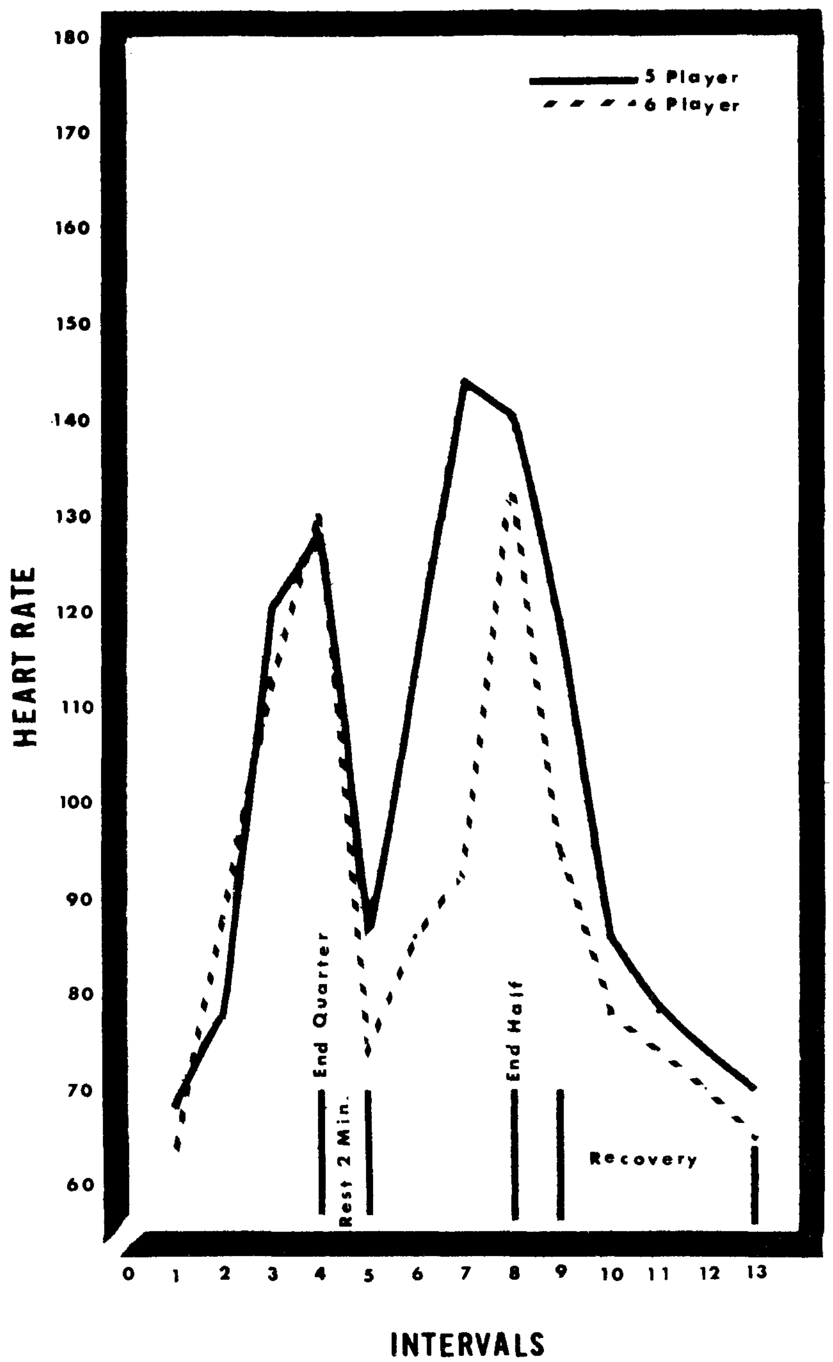

Figure 8

Effect of Five- and Six-Player Basketball on the Heart Rate of Subject TM cite 195 as the average maximal heart rate for men and women 25 years of age. Metheny and others (17) obtained an average maximal heart rate of 197 for 17 women subjects. Michael and Horvath (18) cited 190 as the average maximal heart rate found in women subjects tested. In addition, they reported that the majority of their subjects ceased work when their heart rates reached a point between 175 and 190 beats per minute regardless of their measured maximal heart rate. They concluded that the ability to reach a high heart rate did not appear to differentiate subjects with regard to work capacities.

There is no indication that the average maximal heart rate is reached or even approximated at any point in the present study. The work load does not appear strenuous enough to demand an increase in the heart rate to the 179 to 190 beats per minute level which Michael and Horvath (18) cited as the level at which most work ceased, either as a result of physiological or psychological factors.

Although a higher heart rate is reached in the five-player game, the recovery rates of both are similar. This is corroborated by the work of Michael and Horvath (18), in which they found a similarity in the recovery rates of men and women during the first three minutes following exercise regardless of the time of exercise, the maximal oxygen uptake, or the work load attained.

In a study involving exhaustive and non-exhaustive work, Metheny and others (17) reported that the women's recovery rates were about the same as the men's even though the women had to recover from a higher maximal heart rate.

In Figure 6, the difference in the heart rates recorded during recovery at interval 5 appears to correspond with the difference in heart rates noted at interval 4. Possibly a longer rest period between quarters would eliminate the stairstep effect noted between intervals 4 and 8. This would be difficult to predict since the emotional response could be an important factor at this point.

Distance traveled would seemingly point to a greater work load in the five-player game with an average increase of 45.9 feet per minute per player. This, as well as the heart rate, could indicate the need for additional physical preparation to prevent muscular fatigue from becoming a major limiting factor.

Subjects CG and TM illustrate the importance of fitness and conditioning in this type of activity. In the step test, the oxygen uptake estimate in milliliters of oxygen per kilogram per minute (ml/kg/min) for CG was 42.0. The maximal heart rate for CG in six-player basketball was 168 as compared to 180 for the five-player game. The maximal heart rate in the five-player game would theoretically be high enough to cause a cessation of work (18).

Subject TM predicted a maximal oxygen uptake of 50.0 ml/kg/min in the step test and recorded a maximal heart rate in the five-player game of 144. In the six-player game, the maximal heart rate of TM was 132.

Excluding the diverse fitness levels of CG and TM, little difference was noted in the apparent demands of the two games on either subject as indicated by the heart rate (Figures 7 and 8) and the distance traveled. Subject CG traveled a total of eight feet per minute farther in five-player basketball. Subject TM traveled five feet per minute farther in the five-player game than in the six-player game. The data presented in this study would seem to indicate that the demands on CG and TM in the roving positions of the six-player game were much the same as for their respective forward and guard positions in the five-player game.

Three points are suggested by the limited data of this study. Foremost would be the application of available knowledge in the area of work capacity to activities similar to basketball. The work capacity of each participant should be known. A step test, as administered in this study, consumes a relatively small amount of time and the uptake estimate can be calculated in minutes with sufficient accuracy.

As work capacity can be increased, conditioning programs should be designed to improve the uptake or aerobic capacity of each participant.

Finally, the severity of a work load for an individual can be diminished further by increasing mechanical efficiency with an improvement in skill level.

Chapter 5

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

SUMMARY

The basic purpose of this paper was to study heart-rate reactions of women to the work loads imposed in five- and six-player basketball.

The heart rate for each subject was determined at 13 scheduled intervals in official five- and six-player game situations. The responses of the six subjects were totaled and divided to yield a grand mean for each interval in both games. The results were plotted for comparison in Figure 6.

This process was repeated for the individual responses of subjects CG and TM to facilitate a comparison between the roving forward and guard positions of the six-player game and a forward and guard position in the five-player game. The results were plotted in Figures 7 and 8.

Distance traveled was determined by plotting the path of each subject on a scale-model court (1" = 8') with a drafting paper overlay. The results were computed in feet per minute of official play.

The data in this study indicated that the heart rate in the five-player game increased more rapidly. A higher heart rate was noted in the five-player game. However, there was no indication that the heart rate in the five-player game was high enough at any point to cause a cessation of work as reported by Michael and Horvath (18). The recovery rates of the subjects in both games are similar.

Distance traveled was greater for the five-player game, indicating a more strenuous work load.

There was little difference in the heart-rate response or distance traveled in either game for subjects CG and TM. This would suggest that the roving positions of the six-player game were as demanding for the two subjects as their respective forward and guard positions in the five-player game.

CONCLUSIONS

On the basis of the data presented in this study it may be concluded that:

1. The heart rate is an efficient and practical means of analyzing work load.
2. In terms of team units, the five-player game could be defined as more strenuous.

3. In terms of individual positions, the work load of the roving positions in the six-player game is as great as for a similar forward and guard position in the five-player game.
4. The work capacity or level of fitness is an important factor to consider in evaluating the severity of a work load for individuals.
5. The severity of a work load for an individual may be reduced with training designed to increase the oxygen uptake capacity as well as to increase mechanical efficiency.

RECOMMENDATIONS

1. It is suggested by the results of this study that additional controlled research be conducted relating to work capacity and sports participation by women. The use of cardiac telemetry is especially recommended for additional accuracy.
2. It is also suggested that additional training and conditioning be implemented into basketball programs for women to reduce the relative strenuousness of the activity.

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