The effect of two athletic training programs on aerobic capacity, anaerobic capacity, reaction time, and percent body fat

Paul W. Petersen
THE EFFECT OF TWO ATHLETIC TRAINING PROGRAMS
ON AEROBIC CAPACITY, ANAEROBIC CAPACITY,
REACTION TIME, AND PERCENT BODY FAT

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Paul W. Petersen
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THESIS ACCEPTANCE

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Thesis Committee

Thomas Kidd
Department

Patricia Kolasa
EL Foundations

Kris Berg

Kris Berg
Chairman

7-26-76
Date
# TABLE OF CONTENTS

- **LIST OF TABLES** ........................................ v
- **LIST OF ILLUSTRATIONS** ................................. vi

## Chapter

### I. THE PROBLEM ........................................... 1
- Introduction ............................................. 1
- Significance ............................................ 1
- Problem .................................................. 2
- Research Hypotheses .................................. 2
- Basic Assumptions ..................................... 4
- Delimitations .......................................... 4
- Limitations ............................................. 4
- Definition of Terms .................................... 5

### II. REVIEW OF RELATED LITERATURE ...................... 6
- Aerobic Capacity ....................................... 6
- Anaerobic Capacity ................................... 9
- Reaction Time ......................................... 10
- Percent Body Fat ....................................... 11

### III. PROCEDURES ........................................... 13
- Research Design ....................................... 13
- Test Procedures ........................................ 13
  - Aerobic Capacity ..................................... 13
  - Anaerobic Capacity .................................. 14
  - Reaction Time ........................................ 14
  - Percent Body Fat ..................................... 15
# LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Summary of Conditioning Changes in Basketball Players</td>
<td>21</td>
</tr>
<tr>
<td>2.</td>
<td>Summary of Conditioning Changes in Wrestlers</td>
<td>22</td>
</tr>
<tr>
<td>3.</td>
<td>Comparison of Pre-Season Scores Between the Basketball and Wrestling Teams</td>
<td>23</td>
</tr>
<tr>
<td>4.</td>
<td>Comparison of Post-Season Scores Between the Basketball and Wrestling Teams</td>
<td>24</td>
</tr>
<tr>
<td>5.</td>
<td>Comparison of Mean Gains Between the Basketball and Wrestling Teams</td>
<td>24</td>
</tr>
<tr>
<td>6.</td>
<td>Relationship of Pre-Season Variables Between the Basketball and Wrestling Teams</td>
<td>25</td>
</tr>
<tr>
<td>7.</td>
<td>Relationship of Post-Season Variables Between the Basketball and Wrestling Teams</td>
<td>26</td>
</tr>
</tbody>
</table>
LIST OF ILLUSTRATIONS

Figure

1. Changes in Aerobic Capacity (1.5 mile) . . . . 28
2. Changes in Anaerobic Capacity (440) . . . . 29
3. Changes in Reaction Time . . . . . . . . . . 31
4. Changes in Percent Body Fat . . . . . . . . . 32
CHAPTER I

THE PROBLEM

Introduction

It is perhaps obvious that athletic teams, such as basketball and wrestling, use different conditioning programs during the regular season of competition because of the nature of their sports. Although many coaches initiate particular programs and use them year after year, rarely do they have any definite measurements concerning the effects of the program on their athletes other than a win-loss record. To better understand the conditioning that takes place in various sports, in this study, several parameters of fitness were calculated using the basketball and wrestling teams at the University of Nebraska at Omaha. The measurements will indicate the change in each conditioning variable during the season.

Significance

In the review of related literature, an abundance of studies was found dealing with the effects of short-term exercise programs on various parameters of physical performance, but very few concerning season-long athletic programs. Although the short-term studies were related to this study, a season-long investigation of performance
variables was felt to be needed. This investigation may serve as a comparison with existing related studies, and may hopefully stimulate further research in this area.

Problem

What are the effects of two different athletic programs on the aerobic capacity, anaerobic capacity, reaction time, and percent body fat of varsity college athletes?

Research Hypotheses

1. Aerobic capacity will be significantly increased through training.
   a. The aerobic capacity of the basketball group will increase significantly by the end of the season.
   b. The aerobic capacity of the wrestling group will increase significantly by the end of the season.
   c. The aerobic capacity of the wrestling group will show a significantly greater increase than the basketball group.

2. Anaerobic capacity will be increased significantly through training.
   a. The anaerobic capacity of the basketball group will increase significantly by the end of the season.
b. The anaerobic capacity of the wrestling group will increase significantly by the end of the season.

c. The anaerobic capacity of the wrestling group will show a significantly greater increase than the basketball group.

3. Reaction time will decrease significantly by the end of the season.

a. The reaction time of the basketball group will decrease significantly by the end of the season.

b. The reaction time of the wrestling group will decrease significantly by the end of the season.

c. The reaction time of the wrestling group will show a significantly greater decrease than the basketball group.

4. The percent body fat will decrease by the end of the season.

a. The percent body fat of the basketball group will decrease significantly by the end of the season.

b. The percent body fat of the wrestling group will decrease significantly by the end of the season.

c. The percent body fat of the wrestling group will show a significantly greater decrease
than the basketball group.

Basic Assumptions
The major assumptions of the study were:
1. Regular physical activity will improve physical fitness.
2. There are different levels and types of fitness needed for different sports.
3. Aerobic capacity, anaerobic capacity, reaction time, and percent body fat are major determinants of fitness in basketball and wrestling.

Delimitations
The investigation was limited to fourteen members of the varsity basketball team and nine members of the varsity wrestling team of the University of Nebraska at Omaha. The study lasted five months which is the approximate length of both sports' seasons. The subjects were tested before and after the course of the season to determine the effects of their particular conditioning program.

Limitations
A major limitation involved differences in motivation. The running tests were given before the regular practice session so some athletes may not have exerted themselves maximally knowing that a full practice was to follow. Another limitation was the inability to control any outside conditioning programs with which the athletes may
have been involved. Finally, the study included the measurement of only four variables although there are other variables known to affect performance in these sports.

**Definition of Terms**

**Aerobic capacity.** (Max VO₂ or maximum oxygen consumption). The ability of the body to transport atmospheric oxygen to the mitochondria of the muscle cells through the processes of alveolar ventilation, pulmonary diffusion, blood transport and oxygen utilization.

**Anaerobic capacity.** The ability of the body to do work without the presence of adequate oxygen in the active muscle tissue.

**Reaction time.** The amount of elapsed time between an auditory stimulus and the initiation of a physical response.

**Percent body fat.** The percentage of the total body weight that consists of fatty tissue.
Aerobic Capacity

Many researchers have investigated the effects of a physical fitness program on aerobic capacity. Boyer (1972) found many studies that have demonstrated a significant improvement in aerobic capacity as a result of participation in fitness programs. Byrnes and Kearney (1974:145), in justifying the utilization of Max VO$_2$ as a valid index of cardiovascular endurance, cited "the numerous studies which have verified the actual relationship between endurance performance and maximum oxygen uptake."

Metz and Alexander (1970) found that maximal oxygen intake was significantly (p< .05) related to levels of fitness as measured by the AAHPER Youth Fitness Test in twelve to fifteen year old boys.

Using the time for the mile run to determine aerobic capacity, Skinner and others (1964) discovered a significant decrease (p< .001) in the average mile time from 8:51.3 to 7:36 minutes occurring over a six month exercise period. In order to provide additional fitness data, the previously sedentary men were asked to run as far as they could without
stopping when the six month program concluded. A mean distance of 4.16 miles was covered with only three of the fifteen subjects running less than four miles.

Brown and others (1974), in a study involving college basketball players, found that an eight week program of endurance activities and interval training had significant effects on several fitness variables. Max VO\textsubscript{2} was seen to increase an average of 3.56 ml/kg/min by the end of the training period.

College-age men were also used in a study by Girandola and Katch (1973) to determine the effects of nine weeks of circuit training on aerobic capacity. They found a significant increase (p < .05) in Max VO\textsubscript{2}, measured in ml/kg/min, of 6.7%. They expected higher results, however, and attributed the difference to the short training period.

Tzankoff and others (1972) subjected fifteen sedentary older men, ages 44-66 years, to a six month training program of vigorous recreational activity. The investigators found that the average Max VO\textsubscript{2} increased by 17.1% by the end of the training period.

After studying athletes participating in football, baseball, swimming, track, and gymnastics, Novak and others (1968) suggested that each type of athletic activity required different levels of fitness. On the whole, the authors believed that because of increased physical activity, athletes had a higher average Max VO\textsubscript{2} than non-athletes. However, Kearney and Byrnes (1974) found a
decreased relationship to Max VO₂ as skill levels increased. They concluded that the correlation was restricted by the homogeneity of the members of the ability subgroups.

Jessup and others (1974) found a very low correlation \( r = 0.13 \) between the twelve-minute run and Max VO₂. This did not agree with the \( r = 0.897 \) reported by Cooper, and the authors suggested that the low relationship was due to the homogeneity of their group; whereas, Cooper tested a wide range of subjects. They also pointed out that motivation is a key factor in such a maximal performance test, and, therefore, can influence the results greatly.

Cooper (1969a) contended in his article that the twelve-minute run was a valid test for aerobic capacity and that a male under thirty years of age was in good condition if he could run at least one and one-half miles within the twelve minute period. Testing large groups, however, required a great deal of time and was generally prohibitive. Therefore, Cooper (1968 and 1969b) modified the test on the basis of the time required to run one and one-half miles. An interpolation of scores was made and the modified test is now used for U. S. Air Force personnel.

Coleman and others (1974) administered pre- and post-season fitness tests to a college basketball team using resting heart rate, Max VO₂ as measured by the Balke test, and recovery heart rate. At the conclusion of the season, no significant difference \( (p < 0.05) \) could be seen in any of the values. It was concluded that a season of basketball
competition was of sufficient intensity to maintain the level of fitness achieved during pre-season workouts, but not enough to improve it.

**Anaerobic Capacity**

Astrand and Rodahl (1970) stated that in maximal work over a duration of two minutes or less, anaerobic power is of greater importance than aerobic power. Such work utilized glycosis as the predominant energy source and resulted in the production of large quantities of lactic acid in the muscle tissue.

In testing the effects of strenuous exercise by requiring subjects to run at maximum speed on a treadmill, Margaria and others (1974) learned that all anaerobic energy sources are exhausted within approximately forty seconds. Because of the short time that anaerobic power could be maintained, Margaria and others (1966) devised a test in which they timed subjects running up an ordinary staircase two steps at a time. They felt that the energy release in the first four to five seconds of maximum exertion was a valid indicator of maximal anaerobic power and likened the test to the fifty meter sprint.

de Vries (1975) suggested that anaerobic training is essential in events demanding intensely sustained work from thirty to sixty seconds. He also contended that since very few sports in the United States require a longer sustained effort, anaerobic capacity should be of prime interest to
American athletes.

In research designed to develop anaerobic capacity, Shepard (1972) stated that repetitive acceleration sprints to develop speed and suitable forms of fast interval training were needed to successfully develop anaerobic capacity.

In researching the effects of a season of competition on college basketball players, Coleman and others (1974) found that although parameters of aerobic capacity were not significantly improved, anaerobic capacity was improved significantly by the end of the season.

**Reaction Time**

A major concern in testing reaction time was acquainting the subject to the procedure so that his scores would not be invalid because of a practice effect. Loveless (1974) gave auditory reaction time tests to subjects in three one-hour sessions and used the entire first session for practice.

Botwinick and Storandt (1974) gave their subjects thirty-two trials in reaction time with an auditory stimulus, but discarded the first five because of the practice effect.

The studies of Norrie (1967 and 1974) were in agreement that at least ten trials were needed to eliminate the practice effect. Kellas and Baumeister (1970) were very close to this in their use of twelve trials with an auditory stimulus to adapt their subjects.
In measuring movement time and reaction time simultaneously, Singer and Weiss (1968) discovered a significant decrease in the amount of time it took college wrestlers to perform a sit-out maneuver through an electric eye in response to an auditory stimulus during a week of severe weight reduction.

**Percent Body Fat**

A major finding with respect to percent body fat was that because of the increase in the muscle tissue and decrease in fatty tissue during an exercise program, body weight frequently stayed the same or even increased as the percent of body fat decreases. Boyer (1972), Alexander and others (1968), Brown and others (1974), Girandola and Katch (1973), Skinner and others (1964), Adams (1968), and Johnson and others (1972) all found this to be true in their studies.

In their investigation of the effects of a pre-season training program on college basketball players, Brown and others (1974) discovered a significant decrease in skinfold measurements taken at four different sites as well as a significant decrease of .9% in the percent body fat after the eight week period.

The validity of the skinfold test as a prediction of percent body fat has been questioned by Wilmore and others (1970) and Katch and others (1969). However, Durnin and Rahaman (1967) found correlation coefficients in the
range of -0.80 between skinfold thicknesses and body density. Katch and McArdle (1975), in testing the validity of the Lange Skinfold Caliper, took measurements at the triceps, subscapula, suprailiac, umbilicus, and mid anterior thigh. They found a test-retest reliability of $r=.94-.99$ at each site.
CHAPTER III

PROCEDURES

Research Design

Fourteen members of the varsity basketball team and nine members of the varsity wrestling team at the University of Nebraska at Omaha participated in the five-month investigation. The two groups were tested for aerobic capacity, anaerobic capacity, reaction time, and percent body fat at the beginning and at the end of the regular season of competition.

Tests were administered in November when the season started, and again in March when it ended.

Test Procedure

Aerobic Capacity

The modified Cooper Test (Cooper, 1968 and 1969b) was used to determine each subject's aerobic capacity. Due to the size of the experimental groups, it was felt that the twelve-minute run was impractical. The athletes ran on a 176 yard indoor track and each group was divided into subgroups of seven to eight subjects so that the track would not become too crowded.

The researcher timed the runners with a stopwatch
and lap times were called out for every runner. Assistant coaches of the respective sports kept count of the laps covered by each runner and called the lap count to them each time they passed. As a runner crossed the finish line at the conclusion of the fifteenth lap, his time was called out and was then recorded.

Anaerobic Capacity

Astrand and Rodahl (1970) stated that anaerobic energy sources contributed to approximately 70% of the total energy output in maximal efforts of one minute. Therefore, each subject was timed to the nearest one-tenth of a second in the 440 yard sprint to determine his anaerobic capacity. The test was held on a 176 yard indoor track with 24-48 hours of recovery separating the two running tests. The subgroups were further divided into groups of four to avoid bunching up during the sprint.

The researcher timed the runners with a stopwatch and lap times were called out for each runner. As each runner crossed the finish line, their times were called out and recorded.

Reaction Time

Reaction times were measured with the use of a Dekan Automatic Performance Analyzer using an auditory stimulus and a varied delay start. The researcher was alone in a room with each subject during the testing. The delayed start, the auditory stimulus, and the stopping of the clock
with the handheld switch were demonstrated and explained to
the subject. The subject was then asked to hold the switch
in his dominant hand and use his thumb only when pushing the
button to stop the clock. Fifteen practice trials were
given with varied delays in starts so that the subject, who
was allowed to observe the clock, could familiarize himself
with the procedure. Since the subject was to face away from
the clock, and resetting and starting the clock made dis­
tracting sounds, the researcher clearly said "Reset" and
"Start" as he performed these two functions. Upon conclu­
sion of the practice, the subject was asked to stand and
face away from the clock. Ten trials were given with various
delays and were recorded to the nearest five thousandth of
a second. The mean time of the ten trials was recorded as
the subject's reaction time.

Percent Body Fat

Percent body fat was estimated by the measurement of
skinfolds at four sites on the right side of the subjects' bodies with the use of a Lange Skinfold Caliper. The tips of the thumb and forefinger were used to pinch and lift the skin and underlying fat tissue away from the muscle tissue. Three readings were taken at each site and were then averaged to form the recorded reading.

Skinfolds were taken using the following guidelines:

**Biceps.** Over the midpoint of the muscle belly with the arm hanging vertically and supinated.
Triceps. Over the midpoint of the muscle belly, midway between the olecranon and the tip of the acromion, with the arm hanging vertically and supinated.

Subscapular. Just below the tip of the inferior angle of the scapula, at an angle of about 45 degrees to the vertical.

Suprailiac. Just above the iliac crest in the mid-axillary line.

**Description of Treatment**

Both the basketball and wrestling conditioning programs consisted of aerobic and anaerobic training. Aerobic training was provided in basketball during many of the full-court drills in which constant movement was stressed. Anaerobic training occurred during the ten minutes allocated for wind sprints at the end of each practice as well as during jumping, dodging, and accelerated movements inherent in the sport.

The wrestling team used considerably less running than the basketball team in their training which is attributable to the fact that wrestling is not a running sport. However, wrestlers were conditioned aerobically in that they wrestled at least three eight-minute matches during each practice. For anaerobic training, the wrestlers performed sets of push-ups and sit-ups for maximum repetitions in twelve seconds, fifteen to thirty second wrestling drills, and wind sprints.
Null Hypotheses

1. Aerobic capacity will not be significantly affected by the end of the season.
   a. The aerobic capacity of the basketball group will not be significantly affected by the end of the season.
   b. The aerobic capacity of the wrestling group will not be significantly affected by the end of the season.
   c. There will be no significant difference between the aerobic capacities of the basketball and wrestling groups.

2. Anaerobic capacity will not be significantly affected by the end of the season.
   a. The anaerobic capacity of the basketball group will not be significantly affected by the end of the season.
   b. The anaerobic capacity of the wrestling group will not be significantly affected by the end of the season.
   c. There will be no significant difference between the anaerobic capacities of the basketball and wrestling groups.

3. Reaction time will not be significantly affected by the end of the season.
   a. The reaction time of the basketball group
will not be significantly affected by the end of the season.

b. The reaction time of the wrestling group will not be significantly affected by the end of the season.

c. There will be no significant difference between the reaction times of the basketball and wrestling groups.

4. The percent body fat will not be significantly affected by the end of the season.

a. The percent body fat of the basketball group will not be significantly affected by the end of the season.

b. The percent body fat of the wrestling group will not be significantly affected by the end of the season.

c. There will be no significant difference in the percent body fat between the basketball and wrestling groups.

**Statistical Treatment**

In order to determine the occurrence of a significant difference in test scores within each athletic group, a correlated t test was used. An independent or non-correlated t test was used to compare the treatment effects between the two athletic groups and to determine
the significance of each group's mean gains. Finally, a
Pearson Product-Moment correlation was used to show the
relationships between each of the variables within each
group.
CHAPTER IV

RESULTS

The variables of aerobic capacity, anaerobic capacity, reaction time, and percent body fat were all to be recorded at the beginning and end of both the basketball and wrestling seasons. However, because of unforeseen circumstances, the researcher was unable to test the basketball players in the post-season variable of aerobic capacity. All statistical analyses concerning post-season aerobic capacity have therefore been eliminated.

Significant gains in performance were shown by the basketball team in two of the fitness variables during the season (Table 1). Anaerobic capacity, as measured by 440 yard dash times, improved significantly (p < .05) by the end of the season as the mean dash time was lowered by 2.5 seconds.

The mean time used in the measurement of reaction time for the basketball players also showed significant improvement (p < .05) during the season as it decreased by .015 seconds.

The percent body fat of the basketball players dropped by 1.3%, but the change was not significant.
### TABLE 1
SUMMARY OF CONDITIONING CHANGES IN BASKETBALL PLAYERS

<table>
<thead>
<tr>
<th>variable</th>
<th>pre x</th>
<th>SD</th>
<th>post x</th>
<th>SD</th>
<th>percent change</th>
<th>correlated t ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>anaerobic capacity (440)</td>
<td>59.9</td>
<td>02.66</td>
<td>57.4</td>
<td>02.77</td>
<td>4%</td>
<td>2.43*</td>
</tr>
<tr>
<td>reaction time</td>
<td>0.159</td>
<td>0.0179</td>
<td>0.144</td>
<td>0.0164</td>
<td>9%</td>
<td>2.31*</td>
</tr>
<tr>
<td>percent fat</td>
<td>12.9</td>
<td>3.32</td>
<td>11.6</td>
<td>3.03</td>
<td>10%</td>
<td>1.08</td>
</tr>
</tbody>
</table>

*significant at the .05 level

In the wrestling group, the only significant gain in performance was in reaction time (p< .01) where the mean time improved by .021 seconds (Table 2). Data in Table 2 also indicated that the wrestlers' aerobic and anaerobic capacities showed a decrease rather than an increase as a result of their season of competition.

The percent body fat of the wrestlers decreased markedly by 2.3%, but the change was not enough to be significant.
TABLE 2
SUMMARY OF CONDITIONING CHANGES IN WRESTLERS

<table>
<thead>
<tr>
<th>variable</th>
<th>pre $\bar{x}$</th>
<th>SD</th>
<th>post $\bar{x}$</th>
<th>SD</th>
<th>percent change</th>
<th>correlated t ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>aerobic capacity (1.5 mile)</td>
<td>9:26</td>
<td>1:09.09</td>
<td>9:29</td>
<td>1:09.27</td>
<td>.5%</td>
<td>.09</td>
</tr>
<tr>
<td>anaerobic capacity (440)</td>
<td>1:02.3</td>
<td>:05.12</td>
<td>1:03.8</td>
<td>:05.37</td>
<td>2%</td>
<td>.60</td>
</tr>
<tr>
<td>reaction time</td>
<td>.164</td>
<td>.0186</td>
<td>.143</td>
<td>.0101</td>
<td>13%</td>
<td>4.20**</td>
</tr>
<tr>
<td>percent body fat</td>
<td>12.5</td>
<td>4.89</td>
<td>10.2</td>
<td>5.01</td>
<td>18%</td>
<td>.99</td>
</tr>
</tbody>
</table>

**significant at the .01 level

In the data representing the comparison of the pre-season scores of the basketball and wrestling teams (Table 3), there were no significant differences in pre-season performance between the teams in any of the variables.
### TABLE 3

COMPARISON OF PRE-SEASON SCORES BETWEEN THE BASKETBALL AND WRESTLING TEAMS

<table>
<thead>
<tr>
<th>variable</th>
<th>independent t ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>aerobic capacity (1.5 mile)</td>
<td>.93</td>
</tr>
<tr>
<td>anaerobic capacity (440)</td>
<td>1.48</td>
</tr>
<tr>
<td>reaction time</td>
<td>.64</td>
</tr>
<tr>
<td>percent body fat</td>
<td>.23</td>
</tr>
</tbody>
</table>

A comparison of post-season scores for anaerobic capacity (Table 4) showed a significant difference (p<.01) between the basketball team and the wrestling team. However, other post-season variables were not significantly different.
TABLE 4

COMPARISON OF POST-SEASON SCORES BETWEEN THE BASKETBALL AND WRESTLING TEAMS

<table>
<thead>
<tr>
<th>variable</th>
<th>independent t ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>anaerobic capacity (440)</td>
<td>3.76**</td>
</tr>
<tr>
<td>reaction time</td>
<td>.16</td>
</tr>
<tr>
<td>percent body fat</td>
<td>.84</td>
</tr>
</tbody>
</table>

**significant at the .01 level

A comparison of the mean gain in anaerobic performance during the season (Table 5) showed that the basketball players made a significantly greater improvement (p < .01) than the wrestlers. No other significant differences occurred between groups over the duration of the season.

TABLE 5

COMPARISON OF MEAN GAINS BETWEEN THE BASKETBALL AND WRESTLING TEAMS

<table>
<thead>
<tr>
<th>variable</th>
<th>basketball mean gain</th>
<th>wrestling mean gain</th>
<th>independent t ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>anaerobic capacity (440)</td>
<td>.026</td>
<td>-.01</td>
<td>3.24**</td>
</tr>
<tr>
<td>reaction time</td>
<td>.012</td>
<td>.021</td>
<td>1.30</td>
</tr>
<tr>
<td>percent body fat</td>
<td>1.3</td>
<td>2.3</td>
<td>1.25</td>
</tr>
</tbody>
</table>

**significant at the .01 level
Finally, the relationship of the variables, as determined by pre-season test scores (Table 6), indicated significant correlation coefficients \((p < .01)\) between aerobic capacity and anaerobic capacity, aerobic capacity and percent body fat, and anaerobic capacity and percent body fat.

### TABLE 6

**RELATIONSHIP OF PRE-SEASON VARIABLES BETWEEN THE BASKETBALL AND WRESTLING TEAMS**

<table>
<thead>
<tr>
<th>variables</th>
<th>anaerobic capacity</th>
<th>reaction time</th>
<th>percent body fat</th>
</tr>
</thead>
<tbody>
<tr>
<td>aerobic capacity</td>
<td>.87</td>
<td>-.01</td>
<td>.70**</td>
</tr>
<tr>
<td>anaerobic capacity</td>
<td>-.03</td>
<td>.68**</td>
<td></td>
</tr>
<tr>
<td>reaction time</td>
<td>-.03</td>
<td>.04</td>
<td></td>
</tr>
</tbody>
</table>

**significant at the .01 level**

Upon investigating the relationships between the post-season test scores, no significant correlations were found (Table 7).
TABLE 7

RELATIONSHIP OF POST-SEASON VARIABLES BETWEEN THE BASKETBALL AND WRESTLING TEAMS

<table>
<thead>
<tr>
<th>variables</th>
<th>reaction time</th>
<th>percent body fat</th>
</tr>
</thead>
<tbody>
<tr>
<td>anaerobic capacity</td>
<td>.03</td>
<td>.19</td>
</tr>
<tr>
<td>reaction time</td>
<td></td>
<td>.11</td>
</tr>
</tbody>
</table>
CHAPTER V

DISCUSSION

Figure 1 indicates that the mean time for the one and one-half mile run for the wrestling team increased by five seconds during their season of competition. This result did not coincide with the findings of Skinner and others (1964), Brown and others (1974), Girandola and Katch (1973), and Tzankoff and others (1972) who discovered significant increases in aerobic capacity as a result of various training programs.

Coleman and others (1974), however, found no significant difference in aerobic capacity after a season of basketball competition. Although the results were non-significant, they did see performance gains.

The decrease in performance by the wrestling team in aerobic capacity may be attributed to several factors. First, wrestling not being a running sport, a minimal amount of running occurred during their training. Wrestling predominantly involved the upper body, whereas aerobic capacity was determined by a running test in this study. Biochemical changes that typically take place in skeletal muscle in response to training, probably occurred to a greater degree in the upper body of the wrestlers. The
changes which generally take place as a result of aerobic work include an enlargement of the capillary bed in muscles; an increase in the number and size of the mitochondria, more oxidative enzymes and dehydrogenative enzymes; increased myoglobin, and elevated glycogen stores (Astrand and Rodahl, 1970 and Morehouse and Miller, 1976). All of these changes improve the component of aerobic capacity known as oxygen utilization.

Other factors possibly related to the wrestling

FIGURE 1
CHANGES IN AEROBIC CAPACITY (1.5 mile)
team's decrease in performance include the fact that several of the subjects were suffering from minor injuries, but were still training in preparation for the upcoming national tournament. Finally, the wrestling team as a whole was generally undisciplined and lacked motivation as well as team spirit. This lack of motivation was evident as the team performed their post-season running tests.

Figure 2 shows the results of the 440 yard dash which was used to determine anaerobic capacity. It can be seen that the basketball team improved significantly in

FIGURE 2

CHANGES IN ANAEROBIC CAPACITY (440)

<table>
<thead>
<tr>
<th></th>
<th>Pre</th>
<th>Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basketball</td>
<td>1:02.3 ± 0.05.12</td>
<td>1:03.8 ± 0.05.37</td>
</tr>
<tr>
<td>Wrestling</td>
<td>1:02.66 ± 0.02.77</td>
<td>1:03.4 ± 0.02.77</td>
</tr>
</tbody>
</table>

Figure 2: Changes in Anaerobic Capacity (440)

- Pre: 1:02.3 ± 0.02.66
- Post: 1:03.8 ± 0.03.37

Basketball

- Pre: 1:02.3 ± 0.05.12
- Post: 1:03.8 ± 0.05.37

Wrestling
anaerobic capacity as a result of their season of competition and tended to support the findings of Coleman and others (1974) who also found a significant improvement in aerobic capacity during a season of basketball competition. These results also supported Shepard's contention (1972) that repetitive acceleration sprints and fast interval training, which are inherent in basketball training, will improve anaerobic capacity.

The wrestling team showed a slight decrease in anaerobic capacity which may again be attributed to specificity of training, injuries, and lack of motivation. Once again, factors relating to anaerobic capacity, such as biochemical changes in the musculature, were possibly being developed in the upper bodies of the wrestlers; whereas, the anaerobic test again involved running. The basketball players, on the other hand, received maximum amounts of running in their training which is possibly reflected in significant improvement on the running test.

Some of the principal changes which occur within the musculature in response to anaerobic training are improved shunting, resulting in greater blood flow to the active muscle tissue, and an increased alkaline reserve which permits a greater toleration to lactic acid production. The results of reaction time performance in Figure 3 depict a significant improvement by both teams. The basketball team achieved a significant (p<.05) improvement in reaction time during the season which may be attributed
to the fact that quick reactions and speed of movement were major elements of the sport and were concentrated on daily. The wrestling team showed an improvement in reaction time of even greater significance (p < .01), possibly due to the fact that a great deal of time was spent in practice on reacting quickly to an auditory stimulus (i.e. a whistle); whereas, the stimuli in basketball training were primarily visual.

Although Morehouse and Miller (1976) stated that

FIGURE 3

CHANGES IN REACTION TIME

<table>
<thead>
<tr>
<th></th>
<th>Pre</th>
<th>Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basketball</td>
<td>15.9 ± 1.79</td>
<td>14.4 ± 1.64</td>
</tr>
<tr>
<td>Wrestling</td>
<td>16.4 ± 1.86</td>
<td>14.3 ± 1.01</td>
</tr>
</tbody>
</table>
reaction time itself was affected very little by practice, they did suggest that practice shortened the time required for a total body response. The decreases shown in the reaction time test by the basketball players and wrestlers, coupled with the intensity of quickness training in both sports, seemed to support this statement.

Both teams showed decreases in skinfold measurements as well as percent body fat shown in Figure 4. Although both teams showed a decrease in percent body fat, neither of the decreases were significant. The lack of a significant

FIGURE 4

CHANGES IN PERCENT BODY FAT
decrease by the basketball team did not support the study of Brown and others (1974) who reported significant decreases in skinfold measurements as well as percent body fat in basketball players after eight weeks of pre-season conditioning.

It was hypothesized that the wrestlers would demonstrate a significant decrease in percent body fat due to the large amounts of weight that were generally lost in attempting to qualify for specific weight classes. The lack of a significant decrease may be due largely to the fact that several of the wrestlers could not make the varsity team in the lower weight classes in which they desired to participate. This necessitated moving up one or more weight classes in order to gain a spot on the varsity team. By moving up in this manner, the wrestlers no longer had to watch their weight or caloric intake which was likely to have restricted the team's total fat loss.

Another possible explanation for both teams' failure to significantly decrease their fat composition may have been the level of their pre-season scores. Morehouse and Miller (1976) stated that the average man's percent body fat is approximately 18%. By observing Figure 4, it can be seen that the means of the percent body fat for the basketball and wrestling teams were 12.9% and 12.5% respectively at the beginning of the season. Since these values were well below those considered average, it could be that the athletes did not have enough fat to lose in significant
amounts.

Many researchers, including Alexander and others (1968), Girandola and Katch (1973), Skinner and others (1964), and Johnson and others (1972), used non-athletes in their studies whose percent body fat is generally higher than the conditioned athlete. When these non-athletes were subjected to vigorous training regimens, they generally lost significantly large amounts of fat very quickly.

It was interesting to note that upon comparing the test scores of the pre-season variables, no significant differences were found. This suggested that both teams entered their seasons at relatively the same level of conditioning. When post-season variables were compared, however, the basketball team's mean score for anaerobic capacity was significantly different from the wrestling team's. Upon making a comparison of the mean gain, the basketball team's anaerobic capacity was found to have improved to a significantly greater degree than the wrestling team's. Since this was the only variable to show a significant difference, further credibility is added to the belief that the greater emphasis on running in the basketball program provided the basketball players with an opportunity to score better than the wrestlers on the running tests.

Another interesting observation was the degree to which several of the pre-season variables related to each other for all of the athletes. Significant relationships
appeared between percent body fat and aerobic capacity \( r = .70 \) and anaerobic capacity \( r = .68 \). Since fat creates a demand for extra blood and increases the load that the runner must move, one would expect a positive relationship between percent fat and running time.

A highly significant correlation \( r = .87 \) was also evident between aerobic and anaerobic capacity. At first glance, one may be confused by such a high correlation between the two different types of metabolism. Anaerobic processes function in the absence of oxygen and can only produce energy-producing ATP in small amounts through the process of glycolysis using only carbohydrates. Aerobic formation of ATP is much more prolific and involves the metabolism of carbohydrates and fats in the presence of oxygen. However, sports activities are rarely either all aerobic or all anaerobic and such was the case with basketball and wrestling. Both sports rely on anaerobic functions for quick bursts of action, and aerobic functions for endurance. Aerobic and anaerobic capacities are of equal importance to the nature of both sports, so a high correlation between them is not surprising.

The fact that no significant relationships existed between the post-season test scores involving anaerobic capacity and percent body fat reflected the wrestling team's inability to improve in anaerobic capacity as did the basketball team. By not having post-season scores for the
aerobic capacity of the basketball team, one can only speculate that the relationship between aerobic and anaerobic capacity would remain high.

**Implications for Training**

The results of the data collection in this study held implications for the training programs of basketball and wrestling at the University of Nebraska at Omaha.

**Basketball**

The basketball training program concentrated heavily on running for both endurance and sprinting ability. The results of the sprint training were reflected in the significant improvement of anaerobic capacity during the season. However, since the change in aerobic capacity was not measured, one can only surmise the possible improvement. Without valid test measurements, no implications were made concerning the basketball team's endurance training program.

The researcher felt that the test results showed the anaerobic training in the basketball program to be quite adequate, and suggested the continuance of such a program with little change.

The significant improvement in reaction time was attributable to the many ball handling and defensive technique drills requiring quick changes in direction in response to various stimuli. Again, the significance of the improvement indicated that the training program was
positively affecting the players' quickness in reactions.

Although the basketball players' percent body fat was improved, the change was not significant. As stated earlier in the study, the players entered the season well below what was considered a normal level for percent body fat. The fact that they still showed an average loss of 1.3% reflected the positive effects of the basketball training program on body composition.

The researcher felt that the basketball training program was an excellent regimen for improving the conditioning of the participating athletes at the University of Nebraska at Omaha. The only suggestion was that some dietary information be made available to players whose body fat was above normal. Other than that, the program was well organized and proved highly beneficial to the players' fitness levels.

Wrestling

The most noticeable result of this study was the wrestlers' failure to improve performance in the tests used to determine aerobic and anaerobic capacity. It has been suggested that this was due largely to the fact that the training program concentrated mainly on the development of the upper body.

Several wrestlers who have become national, world, and Olympic champions have expressed similarities in their training regimens. The one thing that each of these
athletes stressed in their individual training programs is a great deal of running. They felt that running, in addition to their upper body training, provided their bodies with the aerobic endurance necessary for competing in an entire match as well as anaerobic power for the short, all-out bursts of energy so often required.

Based on the results of the data, it was the researcher's recommendation that a great deal more emphasis be placed on running in the wrestling program at the University of Nebraska at Omaha. The capacities of aerobic and anaerobic metabolism are of such extreme importance in a sport of this nature that they cannot be excluded from any wrestling program.

The importance of reaction time to an auditory stimulus is of great importance in the sport of wrestling. Many times during a match the wrestlers are started at the sound of a whistle and the man who can react quickest to that sound has a definite advantage over his opponent. The significant improvement of the University of Nebraska at Omaha wrestlers indicated that the emphasis on quick movements in response to a whistle in many of the drills was time well spent.

The wrestlers' mean percentage of body fat decreased by 2.3% to an average of 10.2%. As with the basketball players, the wrestlers entered the season with a low percentage of fat which restricted their ability to lose
significant amounts. It is felt that the 10.2% average was quite adequate and no special effort needed to be made to achieve a lower percentage of body fat.

Conclusions

The data led the researcher to state the following conclusions:

1. The emphasis on sprinting and quick movements in the basketball training program was of sufficient intensity to provide a significant increase in anaerobic capacity.

2. The specificity of training involving the upper body with the wrestling team was not conducive to significantly improving aerobic and anaerobic performance as measured by the one and one-half mile run and the 440 yard dash respectively.

3. Participation in a season of competitive basketball and wrestling significantly improved reaction time for both teams.

4. A season of basketball and wrestling was not of significant value in decreasing the fat composition of the body.

5. The specificity of training involving running allowed the basketball team to show a significantly greater increase in anaerobic capacity than the wrestling team.
Suggestions for Further Study

It is hoped that this study may serve as an incentive for further research on the effects of a season of competition on participants of various sports to determine the different levels of fitness existing in those athletes.

In the event of further studies being done in this particular area, the researcher suggests that:

1. Data be collected on a larger group of subjects from different teams in each sport.

2. Variables be tested at mid-season to determine seasonal trends in fitness.

3. Testing devices such as the bicycle ergometer and Harvard Step Test be used for aerobic capacity and climbing stairs be used for anaerobic capacity in an attempt to limit the effects of specificity training.

4. Since quick, total-body movements are important in these two sports, movement time should be added to the variables tested.

It is interesting to note that although many differences existed in performance scores between the two teams, both teams were highly successful in their respective sports. For much of the season, both teams were rated among the top ten nationally in their respective sports at the NCAA Division II level.
BIBLIOGRAPHY


