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COMPARISON OF THE EFFECTS OF 97 PER CENT AND 21 PER CENT
OXYGEN MIXTURES UPON RECOVERY FROM TREADMILL RUNNING
AMONG MALE WRESTLERS AT UTAH STATE UNIVERSITY

by

Michael P. Brooks

A thesis submitted in partial fulfillment
of the requirements for the degree

of

MASTER OF SCIENCE

in

Health, Physical Education and Recreation

Approved:

UTAH STATE UNIVERSITY
Logan, Utah

1971

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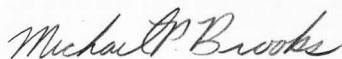
I would like to thank Dr. Lanny Nalder, Dr. James Gessaman, and Mr. Dale Rasmussen for their technical advice and assistance during this study.

I would also like to thank my parents for the time and effort they put forth in helping me to obtain needed equipment for the study.

Special thanks goes to my wife, Karen, for the support she gave me throughout this paper and the typing she performed.

To the wrestling team, and coach Bob Carlson, I would like to thank them for their participation in the study. Success to them in their future seasons.

I would also like to thank Dr. LeGrand Ellis for his instructions concerning the Fry Gas Analyzer.



Michael P. Brooks

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ABSTRACT

Comparison of the Effects of 97 Per Cent and 21 Per Cent Oxygen
Mixtures Upon Recovery From Treadmill Running Among
Male Wrestlers at Utah State University

by

Michael P. Brooks, Master of Science

Utah State University, 1971

Major Professor: Dr. Lanny Nalder
Department: Health, Physical Education and Recreation

A comparison of the effects on recovery while breathing a 97 per cent oxygen mixture and normal compressed atmospheric air after treadmill running was determined among nine male wrestlers at Utah State University. The variables examined were heart rate and percentages of oxygen and carbon dioxide in expired air. The practice of some athletic teams of administering oxygen to participants during time out periods was the motivation for this study.

A great majority of the studies reviewed conclude that oxygen does not play a significant role in aiding recovery from physical activity.

The experiment first consisted of eight runs on the treadmill (Quinton Model 18-49-C) to familiarize the subjects with the equipment and also to enable them to plateau in conditioning for a five minute run at 0 per cent grade at eight miles per hour.

After the training period was completed, the nine subjects went through a series of six runs, each followed immediately by a five minute recovery period while breathing a 97 per cent oxygen mixture for three of the recovery periods, and a 21 per cent oxygen mixture for the other three recovery periods. Heart rate was recorded every 30 seconds during the recovery period by the use of three electrodes on the subjects. Expired air was collected with the use of the Kofrany-Michaelis Respirometer. Air samples were analyzed for percentages of oxygen and carbon dioxide by the Fry Gas Analyzer.

An analysis of variance showed no significant difference in heart rate decline while breathing either gas mixture. At the end of the five minutes of recovery, the subjects expired 3 per cent of carbon dioxide regardless of which oxygen mixture was breathed.

It was concluded that there were no significant differences in the effects on recovery while breathing the 97 per cent oxygen mixture or the 21 per cent oxygen mixture.

(51 pages)

CHAPTER I

INTRODUCTION

Efficient recovery from fatigable activity is of great concern to people interested in physical conditioning. During an athletic event, a team doctor or trainer will administer oxygen to participants that come out of the game for the supposed purpose of aiding recovery. Some teams that come from a lower altitude to play at Utah State University will also use oxygen as an aid to recovery. Oxygen is being used by some teams at all levels of sports; professional, collegiate, and secondary schools. Oxygen was used in the last Olympic Games in Mexico City for the postulated purpose of helping performance and aiding recovery at the high altitude of Mexico City.

It is important for an athlete to be physically fit and be able to recover efficiently if he is to perform skillfully over a long period of time. For an athlete to perform at his highest potential, he has to make quick mental decisions and be able to make quick coordinations. This is why time-out periods should not only be concerned with game strategy, but these periods should also be used to help the participant recover as much as possible and prepare him for more activity. Other items have been used during the time-out period to help prepare the athlete for more activity along with the use of oxygen. Some of these aids consist of: wet towels, ice packs, candy bars, electrolyte solutions, and oranges.

The effects of oxygen administration are both physical and psychological. Physically, oxygen effects the cardiovascular system, respiratory system, and

other physiological systems. There have been reports of confidence and well-being when using oxygen. Can oxygen significantly help a person to recover, or is it a psychogenic aid causing a person to think it is helping him recover?

Statement of the Problem

The purpose of this study was to determine the effects on recovery while breathing a 97 per cent oxygen mixture and a 21 per cent oxygen mixture (normal atmospheric compressed air). The recovery was determined by changes of heart rate and percentages of oxygen and carbon dioxide in expired air.

Justification of Study

There is indecision concerning the use of oxygen during time-out periods. Some teams use oxygen as an aid to recovery and other teams do not. Carlson used oxygen administration at the University of Pittsburgh and reported that it helped athletes recover from basketball.¹ A more recent study at the University of Montana was performed by Bjorgum and Sharkey. They concluded that oxygen did not aid in recovery. Their subjects consisted of trained and non-trained distance runners.²

¹H.C. Carlson, "Athletes Get Oxygen During Rest," Science News Letter, LXII (February, 1953), p. 119.

²Richard K. Bjorgum and Brian J. Sharkey, "Inhalation of Oxygen as an Aid to Recovery after Exertion," Research Quarterly, XXXVII (December, 1966), p. 462.

Research concerning the effectiveness of oxygen administration is necessary so we will not follow an unsupported fad that will come and go with the times. If oxygen is useful in recovery, this would be a great aid for athletes and all concerned with sports and physical conditioning. This study examined two procedures: (1) allowing a person to recover with normal atmospheric compressed air, (2) giving him a higher mixture of oxygen.

Basic Assumptions

It was assumed that the subjects would do their best to obey and conform to the pre-test condition of non-activity. Since the gas tanks were covered, it was assumed that the subjects would not know if they were breathing the 97 per cent oxygen mixture or the 21 per cent oxygen mixture, thus the psychological variables were minimized in affecting the results.

Delimitations

This study was delimited to an altitude of approximately 4,453 feet at Logan, Utah. The workload was delimited to treadmill running at 0 per cent grade at 8 miles per hour for 5 minutes. This was one half of the workload that was used by Bjorgum and Sharkey.³ Gas mixtures used were delimited to 97 per cent oxygen mixtures and 21 per cent oxygen mixtures.

³ibid., p. 462.

Limitations

The following were recognized as limitations to the study.

1. Using a small number of subjects from a group at hand was a limitation in applying the results to all cases encountered in recovery.
2. Approximately 10 per cent of the runs were done when the instructions of pre-test non-activity were not followed. This was an uncontrolled variable.
3. Contamination of expired air samples was also a limitation to the experiment.
4. The different psychological variables in the makeup of each subject was a limitation recognized.

Definition of Terms

1. Bradycardia: "Abnormal slowness of the heart beat."⁴
2. Cardiac minute volume: The amount of blood that is pumped by the heart in one minute.
3. Diastolic blood pressure: The pressure in the arteries at the time when the heart is in the relaxed phase.
4. Exhaustion: "Privation of energy with consequent inability to respond to stimuli."⁵

⁴Dorland's Illustrated Medical Dictionary, (Philadelphia, W. B. Saunders Co., 1965), p. 217.

⁵Ibid., p. 523.

5. Fatigue: Discomfort and decreased efficiency during exercise caused by over taxing of neuromuscular function.⁶
6. Heart rate: Heart beats per minute.
7. Inhalation balloon: Five liter anesthesiology balloon.
8. One atmosphere: "The pressure of the air upon the earth at the sea level (about 15 pounds to the square inch)."⁷
9. Psychogenic: "Of intrapsychic origin; having an emotional or psychological origin (in reference to a symptom), as opposed to an organic basis."⁸
10. Recovery: "To regain a normal position or condition."⁹
11. Respiratory minute volume: The amount of air breathed in one minute.
12. Stroke volume: The amount of blood pumped by the heart in one beat.
13. Systolic blood pressure: The pressure in the arteries at the time of a heart beat.
14. Ventilatory rate: Breaths per minute.
15. Ventilatory volume: The amount of air breathed in one minute.

⁶Per-Olof Astrand and Kaare Rodahl, Testbook of Work Physiology, (New York: McGraw-Hill, 1970), pp. 86-91.

⁷Dorland, p. 159.

⁸Ibid., p. 1249.

⁹Webster's Seventh New Collegiate Dictionary, (Massachusetts, G. & C. Merriam Co., 1967), p. 716.

CHAPTER II

REVIEW OF LITERATURE

There are three periods when oxygen has been given to people to see if it makes significant physiological adjustments and subsequent performance changes. These are: (1) before activity (at rest), (2) during activity, and (3) during recovery. Each of these areas will be covered in the review of literature.

Oxygen During Rest

The effects of 100 per cent oxygen on the cardiovascular system was studied by Whitehorn, Edelmann and Hitchcock.¹ Upon the administration of pure oxygen, they found a decrease in heart rate and stroke volume, thus causing the cardiac minute volume to be lower in their subjects. There was no change in systolic blood pressure, but diastolic pressure rose slightly. Blood pressure was maintained even though there was a lowering of cardiac output because there was an increase in peripheral vascular resistance, caused by vasoconstrictor stimulation. This study supports the use of oxygen in producing a significant change in heart rate during rest. These findings are supported by

¹W. V. Whitehorn, Abraham Edelmann and Fred A. Hitchcock, "The Cardiovascular Responses to the Breathing of 100 Per Cent Oxygen at Normal Barometric Pressure," The American Journal of Physiology, CXLVI (April, 1946), p. 65.

Dripps and Comroe who found the condition of bradycardia and a reduction of cardiac output in their subjects when 100 per cent oxygen was given.² The decrease in pulse rates was caused by increased oxygen tension on the aortic and carotid bodies. As oxygen concentrations in inspired air were lowered from 21 per cent to 18 per cent, there was a significant increase in heart rate, which increased more as oxygen concentration in inspired air was lowered to 10 per cent and 8 per cent. They found that there was a wide variability in oxygen saturation of the blood in the low concentrations of oxygen.³ This study supports the view that when oxygen percentages in inspired air are lowered, heart rate increases significantly and people have different degrees in the oxygen saturation of their blood at rest. This study was not supported by Hangerman, et al., who found no appreciable heart rate changes when 100 per cent oxygen was given to their subjects during rest.⁴ Elbel, Ormond, and Close found an increase in oxygen saturation of hemoglobin upon the administration of 100 per cent oxygen to athletes during rest.⁵ This study tends to support the

²Robert D. Dripps and Julius H. Comroe Jr. "The Effect of the Inhalation of High and Low Oxygen Concentrations on Respiratory, Pulse Rate, Ballisto-Cardiogram and Arterial Oxygen Saturation (Oximeter) of Normal Individuals," The American Journal of Physiology, CXLIX (May, 1947), pp. 290-291.

³Ibid.

⁴Frederick C. Hangerman, et al., "The Effects of Breathing 100 Per Cent Oxygen During Rest, Heavy Work, and Recovery," Research Quarterly, XXXIX (December, 1968), p. 965.

⁵Edwin R. Elbel, Donald Ormond, and Donald Close, "Some Effects of Breathing Oxygen Before and After Exercise," Journal of Applied Physiology, XVI (January, 1961), p. 48.

view that higher oxygen percentages in inspired air would cause higher oxygen saturation of hemoglobin at rest.

Baker and Hitchcock studied the effect of 100 per cent oxygen at one atmosphere on the respiratory system.⁶ They found average increases in ventilation volumes, ventilation rates, and carbon dioxide outputs when 100 per cent oxygen was given to their subjects at one atmosphere during rest. This study supports the view that respiratory rates would increase as oxygen percentages in inspired air increased during rest. This conclusion is also supported by Elbel, Ormond, and Close, who found an increase in respiratory rate in some of their subjects when oxygen was given during rest.⁷ However, this study was not supported by Dripps and Comroe who found immediate decreases in respiratory minute volumes when 100 per cent oxygen was given during rest.⁸ As oxygen percentages in inspired air were lowered to 18 per cent, 16 per cent, 10 per cent, and 8 per cent there was an increase in respiratory minute volume. Decrease in resting ventilation volumes were also found by Hangerman, et al. when oxygen was given at rest.⁹ These latter two studies support the view that slower breathing would be caused by giving a person a higher oxygen mixture.

⁶Saul P. Baker and Fred A. Hitchcock, "Immediate Effect of Inhalation of 100% Oxygen at One Atmosphere on Ventilation Volume, Carbon Dioxide Output, Oxygen Consumption and Respiratory Rate in Man," Journal of Applied Physiology, X (January-May, 1957), p. 363.

⁷Elbel, Ormond, and Close, p. 48.

⁸Dripps and Comroe, pp. 290-291.

⁹Hangerman, et al., p. 965.

Oxygen During Activity

Hangerman, et al. studied the effects of administering 100 per cent oxygen on the cardiovascular system on their subjects during activity and found no appreciable change in heart rate.¹⁰ Elbel, Ormond, and Close found a depressed pulse rate during the first two minutes of exercise which then gradually increased to exercise levels when 100 per cent oxygen was given before activity.¹¹

Hangerman, et al. also studied the effects that 100 per cent oxygen had on the respiratory system during activity and found a marked decline in ventilatory volume during exercise.¹² This study was supported by Bannister and Cunningham, who found decreased ventilatory volumes among their subjects when 100 per cent oxygen was given during activity.¹³ The postulated cause of this effect was attributed to increased oxygen tension on aortic and carotid chemoreceptors. Bannister and Cunningham also found that their subjects ran longer before becoming exhausted when oxygen was added to their inspired air during exercise.¹⁴ This finding was supported by Miller, et al. who

¹⁰ Ibid.

¹¹ Elbel, Ormond, and Close, p. 48.

¹² Hangerman, et al., p. 965.

¹³ R.G. Bannister and D.J. Cunningham, "The Effects on the Respiration and Performance During Exercise of Adding Oxygen to the Inspired Air," Journal of Physiology, CXXV (July, 1954), p. 135.

¹⁴ Bannister and Cunningham, p. 135.

also found increases in time needed for exhaustion when oxygen was administered during exercise.¹⁵ Some people might interpret this as increasing endurance, but technically, it is not because a person would come to rely on this extra oxygen, and his body would not be as taxed as normal to bring about better conditioning.

Karpovich performed a related study concerning the effect of oxygen administration on the performance of swimming. He found,

1. Oxygen inhalation immediately followed by swimming increased the speed in the hundred-yard dash.
2. Oxygen given four to five minutes before a hundred-yard dash has no noticeable effect upon speed.
3. Oxygen breathing in actual competition, unless given at the start, is hardly worth while.¹⁶

Karpovich attributes this added speed to the fact that a swimmer could hold his breath longer, and thus make the swimming coordination more simplified.

Oxygen During Recovery

Hangerman, et al. again found no appreciable effect of 100 per cent oxygen on heart rate during recovery.¹⁷ This supports the view that oxygen

¹⁵ A. J. Miller, et al., "Influence of Oxygen Administration on Cardiovascular Functions During Exercise," Journal of Applied Physiology, V (October, 1952), p. 168.

¹⁶ Peter V. Karpovich, "The Effect of Oxygen Inhalation on Swimming Performance," Research Quarterly, V (May, 1934), p. 29.

¹⁷ Hangerman, et al., p. 965.

administration would be of no value during recovery. Two more studies have different findings. Depressed pulse rates were found by Elbel, Ormond, and Close while 100 per cent oxygen was given during recovery. They also found increased oxygen saturation of hemoglobin during recovery.¹⁸ Carlson also found a decreased pulse rate when oxygen was given, thus supporting the view that oxygen would be an aid to recovery.¹⁹ There was a difference found between recovery pulse rates of non-runners compared to trained runners as found by Bjorgum and Sharkey. Higher pulse rate declines were found among the non-runners when oxygen was given during recovery.²⁰ Although these differences were not significant, it supports the view that unconditioned people would have a greater use of oxygen during recovery.

Carlson's study found a decrease in initial respiratory rates when oxygen was given during recovery.²¹ This study was supported by Elbel, Ormond and Close who also found decreased ventilatory volumes when oxygen was given during recovery.²² These latter two studies support the benefit of oxygen as an

¹⁸ Elbel, Ormond, and Close, p. 48.

¹⁹ H.C. Carlson, "Athletes Get Oxygen During Rest," Science News Letter, LXII (February, 1953), p. 119.

²⁰ Richard R. Bjorgum and Brian J. Sharkey, "Inhalation of Oxygen as an Aid to Recovery After Exertion," Research Quarterly, XXXVII (December, 1966), p. 462.

²¹ Carlson, p. 119.

²² Elbel, Ormond and Close, p. 48.

aid to recovery. Hangerman et al. also found slight declines in recovery ventilation volumes among his subjects while oxygen was given during recovery.²³

The decreases, however, were insignificant.

More studies are needed to form a stronger understanding of the use of oxygen and its relationship to physical conditioning and recovery. Every day, people are understanding the importance of the need of physical conditioning in this technical world. Sports are increasingly becoming more popular because of the increase in leisure time. People want to be in good health and have their bodies function efficiently. This increased interest in the importance of sports and physical conditioning forms the basis for research concerning the use of oxygen as an aid to recovery. Research is needed to form an understanding of the objectivity and practicality of the use of oxygen as an aid to recovery in order to obtain fundamental facts to build upon in future studies.

²³Hangerman, et al., p. 965.

CHAPTER III
METHOD OF PROCEDURE

Training Period

The subjects were trained by a series of eight runs on the treadmill (Quinton Model 18-49-C) to familiarize them with the equipment and also to enable them to plateau in conditioning for a five minute run at 0 per cent grade at eight miles per hour. Resting heart rate was manually taken in the wrist area and the treadmill manual speed control was set at eight miles per hour.¹ The subjects were told to begin the run and the timer was set for five minutes. Immediately after five minutes, heart rate was determined by using a stethoscope on the carotid artery in the neck region. A subject was said to be plateauing in conditioning when he was dismounting the treadmill at approximately the same heart rate at the end of the five minute run.

The training period and experimental runs took place during the months of April and May, 1971. The runs took place during the morning and afternoon on all days of the week except Saturday and Sunday.

Skin Preparation

Skin preparation and electrode placement was first completed. Three electrodes were used. Two electrodes, "... were placed below the fifth rib,

¹Quinton Instruments, Instructions for the Operation of the Quinton Treadmill Model 18-49-C, Seattle, Washington, pp. 5-8.

lateral to the sternum and ventral to the origin of the serratus anterior muscle of the fifth and sixth ribs."² One electrode (ground) was placed just below the xiphoid process of the sternum. They were all connected to a pre-amplifier strapped around the subject's waist. The lead from the pre-amplifier was plugged into the heart rate control panel of the treadmill control unit. The heart rate control panel was turned on and the subject's heart rate was read on the beats per minute gauge.

The Run

The treadmill manual speed control was set at eight miles per hour and the manual elevation control was set at 0 per cent grade. The timer was set for five minutes and the subject began the run.

During the run, the gas administering and gas collecting apparatuses were prepared. The plastic tubing from the gas tank to the inhalation balloon connected to the in-port of the gas mask, was checked for bad connections. The gas mask was cleaned by wiping with alcohol. The gas collecting apparatus was a Kofrany-Michaelis Respirometer. The per cent lever of the respirometer was turned to 6 per cent and the rubber gas collecting bladder was purged of its contents and connected to the out-port of the respirometer. The on-off lever was

²Lanny J. Nalder, "The Relation of Carbon Dioxide Output, Change in pH and Heart Rate Among Cross Country Runners at 6.5 Miles Per Hour at 15 Percent Gradient Until Exhausted," (Unpublished Ph.D. dissertation, University of Utah, 1969), p. 42.

turned to the on position.³ The rubber tubing from the out-port of the gas mask connected to the in-port of the respirometer was also checked for bad connections. Ten seconds before the exercise bout was over, the subject's heart rate was recorded and the gas regulator was turned on to keep a continuous flow of gas to the inhalation balloon connected to the gas mask.

The Recovery Period

Immediately at the end of the five minute run, the subject stepped off the treadmill and quickly sat down. The gas mask was placed over his mouth and nose. The five minute recovery period consisted of recording the subject's heart rate decline every thirty seconds from the heart rate gauge on the treadmill control unit and collecting 6 per cent of the average subject's expired air through the respirometer. At the end of the recovery period, the respirometer and the gas regulator were turned off. The mask was taken from the subject's face and the heart rate control panel was turned off on the treadmill control unit. The gas collecting bladder was clamped and disconnected from the out-port of the respirometer. A prepared syringe (barrel coated with 0.5 per cent sulfuric acid) was inserted into the neck of the bladder; the clamp was loosened and a 4 ml. gas sample was taken in the syringe for gas analysis of the expired air for the per cent of oxygen and carbon dioxide. The syringe was inserted into a rubber eraser to avoid leakage.

³E. A. Muller, Instructions for the Respiration Gas Meter of the Max-Planck Institute for Work Physiology, (Unpublished pamphlet of instructions, Dortmund, Germany, 1963), pp. 1-6.

The electrodes and preamplifier were taken off the subject. The electrodes were cleaned and prepared for the next subject. The prepared syringes containing the gas samples were then taken to the chemical laboratory for gas analysis.

Gas Analysis

The Fry Gas Analysis Technique was used to compute the per cent of oxygen and carbon dioxide in the expired air taken during the recovery period. The procedure was as follows:

A. Preparation of the air sample:

1. Attach a small gauge hypodermic needle to a 5 ml. glass syringe with a glass tapered tip (a Luer-lock syringe should not be used as the metal is apt to crack when exposed to acid).
2. Thoroughly wet the barrel of the syringe by drawing up a small amount of 0.5% H_2SO_4 into the syringe. Expel the excess acid (the acid serves to prevent the CO_2 from dissolving into the water seal of the syringe).
3. Remove approximately 2 ml. of gas from the sample of air you want to analyze.
4. Immediately plug the needle by inserting the free end of the needle into a soft rubber stopper to avoid minor errors due to diffusion of gases or accidental movement of the plunger. Be sure that a good seal is obtained on the needle.

B. Introduction of gas into Fry Gas Analyzer.

1. Turn the knob on the instrument until the Hg comes up to the bottom of the cup at the top of the buret.
2. Put a dropper full of 0.5% H_2SO_4 in the cup and draw the acid down to the top of the bulb at the base of the buret.

3. Inject the air from the syringe prepared above into the instrument through the injection port on the bulb at the base of the buret. Caution: Make sure that no gas is left trapped in the side arm.
4. If any Hg was pushed up into the buret, let it fall back into the bulb. Do not get any more acid into the bulb than is necessary.
5. Turn the knob of the instrument so that the air sample is pushed up into the buret. Expel any excess gas through the cup at the top of the buret so that a column of gas in the buret measures approximately 6 cm.
6. Set top of gas meniscus to zero on the buret.
7. After allowing 4 minutes for the acid to drain down from the walls of the buret, adjust the meniscus to zero and read the lower meniscus level on the buret.
8. Place a dropper full of $n/2$ KOH in the cup so that it is on top of the remaining acid seal.
9. Draw the contents of the buret down to the bottom of the buret. In doing so, the walls of the buret are coated with KOH. Note: The area occupied by the gas bubble should be coated with the KOH.
10. Move the gas bubble up and down the buret several times so that the CO_2 can be absorbed by the KOH.
11. After the CO_2 has been absorbed, remove the excess KOH, adjust the upper meniscus to zero and take new reading as you did above.
12. Place a dropper full of 2-Anthroquinonesulfonic acid reagent in the cup and repeat the steps above. This reagent absorbs the O_2 from the solution and the difference in volume is due to the removal of oxygen from the air sample. The remaining air contains the N_2 and other inert gases.
13. Expel the sample and reagents, and wash the apparatus three times with 0.5% H_2SO_4 to clean the buret and acidify the apparatus for the next analysis.

REAGENTS FOR FRY GAS ANALYZER:

- A. Acid rinse--0.5% H₂SO₄ in a small bottle equipped with a medicine dropper.
- B. CO₂ absorber--N/2 KOH in a small bottle equipped with a medicine dropper.
- C. O₂ absorber--dissolve 1 gram of 2-anthraquinonesulfonic acid (sodium salt) and 10 grams sodium hydrosulfite in 100 ml. of N/2 KOH. Mix rapidly to dissolve reagents and then filter through gauze. Store in 50 ml. syringes fitted with a short length of rubber hose fitted with a pinch clamp to prevent the solution from taking up O₂ from the air and becoming exhausted.

Calculations for the percentages of O₂ and CO₂ are the following:

$$\% \text{ of CO}_2 = \frac{\text{volume 1} - \text{volume 2}}{\text{volume 1}} \times 100$$

$$\% \text{ of O}_2 = \frac{\text{volume 2} - \text{volume 3}}{\text{volume 1}} \times 100^4$$

The Subjects

The subjects consisted on nine male wrestlers at Utah State University. The ages of the subjects ranged from eighteen to twenty-four years old. The weight of the subjects ranged from 113 pounds to 193 pounds. The height of the subjects ranged from 5 feet to 6 feet 2 inches.

⁴LeGrand C. Ellis, Instructions for the Operation of the Fry Gas Analyzer (Unpublished pamphlet of instructions, Utah State University, Department of Physiology, 1969), pp. 1-3.

CHAPTER IV
ANALYSIS OF RESULTS

Mean heart rates were presented to the Utah State University statistics department for processing in an IBM 360 computer. An analysis of variance program was applied to the data.

Data, concerning percentages of oxygen and carbon dioxide in expired air, were not processed in the computer because of the simplicity of analyzing this data. The means for the expired air percentages of oxygen and carbon dioxide had a definite homogeneity so the computer was not used.

Heart Rate

The mean heart rate declines during recovery breathing the 97 per cent oxygen mixture were compared with the mean heart rate declines during recovery breathing the 21 per cent mixture by an analysis of variance. At a level of $\alpha = .05$, the tabulated F was 6.2. All F ratios computed from the experimental data were below 6.2. The average F ratio was .09. For there to be a significant difference between the two recovery methods, the F ratios would have to be greater than 6.2.

Figures 1 through 9 graphically compare the mean heart rate declines for both recovery methods over a five minute recovery period for each subject.

Figure 1 compares the 2 mean heart rate declines while breathing the 97 per cent oxygen mixture or the 21 per cent oxygen mixture for subject A. This subject tended to have similar declines for both recovery methods. The subject began the recovery period with an average heart rate of 165 beats per minute and when the high oxygen mixture was used, he finished the 5 minute recovery period with an average heart rate of 71 beats per minute. The lower oxygen mixture application end the recovery period with an average heart rate of sixty eight beats per minute.

Figure 2 compares the two mean heart rate declines while breathing the 97 per cent oxygen mixture or the 21 per cent oxygen mixture for subject B. The subject had a slightly better heart rate decline while using the lesser mixture of oxygen. Heart rate tended to decline and then increase approximately four to six heart beats per minute at the three minute interval to level out through the two remaining minutes of recovery. The subject began the recovery period with an average heart rate of 103 beats per minute and ended the period with an average heart rate of 78 beats per minute when using the high oxygen mixture. The subject ended with an average heart rate of seventy two beats per minute while using the lesser oxygen mixture.

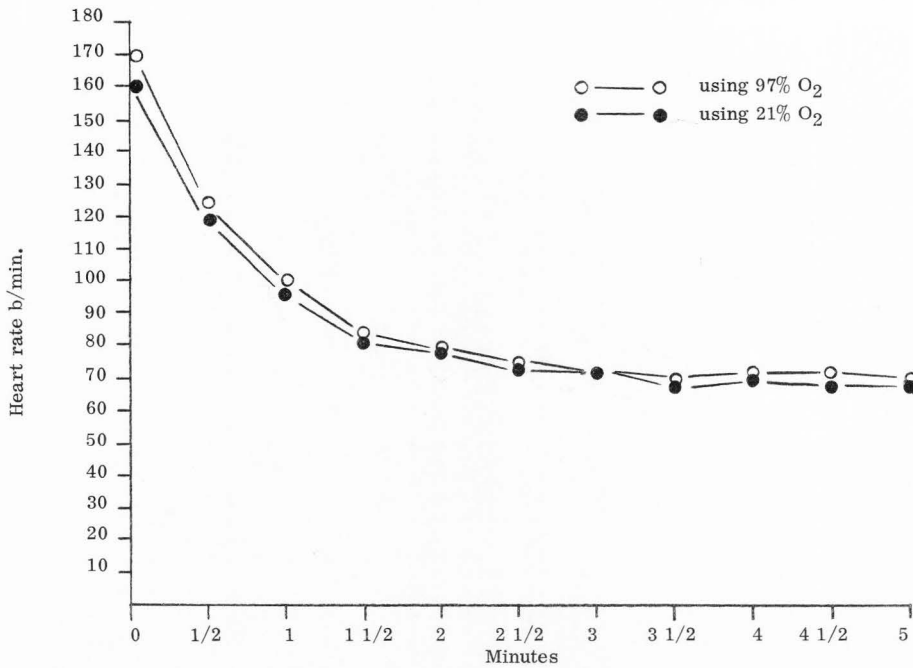


Figure 1. Mean heart rate decline during recovery for subject A.

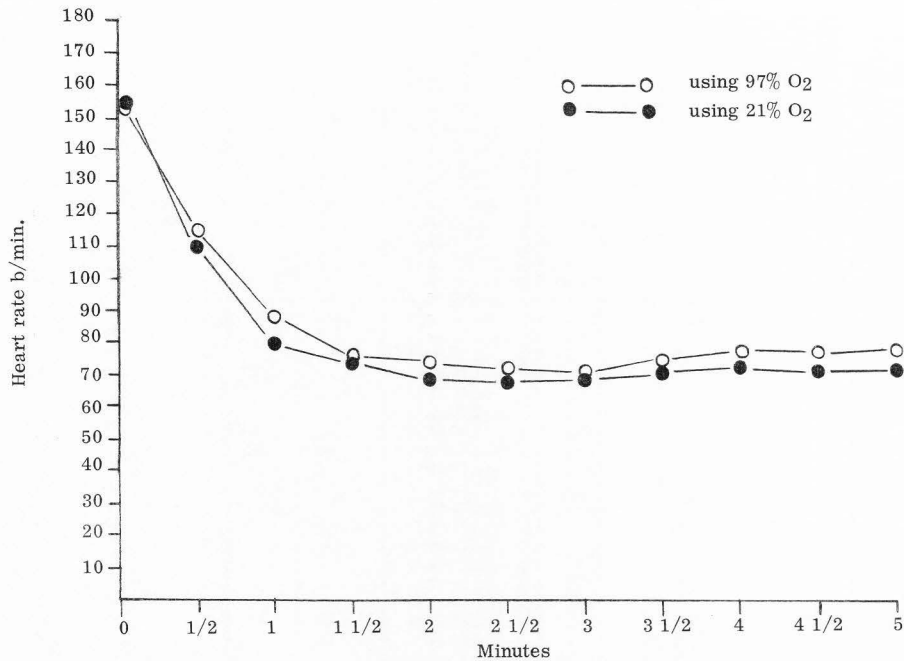


Figure 2. Mean heart rate decline during recovery for subject B.

Figure 3 compares the two mean heart rate declines while breathing the 97 per cent oxygen mixture or the 21 per cent oxygen mixture for subject C. As subject B, subject C also had slightly better heart rate declines while using the 21 per cent oxygen mixture. Subject C also had heart rate declines that increased two to eight beats per minute at the three minute interval to level out for the remaining two minutes of recovery. Subject C began the recovery period with an average heart rate of eighty eight beats per minute while breathing the 97 per cent oxygen mixture. Subject C had an average heart rate of eighty-three beats per minute at the end of the recovery period while using the lesser oxygen mixture.

Figure 4 compares the two mean heart rate declines while breathing the 97 per cent oxygen mixture or the 21 per cent oxygen mixture for subject D. Subject D had similar heart rate declines but did slightly better with the higher mixture of oxygen. Subject D began the period of recovery with an average heart rate of 152 beats per minute and ended the period with an average heart rate of 75 beats per minute while using the high oxygen mixture. When subject D breathed the lesser oxygen mixture, he ended the recovery period with an average heart rate of eighty beats per minute.

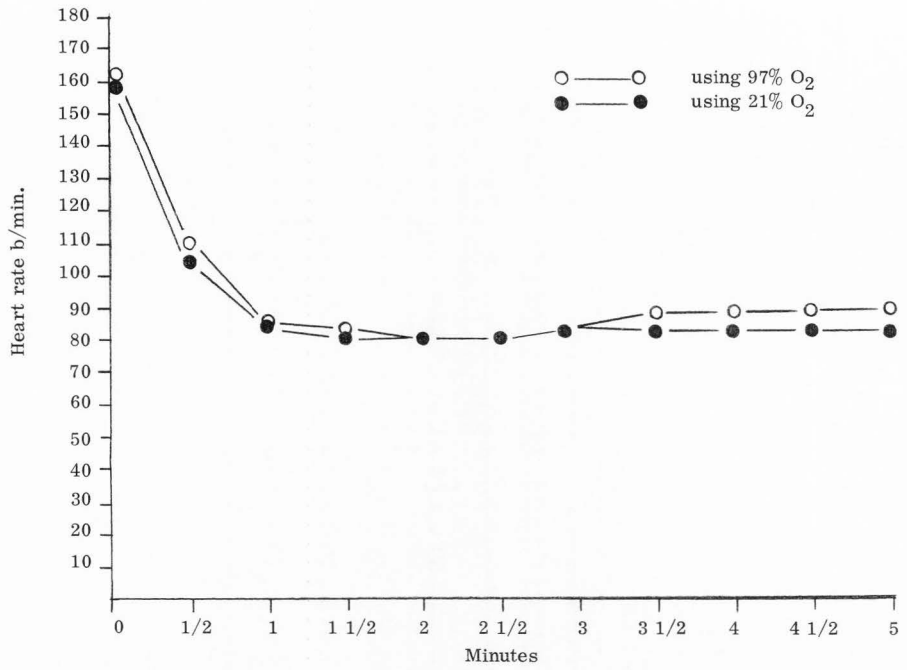


Figure 3. Mean heart rate decline during recovery for subject C.

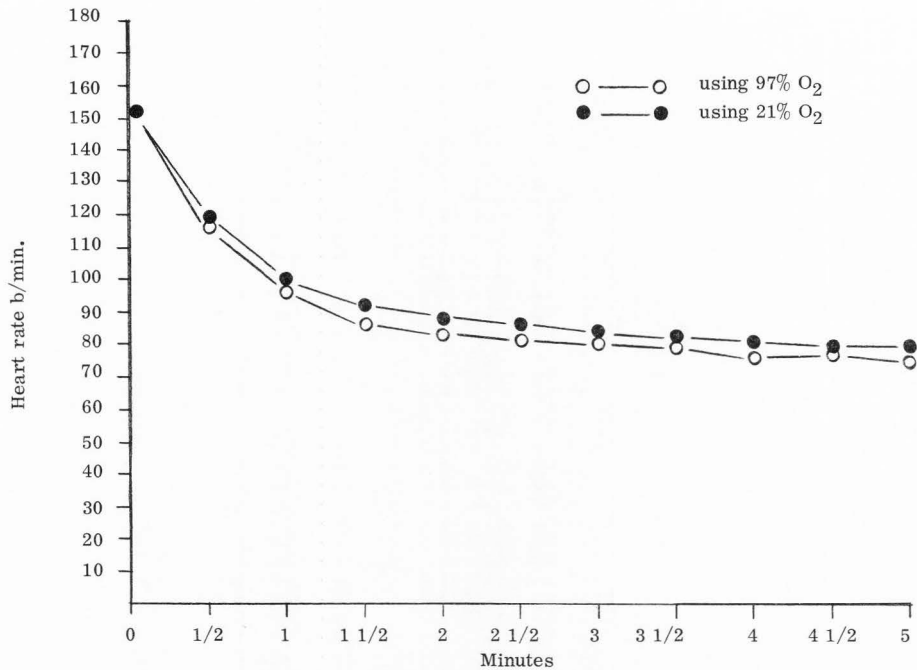


Figure 4. Mean heart rate decline during recovery for subject D.

Figure 5 compares the two mean heart rate declines while breathing the 97 per cent oxygen mixture or the 21 per cent oxygen mixture for subject E. Subject E also had similar heart rate declines with the two recovery methods. Subject E had an average heart rate of 90 beats per minute at the end of the period when he used the high oxygen mixture and he had an average heart rate of 92 beats per minute when he breathed the 21 per cent oxygen mixture.

Figure 6 compares the two mean heart rate declines while breathing the 97 per cent oxygen mixture or the 21 per cent oxygen mixture for subject F. Subject F had an average heart rate of 174 beats per minute when he began the period of recovery and while breathing the 97 per cent oxygen mixture. Subject F ended the period with an average heart rate of 88 beats per minute. While breathing the 21 per cent oxygen mixture, subject F had an average heart rate of 90 beats per minute at the end of the recovery period.

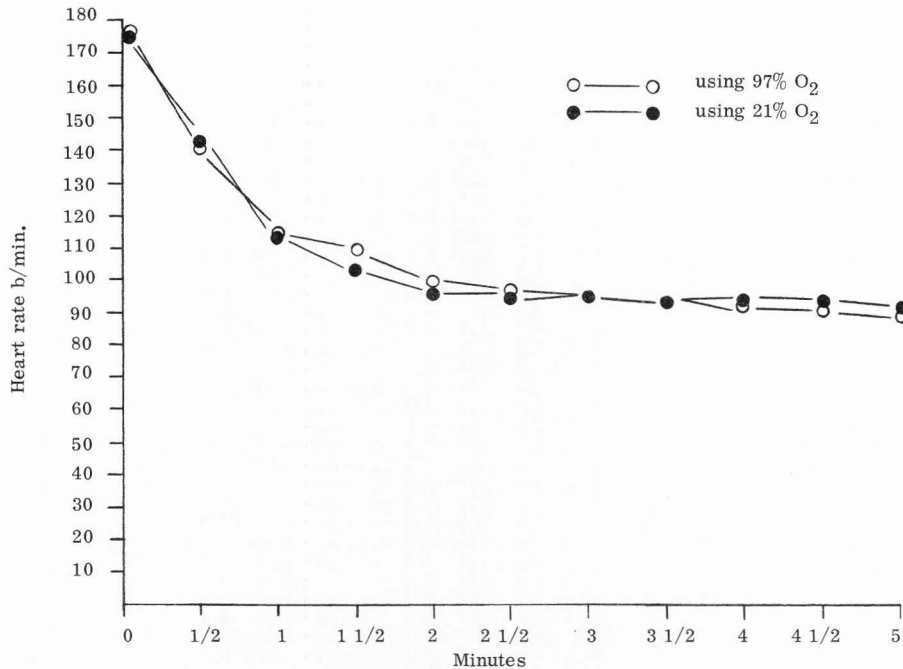


Figure 5. Mean heart rate decline during recovery for subject E.

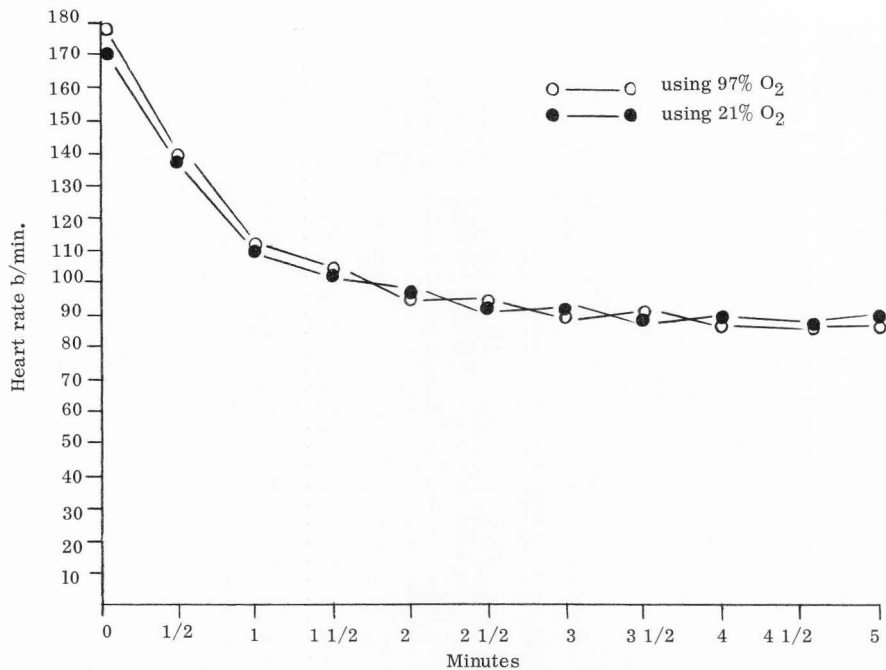


Figure 6. Mean heart rate decline during recovery for subject F.

Figure 7 compares the two mean heart rate declines while breathing the 97 per cent oxygen mixture or the 21 per cent oxygen mixture for subject G. This subject had a slightly better heart rate decline while breathing the higher oxygen mixture. Subject G started the recovery period with an average rate of 163 beats per minute, and he had an average heart rate of 83 beats per minute at the end of the recovery period while breathing the high oxygen mixture. Subject G had an average heart rate of 87 beats per minute at the end of the period while he breathed the lesser oxygen mixture.

Figure 8 compares the two mean heart rate declines while breathing the 97 per cent oxygen mixture or the 21 per cent oxygen mixture for subject H. Subject H had slightly better recoveries while breathing the high oxygen mixture. An average heart rate of 177 beats per minute began his recovery period, and subject H finished the period of recovery with an average heart rate of 84 beats per minute while breathing the 97 per cent oxygen mixture. This subject had an average heart rate of 90 beats per minute at the end of the recovery period while breathing the 21 per cent oxygen mixture.

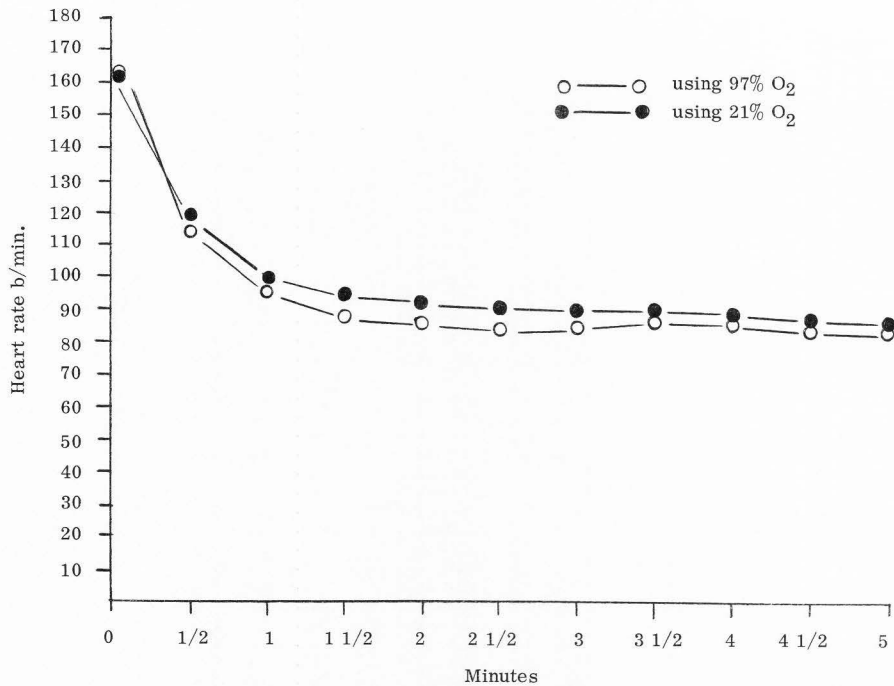


Figure 7. Mean heart rate decline during recovery for subject G.

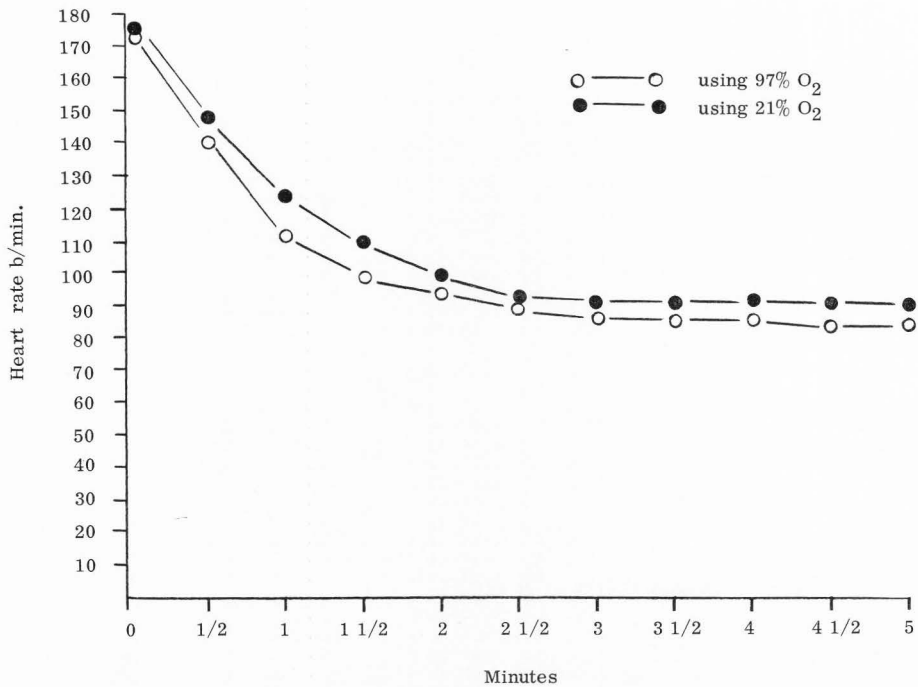


Figure 8. Mean heart rate decline during recovery for subject H.

Figure 9 compares the two mean heart rate declines while breathing the 97 per cent oxygen mixture or the 21 per cent oxygen mixture for subject I. Subject I had a slightly better heart rate decline with the 97 per cent oxygen as did subject H. Subject I began the period of recovery with an average heart rate of 167 beats per minute, and had an average heart rate of 90 beats per minute at the end of the period while breathing the high oxygen mixture and had an average heart rate of 95 beats per minute while breathing the lesser oxygen mixture at the end of the recovery period.

Figure 10 compares the mean heart rate declines while breathing the 97 per cent oxygen mixture or the 21 per cent oxygen mixture for all subjects. The subjects dismounted the treadmill at an average heart rate of 165 beats per minute. Dismounting heart rates ranged from 180 beats per minute to 144 beats per minute. The average heart rate at the end of 5 minutes of recovery while breathing the 97 per cent oxygen mixture was 83 beats per minute. The range was from 102 beats per minute to 68 beats per minute. The average heart rate at the end of five minutes of recovery while breathing the 21 per cent oxygen mixture was 84 beats per minute. The range of this variable was from 100 beats per minute to 64 beats per minute. It can also be seen that the rate in decrease in heart rate is very similar when the two recovery methods are compared to each other. It can be seen from this graph that the mean heart rate declines for all of the subjects during recovery are very similar when the subjects breathed either the high or lesser oxygen mixture.

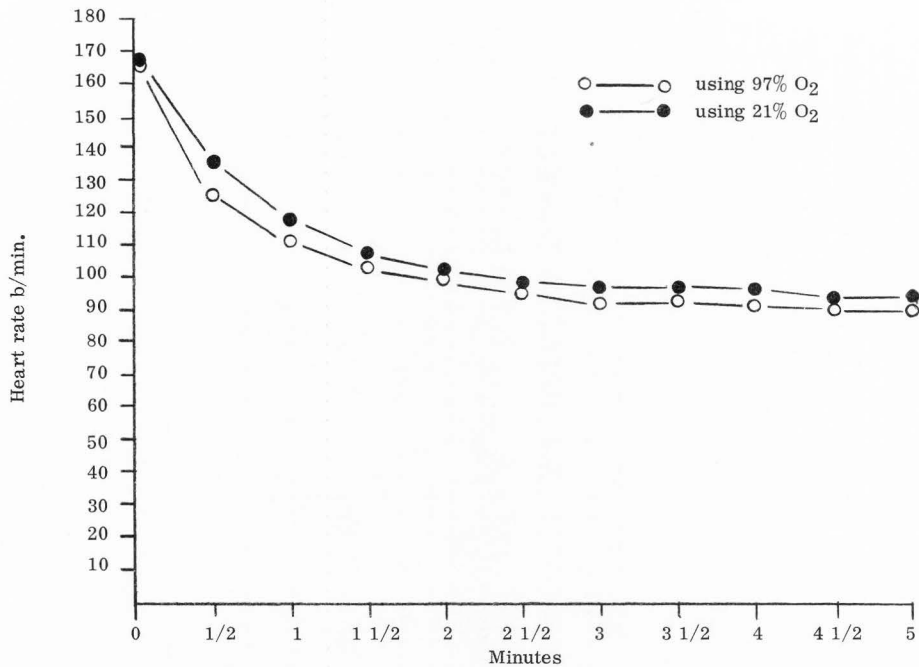


Figure 9. Mean heart rate decline during recovery for subject I.

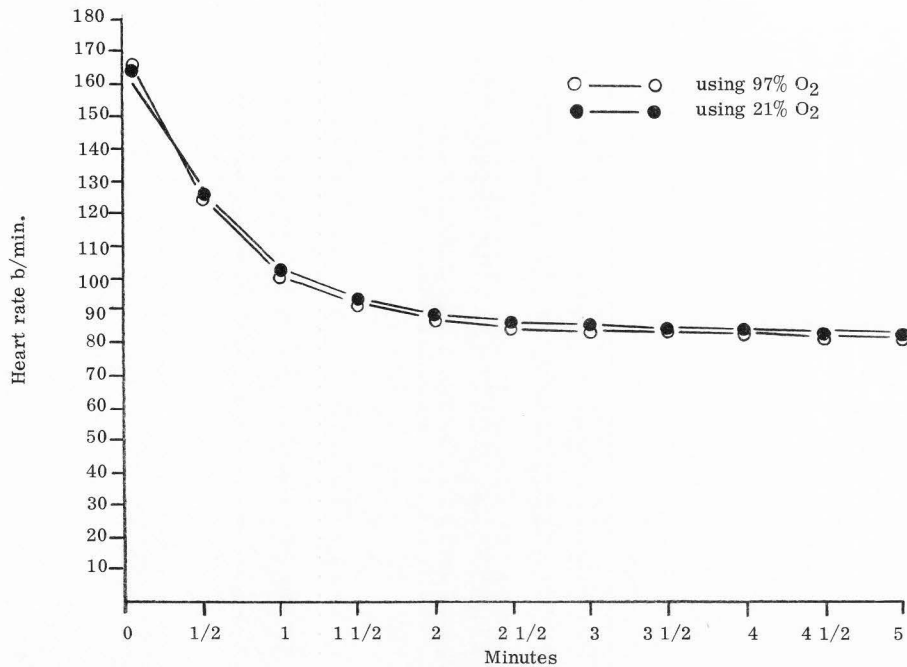


Figure 10. Mean heart rate decline during recovery for all subjects.

Expired Air Percentages

Table 1 shows the mean percentages of oxygen and carbon dioxide in expired air for each subject while breathing the 97 per cent oxygen mixture or the 21 per cent oxygen mixture.

Table 1. Mean oxygen and carbon dioxide percentages in expired air from five minutes of recovery using 97% and 21% oxygen mixtures

97% Oxygen mixture			21% Oxygen mixture		
Subject	% Oxygen	% Carbon Dioxide	Subject	% Oxygen	% Carbon Dioxide
A	83	3	A	19	3
B	83	3	B	19	3
C	81	3	C	19	3
D	82	3	D	19	3
E	82	3	E	18	3
F	82	3	F	17	3
G	81	3	G	18	3
H	83	3	H	17	3
I	82	3	I	18	3
ALL	82	3	ALL	18	3

Table 1 shows that regardless of whether the subjects were breathing the high oxygen mixture or compressed air, their average expired air collected over five minutes of recovery contained an average of 3 per cent carbon dioxide. This means that all subjects were utilizing the same amount of oxygen regardless of which oxygen mixture they were breathing. The table also shows the mean percentages for all subjects combined. The average per cent of oxygen in expired air while breathing the 97 per cent oxygen mixture was 82 per cent. The range was from 83 per cent to 81 per cent of oxygen in expired air. The average per cent of oxygen in expired air while breathing the 21 per cent oxygen mixture was 18 per cent. The range of the variable was from 19 per cent to 17 per cent of oxygen in expired air.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary and Conclusions

The purpose of this study was to determine the effects on recovery while breathing a 97 per cent oxygen mixture and a 21 per cent oxygen mixture (normal atmospheric compressed air). The effects examined were determined by heart rate and percentages of oxygen and carbon dioxide in expired air. Conclusions from this study would help in forming a better understanding of the usefulness of giving oxygen to athletes during time-out periods by some athletic teams.

The subjects were nine varsity wrestlers at Utah State University who began this study one week after their wrestling season had ended.

The study consisted of a training period for all subjects. This consisted of eight runs on a treadmill to enable the subjects to plateau in conditioning and familiarize themselves with the equipment. The experiment consisted of six runs on a treadmill at 0 per cent grade at 8 miles per hour for five minutes. After the runs, the subjects breathed either the 97 per cent oxygen mixture or the 21 per cent oxygen mixture for five minutes. Heart rate decrease and percentages of oxygen and carbon dioxide in expired air were taken during the five minute recovery period and compared. A statistical program of analysis of variance was used to compare the effect of the two gas mixtures on recovery.

A problem in this study was controlling the pre-test condition of non-activity. Approximately 10 per cent of the test runs were performed when subjects checked in with higher than their normal resting heart rates.

It was found that the amount of workload was at the submaximal exercise level for these conditioned athletes. They were dismounting the treadmill at an average heart rate of 165 beats per minute, which is below maximal exercise heart rates.

Results showed that there was no significant difference in speed of recovery when either the 97 per cent oxygen mixture was breathed or the 21 per cent oxygen mixture was breathed. Even though five of the nine subjects had slightly greater heart rate declines while using the high oxygen mixture, these differences were not significant when statistically applied. Also, percentages of carbon dioxide in expired air during the recovery period was very similar when using either recovery mixture.

These findings support the findings of the majority of studies reviewed including Hangerman et al.,¹ Bjorgum and Sharkey,² and Miller et al.,³ and

¹Frederick C. Hangerman, et al., "The Effects of Breathing 100 Per Cent Oxygen Before and After Exercise," Research Quarterly, XXXIX (December, 1968), p. 41.

²Richard R. Bjorgum and Brian J. Sharkey, "Inhalation of Oxygen as an Aid to Recovery After Exertion," Research Quarterly, XXXVII (December, 1966) p. 462.

³A.T. Miller, et al., "Influence of Oxygen Administration on Cardiovascular Functions During Exercise," Journal of Applied Psychology, V (October, 1952), p. 168.

within the delimitations of this study, it was found that a higher concentration of oxygen as compared to regular atmospheric compressed air did not aid in the speed of recovery.

Recommendations

To help form a stronger understanding of the effect of oxygen administration on recovery, future studies should concern themselves with the following:

1. The psychological effects that the administration of oxygen has on recovery.
2. The comparison of submaximal and maximal exercise periods and how oxygen effects their corresponding recovery periods.
3. The comparison of oxygen administration on different levels of acclimatized athletes.
4. The facts hindering or helping a person relying on extra oxygen for recovery and its effect on physical conditioning.

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