THE EFFECTS OF AMMONIA INHALATION ON MUSCULAR STRENGTH, ANAEROBIC CAPACITY, POWER, AND PERFORMANCE

A Thesis

by

Mary Paula Green

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APPROVED BY:

Harold S. O'Bryant
Chairperson, Thesis Committee

Vaughn K. Christian
Member, Thesis Committee

Robert L. Johnson
Member, Thesis Committee

E. Ole Larson
Chairperson, Department of Health Education,
Physical Education and Leisure Studies

Joyce V. Lawrence
Dean of Graduate Studies and Research

ABSTRACT

THE EFFECTS OF AMMONIA INHALATION ON MUSCULAR STRENGTH, ANAEROBIC CAPACITY, POWER, AND PERFORMANCE. (October 1985)

Mary Paula Green, B. S., Appalachian State University

M. A., Appalachian State University

Thesis Chairperson: Harold S. O'Bryant

The purpose of this study was to investigate the use of ammonia inhalation as an ergogenic aid on muscular strength, anaerobic capacity, power, and a selected performance task.

Thirty-five subjects participated in the study and were divided into two groups. One group included 18 females, and the second group consisted of 17 males. All subjects participated in a periodization weight training program. The groups trained two days a week for 11 weeks. The subjects were tested prior to the training program and were tested again at the end of the 11 weeks. Thus, the same subjects performed as untrained and trained. For all of the selected tests and tasks, each subject was tested once inhaling ammonia and again without inhaling ammonia prior to the actual test or task and therefore acted as his or her own control. The treatment and control conditions were counterbalanced prior to the testing sessions.

The selected performance task was a 40 yard dash. Muscular strength was determined by a one repetition maximum (1RM) parallel squat and supine bench press. A modified Wingate cycle ergometer test was used to measure anaerobic capacity while anaerobic power was determined by the vertical jump test and the Lewis Formula.

Pre and post training data were collected and analyzed using analysis of variance (ANOVA) with repeated measures, implementing a 2x(2(2)) factorial design for each test and task. For determination of significance, an alpha level of $p \leq .05$ was used for all variables.

Significant gains were made in all anaerobic capacity, power, and strength measurements after training. The gains were attributed to the periodization weight training program. Male subjects performed significantly better than the female subjects in all strength, anaerobic capacity, power, and speed measurements. Significant improvements were noted in the anaerobic power tests (vertical jump test and Lewis Formula) and 1RM supine bench press measurements when ammonia was inhaled prior to the measurements. A significant interaction existed between the ammonia inhalation treatment and gender for the vertical jump test and Lewis Formula. The author concluded that ammonia inhalation might be an effective ergogenic aid in events requiring strength and anaerobic power if the events emphasized gross muscle mass movements rather than technique.

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CHAPTER 1

Introduction

The use of ergogenic aids has often been thought to give the athlete an "extra-competitive edge" necessary to outperform the opponent (McArdle, Katch & Katch, 1981). Ergogenic aids are substances or phenomena that are workproducing aids and are capable of enhancing athletic performance (Morgan, 1972). Some examples of ergogenic aids used by athletes are drugs, music, warm-up, oxygen, vitamins, carbohydrates, water, mental practices, and various forms of suggestion including hypnosis (Morgan, 1972).

Many factors have been reported to influence the effectiveness of ergogenic aids. Task specificity, individual response, motivational and arousal aspects, and paradoxical distance effects all influence the ability of a particular substance to enhance performance (Morgan, 1972; Oxendine, 1976).

The use of drugs as ergogenic aids has been very popular and yet a controversial issue. Various drugs such as caffeine, amphetamines, anabolic steroids, and ephedrine were reported (Burks, 1981) as common drugs used by athletes. Research investigating the effects and usefulness of drugs used by athletes is available. For example, anabolic steroids have been widely used to enhance strength, power, and speed. Weightlifters, football players, shot putters, discus throwers, and swimmers are just a few of the types of athletes using anabolic steroids (Burks, 1981).

Another drug-like substance now being used by many strength and power athletes is ammonia. Ammonia inhalation was reported as being used by many powerlifters and some Olympic weightlifters. Coaches, trainers, and athletes have felt ammonia inhalation improved a maximal effort in strength performance due to an increased state of arousal (M. H. Stone, personal communication, April 10, 1985; Stone & O'Bryant, 1984). The use of ammonia as an ergogenic aid is questionable due to the lack of sufficient research on the use of ammonia. Only data from two unpublished research projects were available for review investigating the use of ammonia as a performance aid (Moody & O'Bryant, 1984a; 1984b). Thus, the present researcher felt that due to lack of relevant research and due to the controversy surrounding many other ergogenic aids used by strength and power athletes, a definite need for further investigation of ammonia inhalation as such is warranted.

Statement of Purpose

The purpose of the study was to investigate the use of ammonia inhalation as an ergogenic aid in five various strength, anaerobic capacity, power, and performance related tasks. The performance task was a 40 yard dash, with both the one repetition maximum (1RM) parallel squat and 1RM supine bench press as the strength measures. In addition, anaerobic capacity was determined by a modified Wingate procedure while a vertical jump test and the Lewis Formula was used as the measure for anaerobic leg power.

Review of Literature

The review of literature concentrates on several areas related to ergogenic aids including: Factors influencing the effectiveness of ergogenic aids, examples of ergogenic aids, and detailed descriptions of ergogenic aids used in sports requiring strength, power, and speed.

Influencing Factors

Morgan (1972) reported that ergogenic aids may possibly enhance performance by a small percentage and perhaps determine the difference between winning and losing in competition. For example, based on a 100 year old record model, Laties and Weiss (1981) have estimated an individual must make training improvements over a six to seven year period to improve the time to run one mile by only one percent. Yet by taking amphetamines an individual might have improved the one mile time much faster than the required training time. Perhaps the difference in time may have meant the difference in a fourth place finish and a first place finish.

The effectiveness of ergogenic aids has been influenced by several interrelated factors. The nature of the physical performance was reported (Morgan, 1972) as important in determining the type of ergogenic aid needed to improve performance. Some ergogenic aids have been reported to enhance endurance type performances while other ergogenic aids were thought to improve performances in activities requiring strength, speed, and power. Still some ergogenic aids have been used with both aerobic and anaerobic types of athletes (Laties & Weiss, 1981).

Ergogenic aids have also influenced individuals differently. Ikai and Steinhaus (1961) suggested individual experiences were responsible for differences in actions between persons and also influenced differences in one person from one moment to moment and day to day. Simonson (1971) stated, that based on previous research, performance aids improved maximum contractions and durations of submaximum performance most in those subjects that were poorly motivated by removing some type of inhibition. Persons who were highly motivated were capable of maximum performance or maintaining submaximal performance without the use of a performance aid.

Differences in response to ergogenic aids were also influenced by psychological aspects. Motivation has generally been thought to enhance performance moreso than when motivation was not present (Oxendine, 1976). Oxendine stated the effectiveness of motivation varied with the individual and the type of performance. Cratty (1968) reported an optimal level of motivation existed for a best performance in a specific activity. Cratty stated an individual's ability to raise or lower tension levels within himself prior to the performance enhanced success in athletic performance. The tension level was indicative of a person's level of activation

(Cratty, 1968). Oxendine (1968) listed various optimal arousal levels needed for a maximal performance in particular types of activities. Gross motor activities involving strength, power, and speed required a very high level of arousal. In activities not requiring strength, power, and speed a high level of arousal was unnecessary for optimal performance and sometimes was detrimental to performance.

Several "psyching-up" drugs have allowed athletes to compete or train at higher levels of arousal than normal. Psychomotor stimulants such as amphetamines, sympathominetics such as ephedrine, and central nervous system stimulants such as caffeine were drugs thought to enhance arousal (Burks, 1981; Laties & Weiss, 1981).

Users tried to increase the state of arousal by using certain ergogenic aids while at the same time were warned about the paradoxical "distance effects" of some ergogenic aids. Increased dosage of a particular ergogenic aid beyond a certain point has been reported as detrimental to performance (Morgan, 1972; Stone & O'Bryant, 1984).

Another psychological aspect concerning the use of ergogenic aids was the user's thoughts about possible performance benefits due to intake of ergogenic aids. Morgan (1972) and Smith and Beecher (1959) reported that an individual's performance may improve when using ergogenic aids simply because the individual felt the aid would enhance performance.

Ergogenic Aid Examples

Despite various factors that have been reported to influence the usefulness of ergogenic aids, athletic performers, coaches, and trainers have encouraged the use of many various substances and phenomena thought to enhance performance. Drugs, mental practice and suggestion, blood doping, ammonia, cold application, gun shot and loud verbal shouts were suggested by authorities as examples of ergogenic aids (Horvath, 1982; Ikai & Steinhaus, 1961; Mathews & Fox, 1976; McArdle et al., 1981; Stone & O'Bryant, 1984).

Strength, Anaerobic Power, and Speed Aids

Of particular interest were ergogenic aids used to enhance strength, power, and speed gains. Drugs such as amphetamines, caffeine, ephedrine, anabolic steroids, and ammonia were all reported as types of ergogenic aids used by strength-power athletes. Some drugs such as ammonia were reported as possibly increasing the state of arousal of a performer during training and competition (Stone & O'Bryant, 1984), while other drugs such as anabolic steroids were capable of psychological benefits and enhancing muscle growth and tissue repair (Mandell, Stewart, & Russo, 1981).

Burks (1981) stated amphetamines were popular among football players and cyclists. Athletes have used amphetamines mainly because the athletes felt the drug facilitated speed and endurance. Some researchers (Chandler & Blair, 1980) have recommended further research concerning amphetamines possible influence on muscular power-dominated movements was needed.

Caffeine and ephedrine, central nervous system stimulants, have been popular drugs with strength-power athletes. Cyclists and runners have used caffeine to enhance performance, while ephedrine has been popular with swimmers (Burks, 1981).

A drug used mainly by strength and power athletes in recent years has been anabolic steroids. Several sources (Burks, 1981; McArdle et al., 1981; Stone & O'Bryant, 1984) reported on the wide use of anabolic steroids, and the drug's physiological and performance effects. Weightlifters, football players, body builders, runners, and swimmers were a few examples of the many different athletes using anabolic steroids. Anabolic steroids were thought to enhance muscular growth, tissue repair, and help improve strength, power, and speed in physical performance (Mandell et al., 1981; Stone & O'Bryant, 1984). McArdle et al. (1981) stated the small residual androgenic action of anabolic steroids may cause the athletes to be more aggressive and competitive during training and competition for a longer duration of time.

Although many drugs are believed by coaches, trainers and athletes to aid performance or training development, there were several negative aspects surrounding drug use. The most obvious problem with drug use was possible dangerous side effects. For instance, McArdle et al. (1981) reported possible side effects of using amphetamines were emotional or physiologic drug dependency, headaches, dizziness, confusion, and specific cardiovascular problems. Serious side effects have also been related to anabolic steroid use such as atherosclerosis, hypertension, and possible cancer (Stone & O'Bryant, 1984).

Other controversies concerning drug use in sports included banning of many drugs by the International Olympic Committee, questions about research investigating drug use, conflicting attitudes towards drug use between the medical field and athletes who are increasingly accepting drug use in sports, the increasing use of drugs by original nonusers to remain highly competitive with regular drug users, etc... (McArdle et al., 1981; Stone & O'Bryant, 1984). Ethical and moral values have also been affected by the increased use of drugs (Stone & O'Bryant, 1984).

Another drug-like substance popular with strength-power athletes, especially powerlifters and to a less extent Olympic weightlifters, has been ammonia. Dr. Michael H. Stone, the Director of Research at the National Strength Research Center at Auburn University, reported ammonia was used by a number of powerlifters at every powerlifting meet to enhance the powerlifter's performance. The ammonia was suggested to increase the arousal level of the user (M. H. Stone, personal communication, April 10, 1985). According to Oxendine's levels of arousal, weightlifters were athletes who required a high state of arousal to perform at a maximal level (Oxendine, 1968). Use of ammonia inhalation as an ergogenic aid was probably less prevalent among Olympic weightlifters due to the high state of arousal involved. The arousal level was suggested as being high enough to interfere with the technique of the lift. Stone reported the lifting technique was very important in Olympic weightlifting and less important in powerlifting. The lifts in powerlifting competition required more emphasis on gross motor skill and strength with less emphasis on technique (M. H. Stone, personal communication, April 10, 1985).

Unlike other drugs, very limited research was available on the use of ammonia inhalation as an ergogenic aid. Only two unpublished studies were available for review. Moody and O'Bryant (1984a) investigated the use of ammonia inhalation as an ergogenic aid in lifting weight. Twelve trained female subjects performed a 1RM parallel squat and a 1RM bench press. Groups were counterbalanced for treatment, an experimental treatment with ammonia inhalation before lifts and a control treatment without ammonia inhalation. No significant difference was found between the ammonia and nonammonia conditions for the 1RM bench press at the .05 level of confidence. There was a significant difference at the .05 level of confidence between the ammonia and nonammonia conditions for the 1RM parallel squat. In a second study Moody and O'Bryant (1984b) investigated the use of ammonia with trained and untrained individuals. There were 5 trained male subjects and 10 untrained subjects. The procedures were similar to the procedures in the previous study (Moody & O'Bryant, 1984a). There was no significant difference between the ammonia and nonammonia lifts for either the trained nor the untrained groups. The group interaction was also nonsignificant. Moody and O'Bryant did report for the parallel squat an increased amount of weight was lifted after ammonia inhalation (Moody & O'Bryant, 1984a). Based on the first study's findings the authors concluded ammonia inhalation enhanced performance in weightlifting events using large muscle groups.

Nothing conclusive was reported in Moody and O'Bryant's second study, but the researchers did suggest that muscular performance for trained and untrained males might be improved by the use of ammonia in events using large muscle groups. Neither study mentioned a control for motivation, and both studies used small subject sizes. Moody and O'Bryant (1984a, 1984b) suggested recommendations for future research investigating ammonia inhalation which included larger sample sizes and competitive powerlifters.

Until further research investigating the use of ammonia as an ergogenic aid is available, the effectiveness of ammonia in enhancing performance is questionable. Researchers have reported several ergogenic aids which may or may not be similar to the arousal effects of ammonia inhalation. Phenomena such as gunshot, loud shouting, and various means of cold applications and the effects on strength have been researched.

Ikai and Steinhaus (1961) investigated the effects of gun shot and loud shouts on the maximum strength of right arm flexor muscles of 25 subjects, 17 males and 8 females. A .22 caliber gun was fired 2, 4, 6, 8 and 10 seconds before the maximal pull was to be performed. The subjects were not warned when the shot would occur. During the final pull, the subjects were told to shout as loudly as possible. No exact time was given for when the testing would end. The researchers found that after gun shot, performance was significantly better than the performance with no prior gun shot. Similarly the after shout maximal pull was better than the maximal pull with no shot or shout. Both findings were significant at the .001 level of confidence. Ikai and Steinhaus felt the theory that human strength performance is limited by psychologically induced inhibitions best explained the study's findings. According to the theory, unusual sensory experience such as gun shot or loud shouts inhibited the internal inhibitions associated with human strength, the aches and pains of maximal effort. Ikai and Steinhaus felt the time between shots effected the maximal pull although the statement was not statistically conclusive. The same basic theory concerning inhibitory mechanisms was used to explain why pulls with 4 to 10 seconds between shots were better. The researchers concluded the limits of human strength were determined by psychological factors and not physiological influences.

In another study investigating the effects of gun shot, (Brubaker, 1968), a gun was fired while subjects rode a cycle ergometer. Two groups of 18 and 20 subjects performed a test in which total workload was measured while subjects pedaled the ergometer. The groups were counterbalanced for experimental and control conditions. The gun shot occurred when each subject's pulse rate read 175 beats per minute. No verbal encouragement was given during the tests. Among the findings, Brubaker reported significant increases at the .05 level of confidence in work performed when the test was performed with a gun shot during the test. Gun shot was an effective ergogenic aid and improved work performance while pedaling a cycle ergometer (Brubaker, 1968).

Another phenomena which has received considerable attention as a possible ergogenic aid has been cold stimulus. Falls (1972) stated that based on the available literature, cold application was more likely to enhance physical performance than hot application was. Due to the high heat capacity of cold water, cold water was the most effective cold stimulus. Two means of applying cold as an ergogenic aid have been cold showers and cold applications to the abdominal region (Falls, 1972; Horvath, 1982). Rosen (1952) found that runners ran significantly faster times in a 440 yard dash after applying an abdominal cold spray. Sixteen subjects performed the 440 yard run twice on separate days, the first day without a cold spray and the second day with a cold spray. The findings were significant at the .05 level of confidence. The effects of a rest period, exercise, and a cold spray on spot-running performance of 18 male subjects were investigated by Sills and O'Riley (1956). The researchers found that cold spray improved spot-running performance more than rest or exercise did.

The effects of a cold shower on skin temperature and exercise rate were investigated by Falls and Humphrey (1970). The researchers noted several possible physiological reasons for enhanced physical performance when using cold application. The four different experimental conditions were no shower, a 3-, a 6-, and a 9-minute shower. The experimental conditions preceded walking on a treadmill during which workload was measured. Subjects rested for ten minutes between all shower conditions and workload measurements. Among the results were significantly lower ($p \leq .05$) exercise heart rates for all three shower conditions than when no shower preceded exercise. The exercise heart rate for the work period after a 9-minute cold shower was significantly lower than the workload associated with the 3-minute shower. Although Falls and Humphrey did not know exactly why the exercise heart rate was reduced, the researchers felt that possible lower skin temperatures may have influenced the findings. Falls (1969) also reported a 10-minute shower significantly reduced exercise and recovery heart rates even after 20 minutes lapsed between the shower and submaximal exercise. Falls suggested initiating exercise soon after a 10-minute shower resulted in low circulatory costs.

Horvath (1982) and Johnson and Leider (1977) cited several studies which found significant increases in post-recovery grip strength and other studies which reported no increases in grip strength in post-recovery conditions. Johnson and Leider (1977) investigated the effect of a cold bath on maximum handgrip strength of 12 female subjects. Following a cold bath to the forearm, grip strength significantly decreased below pre-treatment and post-treatment measurements. However after a post-recovery period, grip strength significantly increased compared to control treatments of the same time and pre-treatment measures for either treatment group. Possible explanations for the rebound grip strength included increased vasodilation and muscle temperature after the forearm was removed from the cold bath.

Coppin, Livingstone, and Kuehn (1978) also determined the effects of forearm immersion in a cold water bath. Ten males and four females participated in the study. Grip strength significantly decreased after immersion. Normal strength returned after 40 minutes of post-immersion. Unlike Johnson and Leider (1977), Coppin et al. (1978) found no significant increases in post-immersion grip strength above pre-immersion measures.

Null Hypothesis

The following null hypothesis was tested for selected strength parameters, a performance task, anaerobic capacity, and power tests of this study:

1. There will be no significant difference between ammonia inhalation and non-ammonia inhalation treatments for all tests and groups.

Operational Definitions

Terms used in the present study are as follows:

Repetition maximum. - Maximum amount of weight lifted for a specified number of repetitions (1RM, referred to in strength testing).

1RM. - Maximum amount of weight lifted for one repetition.

Assumptions

During the study the following assumptions were made:

1. Each subject did not participate in any other training program other than the training program designated for the present study.

2. Each subject put forth a maximum effort in all training and testing sessions.

Delimitations

1. Training sessions were limited to twice a week for each of the 11 weeks of training for all subjects.

2. Subjects were limited to untrained and trained subjects only.

Limitations

1. Prior knowledge of the use of ammonia inhalation as an ergogenic aid may have influenced subjects' performances.

2. Due to inclement weather, subjects were unable to complete all required training sessions. One week of 5 sets x 10 repetitions was eliminated from the first 5 week training schedule.

Significance of the Study

The use of many ergogenic aids to enhance physical performance has been investigated. Information such as advantages and disadvantages of using the ergogenic aids, task specificity, possible mechanisms for performance improvement, and possible harmful side effects has been hypothesized. Such information has been reported about ergogenic aids such as drugs, sound stimulus, and cold stimulus. One popular ergogenic aid, ammonia inhalation, has not received the same considerable amount of research investigation. Ammonia inhalation has been widely used by powerlifters and by some Olympic weightlifters (M. H. Stone, personal communication, April 10, 1985; Stone & O'Bryant, 1984).

Yet no research has reported any increased performance in muscular strength facilitated by ammonia inhalation (Moody and O'Bryant, 1984a; 1984b). Thus research is needed that investigates the use of ammonia inhalation as an ergogenic aid to enhance physical performance. Quite possibly, ammonia inhalation might enhance improvements in other performance areas besides dynamic strength measures such as weightlifting. Other sports that require strength, power, and speed might also benefit from ammonia inhalation prior to training and competition. Also if ammonia inhalation was found to be ineffective as an ergogenic aid, persons using the ammonia to improve performance may need to search for other means of enhancing performance. Hopefully questions concerning the use of ammonia inhalation can be answered by the completion of this study.

CHAPTER 2

Methodology

The purpose of the study was to investigate the use of ammonia inhalation as an ergogenic aid on muscular strength, anaerobic capacity, power, and a selected performance task. The performance task was a 40 yard dash. Muscular strength was determined by a 1RM parallel squat and a 1RM supine bench press. Anaerobic capacity was determined by a modified Wingate cycle ergometer test while anaerobic leg power was measured by the vertical jump test converted to power with the Lewis formula.

Subjects

Twenty females and 22 males participated in the study. The subjects were volunteers from beginning weight training classes and an approved weight training program at Appalachian State University. All subjects were untrained prior to the study and had not been weight training for at least one month prior to the beginning of the study. Each subject was required to sign a consent form to participate in the study and agreed to not participate in any further training during the duration of the study (refer to Appendix A). Subjects were tested prior to training and were tested again at the end of the 11 week weight training program. After 11 weeks the subjects were considered trained, and thus the same subjects performed as trained and untrained. For all of the selected tasks, each subject was tested once inhaling ammonia prior to the testing session and once without inhaling ammonia prior to the testing session. Therefore each subject participated as his or her own control.

Materials

Various equipment was used for the testing sessions. When subjects inhaled ammonia, a container with cotton balls immersed in liquid ammonia was available for use.

Preliminary measures. All body weight and height measures were made using Health-O-Meter medical scales.

Forty-yard dash. Handheld stopwatches were used to record total running time.

1RM Parallel Squat and Bench Press. The Appalachian State University varsity weight training facilities and appropriate equipment were used during all training and testing sessions.

Modified Wingate Anaerobic Cycle Ergometer Test. The Wingate cycle ergometer standard protocol (Inbar, 1982) was used on a Monark ergometer fitted with a microswitch revolution counter and interfaced with a P.E.T. 4032 model micro computer. Appropriate software was used to calculate power in watts every 0.2 seconds (Nicklin, 1983). A handheld stopwatch was used to record total elapsed test time.

Vertical Jump Test and Lewis Formula. A centimeter vertical jump board was used to determine each subject's vertical jump measurements. Powdered chalk was used on the fingertips for measurement accuracy. Appropriate computer software was used to calculate power using the vertical jump data and the Lewis Formula (Mathews and Fox, 1976).

Procedures

The use of ammonia inhalation as an ergogenic aid was investigated using measurements that exemplified performances in sports requiring strength, power, and speed. The effects of ammonia on anaerobic capacity and leg power was studied using the modified Wingate test and vertical jump test with the Lewis Formula respectively. The performance task used to investigate the effects of ammonia inhalation on speed was a 40 yard dash. The use of ammonia inhalation for strength effects was studied using a 1RM parallel squat and a 1RM supine bench press. Subjects were tested prior to training and tested again after 11 weeks of training. Prior to the testing sessions, the subjects were divided equally into two groups to counterbalance the treatment of ammonia inhalation. Maximal efforts for each testing session were recorded for statistical use (refer to Appendix B). Preliminary measurements of age, height, and body weight were recorded for each subject prior to the pre-testing sessions (refer to Table 1).

For testing sessions in which ammonia was inhaled, each subject was instructed to deeply inhale liquid ammonia from a glass container and then perform the particular test or task within 5 to 10 seconds after inhaling the ammonia (M. H. Stone, personal communication, April 10, 1985). Ammonia was inhaled only before the actual test or task and not during the stretching or warmup time. The order of testing and rest in between tests was set up to

Table 1

Biometric Data: Group Means and Standard Deviations

Group	Age (years)	Height (cm)	Body Weight (Kg)
Males, n=22	$\overline{X}$=19.64	$\overline{X}$=178.23	$\overline{X}$=75.41
	$\overline{SD}$= 1.71	$\overline{SD}$= 6.05	$\overline{SD}$= 7.93
Females, n=20	$\overline{X}$=20.05	$\overline{X}$=164.18	$\overline{X}$=60.12
	$\overline{SD}$= 2.84	$\overline{SD}$= 6.37	$\overline{SD}$= 7.20

Note. $\overline{SD}$ values are expressed in (±)

allow adequate recovery time for the anaerobic energy system (McArdle et al., 1981). The administering of the ammonia inhalation treatment was identical for the pre and post training measurements and gender. The pre and post training testing orders were different due to scheduling conflicts (refer to Appendix C).

Performance Task. Subjects were instructed to stretch and warmup prior to running. Each subject was instructed to give a maximal effort while running. When ready and positioned for testing, the subject was given the command "Ready, Go" and proceeded to run in a maximal effort for 40 yards. The 40 yard dash has been a popular means of measuring speed with performers such as football players (McArdle et al., 1981). Subjects began running from a standing start. A timer was positioned at the finish line to record running times. A testing assistant was present to provide encouragement to each subject during the running performance.

Strength measures. Prior to 1RM strength measurements, each subject was instructed on proper techniques of a parallel squat and a supine bench press (Johnson & Nelson, 1979; Stone & O'Bryant, 1984). After proficiency in technique was acquired, a 1RM parallel squat and a 1RM supine bench press were performed. A parallel squat was considered a large muscle group, lower body lift, and a supine bench press lift was considered a small muscle group lift, upper body lift. Both strength measurements were made during the same testing session and treatment measurements were made on separate days. O'Shea (1966), Stone and O'Bryant (1984), and

Withers (1970) acknowledged 1RM were the best indicators of dynamic strength. Johnson and Nelson (1979) reported a reliability coefficient of r=.93 for the supine bench press and r=.95 for the parallel squat. Before 1RM attempts, stretching was done for several minutes and warmup sets were used. The warmup sets were increasingly intense to limit variation possibly resulting from acute adaptations in the neuromuscular system (Astrand & Rodahl, 1977). Testing instructions and data sheets for warmup and strength mesaurements were provided for each subject (refer to Appendix D).

A 1RM parallel squat was performed to measure dynamic leg and hip strength. Subjects were required to achieve a position where the top of the thigh was parallel to the floor. A 1RM supine bench press was performed to measure dynamic arm and shoulder strength.

Modified Wingate Anaerobic Cycle Ergometer Test. Standard protocol for the Wingate Anaerobic Test was used (Inbar, 1982), except for several modifications. The resistance load was set prior to testing at 0.087 Kiloponds Kg^{-1} of body weight for males and 0.075 Kiloponds Kg^{-1} of body weight for females (Inbar, 1982). Prior to the modified Wingate anaerobic cycle ergometer test, the body weight of each subject was measured with the subject wearing the test clothing attire. Subjects were individually fitted for seat height in an appropriate manner for pedaling (Christian and Johnson, 1981). Each subject was instructed to pedal in an "all-out" effort for 20 seconds (Christian, 1983). At the command "Ready, Go" each subject began pedaling from a loaded start until instructed to stop. The predetermined resistance load was monitored during the test by a testing assistant. A computer printout containing the power data and cumulative time per switch cycle were obtained for each subject (refer to Appendix F). The power data was recorded in watts and converted to $Kg \cdot m \cdot sec^{-1}$.

Vertical Jump Test and Lewis Formula. The vertical jump test and Lewis Formula have been used as a measurement of anaerobic power (Mathews and Fox, 1976). Standard protocol for Sargent Chalk Jump Test (Johnson and Nelson, 1979) was used. Subjects were allowed free arm swing during the jump. One practice jump was allowed and the best of three trials was recorded for statistical purposes. Each subject was encouraged to perform in a maximal effort. Vertical jump measurements were recorded to the nearest one-tenth centimeter. Vertical jump measurements will be incorporated into the Lewis Formula: power ($kg \cdot m \cdot sec^{-1}$) = $\sqrt{4.9}$ x body weight (kg) x $\sqrt{VJ(m)}$ to determine anaerobic power (Mathews and Fox, 1976). Prior to the vertical jump test, the body weight of each subject was measured with the subject wearing the power test clothing attire.

Training Program

Frequency. Subjects trained two days per week for a total 11 week double periodization program.

Exercises. Subjects were required to perform stretching exercises prior to the exercise session. Light to moderate weights were lifted prior to major muscle mass exercises. Weight lifting exercises were chosen based on the exercises general contribution to the conditioning of the major muscle groups and specific to the required strength, power, and task measurements (refer to Table 2). Each subject maintained a cumulative record of the weight lifting exercises, volume, resistance, and the intensity used for each workout (refer to Appendix F).

Protocols. An 11 week double periodization weight training program was used based on the principles and guidelines of a double periodization program (Stone & O'Bryant, 1984; Stone, O'Bryant, & Garhammer, 1981; Stone, O'Bryant, Garhammer, McMillan, & Rozenek, 1982) (refer to Table 3).

Data Analysis

The data were analyzed using Bio-Medical Data Processing (BMDP) statistical package along with analysis of variance (ANOVA) with Repeated Measures, implementing a 2 x (2(2)) factorial design for each task, test, and strength measure.

Criterion for significance. For determination of significance in all measurements an alpha level $p \leq .05$ was employed.

Table 2

Exercises Used in Weight Training Program

1. Parallel squats
2. Supine bench press
3. Clean pulls (from mid-thigh)
4. Bicep curls
5. Leg curls
6. Bent-knee situps
7. Hyperextensions

Table 3

Weight Training Program Schedule

Exercises	Training Schedule						
	2wks	2wks	1wk	1wk	2wks	2wks	1wk
Parallel squat	5x10	*3x5	+3x2	Active Rest	5x10	*3x5	+3x2
Supine Bench Press	5x10	*3x5	+3x2		5x10	*3x5	+3x2
Clean Pulls (mid-thigh)	5x10	*3x5	+3x2		5x10	*3x5	+3x2
Bicep curls	3x10	3x10	3x10		3x10	3x10	3x10
Leg curls	3x10	3x10	3x10		3x10	3x10	3x10
Bent-knee situps	3x10	3x10	3x10		3x10	3x10	3x10
Hyperextensions	3x10	3x10	3x10		3x10	3x10	3x10

*Cooldown set - (1x10): 70% original 1RM
+Cooldown set - (1x10): 75% original 1RM
Active rest - One week of no lifting; May participate in activities that require speed, strength, anaerobic power such as basketball, tennis, racquetball, sprints, etc...

CHAPTER 3

Results

The data were analyzed to determine the effects of ammonia inhalation on speed, muscular strength, anaerobic capacity, and leg power. Differences in performance due to the weight training program and gender were also noted. An alpha level of $p \leq .05$ was employed in all measurements to determine the significance of the results. Refer to Appendix G for means and standard deviations. Refer to Appendix H for ANOVA tables.

Speed

The 40 yard dash was used as a performance measurement of speed. No significant improvements in speed were noted after the 11 week weight training program. The male subjects had significantly greater speed than the female subjects. No significant difference in speed existed due to the treatment of ammonia. The null hypothesis was not rejected at an alpha level of $p \leq .05$.

Strength

Parallel Squat. A 1RM of a parallel squat was used as a large muscle mass lift to measure lower body strength. Significant improvements in lower body strength were noted after the 11 week weight training program. Noted differences in lower body strength existed between the male and female groups. The parallel squat strength measurements for the male subjects were significantly greater than for the female subjects. The treatment of ammonia inhalation did not significantly influence the parallel squat strength measurement. The null hypothesis was not rejected at an alpha level of $p \leq .05$.

Supine Bench Press. A 1RM of a supine bench press was used as a small muscle mass lift to measure uppper body strength. Significant improvements in upper body strength occurred after the 11 week weight training program. Significant upper body strength differences existed between the male and female groups. Supine bench press strength measurements were greater for the male subjects. The treatment of ammonia inhalation significantly influenced the supine bench press 1RM strength measurements. The null hypothesis was rejected at an alpha level of $p \leq .05$. Greater 1RM values were recorded for upper body strength measurements completed after the subjects inhaled ammonia (refer to Figure 1).

Anaerobic Leg Power

Vertical Jump Test and the Lewis Formula. The vertical jump estimated anaerobic leg power in a ballistic movement. Significant improvements in anaerobic leg power occurred after the 11 week weight training program. The male subjects had significantly greater anaerobic leg power than the female subjects. When the subjects inhaled ammonia prior to performing the vertical jump, significant improvements were noted in anaerobic leg power when compared to vertical jump performances completed without inhaling

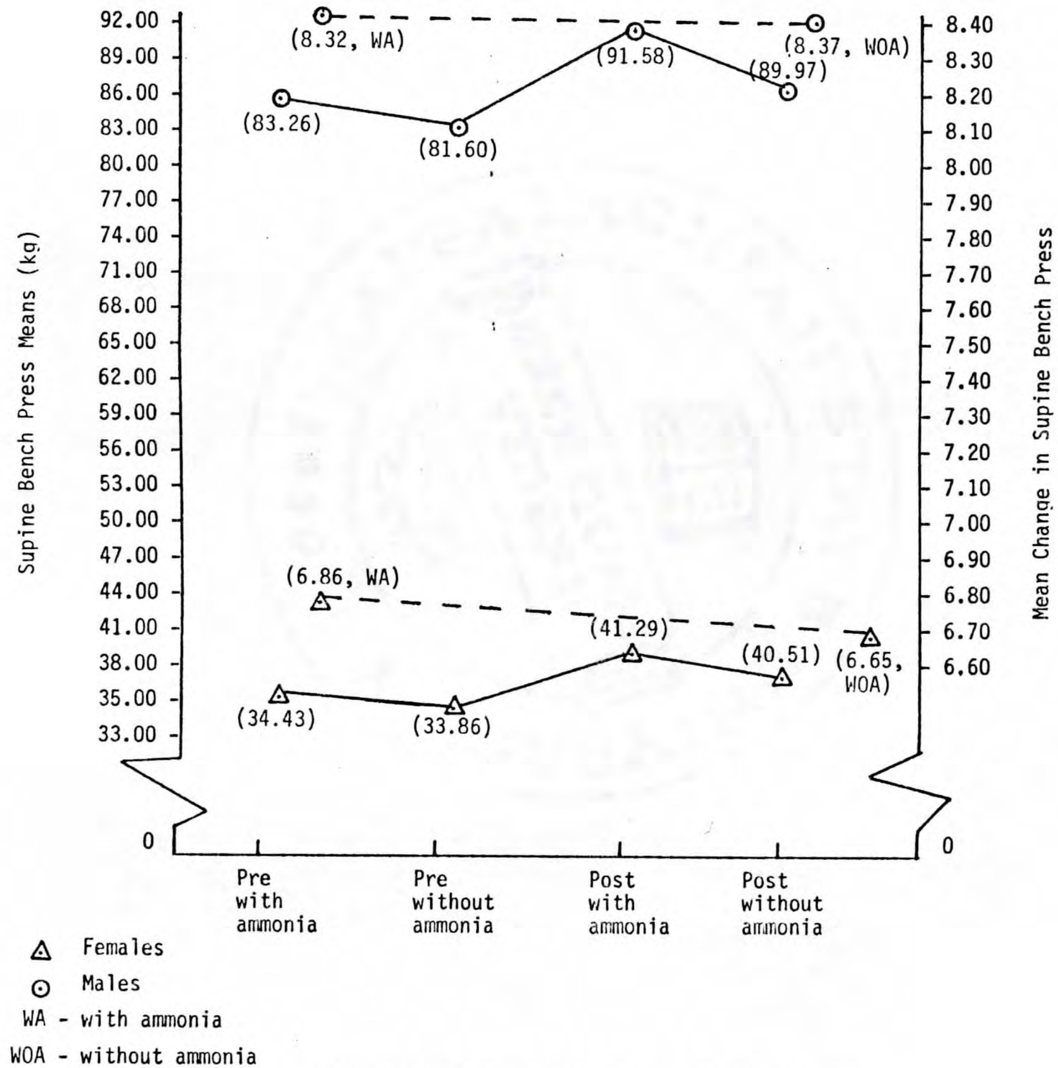
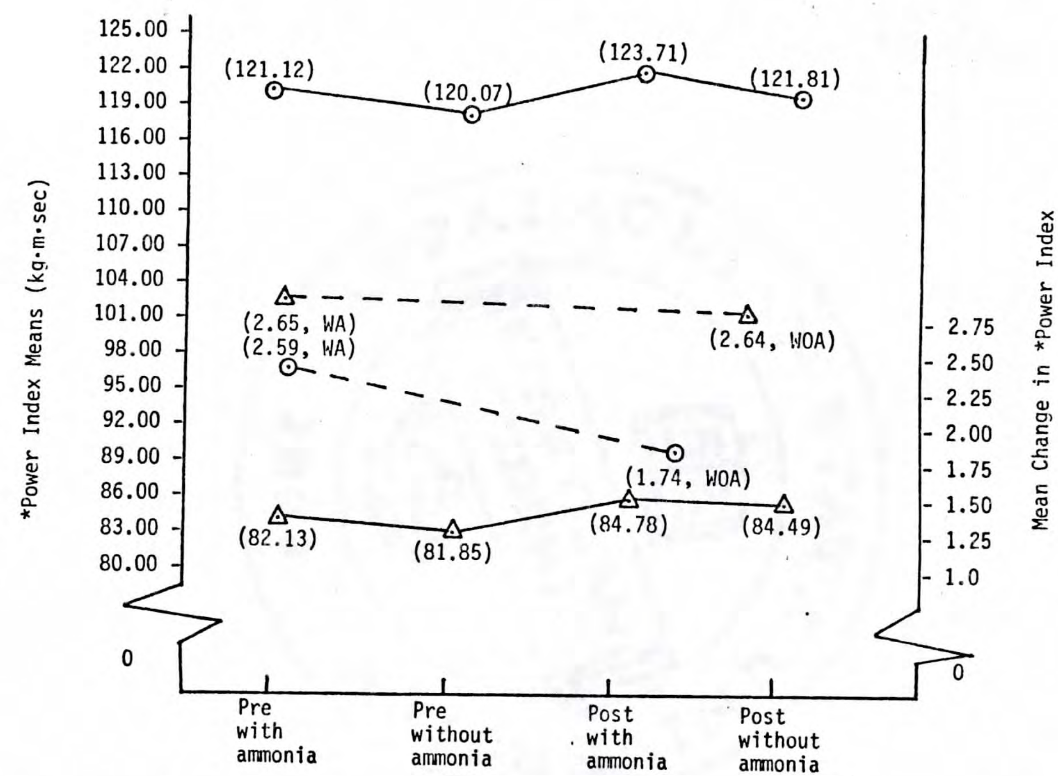


Figure 1. Supine Bench Press and Mean Changes

ammonia (refer to figure 2). The null hypothesis was rejected at an alpha level of $p \leq .05$. A significant interaction existed between the treatment of ammonia inhalation and gender. Male subjects performed significantly better than the female subjects when ammonia was inhaled prior to the vertical jump measurements (refer to Figure 1). No significant interactions were noted.

Anaerobic Capacity

Modified Wingate Anaerobic Cycle Ergometer Test. Peak power was recorded as the maximum anaerobic power value for the ergometer test. Significant anaerobic power improvements were noted after the 11 week training program. Peak anaerobic values were significantly greater for the male subjects than for the female subjects. No significant difference existed in anaerobic power performances due to the treatement of ammonia inhalation. The null hypothesis was not rejected at at alpha level of $p \leq .05$.



* Vertical Jump Test and Lewis Formula
△ Females
⊙ Males
WA - with ammonia
WOA - without ammonia

<u>Figure 2</u>. Power Index and Mean Changes

CHAPTER 4

Discussion

Of the 42 total subjects, 20 females and 22 males, who originally agreed to participate in the study, 18 females and 17 males completed all pre- and post-training requirements. Of the total 35 subjects who completed all training requirements, several subjects were not able to complete all testing requirements for various reasons. The training benefits of the 11 week weight training periodization program were shown to be significant in the strength and anaerobic power test measurements. Significant strength and anaerobic power gains were also reported in other periodization weight training programs (O'Bryant, 1982; Stone et al., 1981; Stone et al., 1982). The difference between previous research investigating periodization weight training programs and the present study was that previous research incorporated three to four days a week programs while the present study made use of a two day a week program.

Lack of significant improvements in speed after training may have been in part due to limits of the available equipment. Use of shorter distances and sophisticated testing equipment may improve the use of a performance task to measure speed. Lack of training for the 40 yard dash may have also contributed to the results.

The male subjects were superior to the female subjects in all strength, anaerobic power, and speed measurements. Males on the average have more total muscle mass tissue than females, thus the strength, anaerobic power, and speed differences between the groups supported current research (Mathews & Fox, 1976; McArdle et al., 1981). The lack of a significant interaction between gender and the training treatment indicated no group was significantly greater ($p \leq .05$) than the other in rate of training.

The findings of the present study were in conflict with the results reported by Moody and O'Bryant (1984a, 1984b). In their first study, the ammonia inhalation treatment significantly improved the performance of 12 female athletes in 1RM of parallel squat strength measurements. No significant differences were reported between the ammonia inhalation and control treatments for 1RM supine bench press strength measurements. In the second study the investigators reported no differences existed between the ammonia and control conditions for the parallel squat or the supine bench press measurements. Ten untrained and 5 trained male subjects participated in the second study. The researchers concluded weight lifting events using large muscle mass events such as the parallel squat benefited by using ammonia inhalation as an ergogenic aid prior to lifting. Lack of additional research made a comparison between the available research and the present study difficult. The present study used a larger sample size and also provided a means of controlling factors such as motivation in comparison to Moody and O'Bryant's research (Moody & O'Bryant, 1984a, 1984b).

Stone (personal communication, April 10, 1985), noted the use of ammonia inhalation among Olympic weight lifters was limited due to possible arousal interference with technique in completing a lift. Powerlifters were required to complete lifts in which gross muscle mass movements were more important than technique. Competitive powerlifters were more prevalent users of ammonia inhalation. The present study's findings may support Stone's proposed viewpoint. An arousal effect may have stimulated the subjects to perform better in events requiring more emphasis on gross muscle mass movements rather than technique. The supine bench press and vertical jump were performance events in which gross muscle mass movement may have been more important than technique when compared to events such as the parallel squat 1RM and the 40 yard dash. The use of ammonia inhalation significantly improved 1RM supine bench press and vertical jump measurements. The parallel squat and the 40 yard dash were measurements requiring proficiency in proper technique. Performing a 1RM parallel squat with the thigh position horizontal to the floor may have been a problem for subjects in the present study. Inhaling ammonia may have interfered with the concentration level needed to complete the parallel squat. An explanation for the results in the 40 yard dash was less obvious. The ammonia inhalation may have interfered with the concentration of the subject when preparing for the tester's signal to start running. Technique and concentration problems may have also been sources of error and may explain why neither ammonia inhalation nor control conditions significantly influenced 1RM parallel squat strength and speed measurements.

The only significant interaction which existed was between gender and ammonia treatment for the vertical jump and the Lewis Formula anaerobic power test. The male group performed better than the female group performed when ammonia was inhaled before the vertical jump measurement. Due to lack of consistency for this particular interaction in the other performance measurements, a precise explanation for the gender and ammonia inhalation was not available.

The modified Wingate cycle ergometer test required more emphasis on gross muscle movement rather than technique. The anaerobic capacity test also required a certain amount of concentration by the subject in preparation for the tester's signal to start. Ammonia inhalation prior to the test may have interfered with the subject's concentration. Interference with the subject's concentration may have also been a source of error and explain why neither the ammonia inhalation or the control conditions influenced performance.

There were no significant interactions between training and ammonia inhalation treatments for the supine bench press and vertical jump measurements. An elite group which had weight trained for at least one year was not available for testing measurements. To fully analyze the effects of ammonia inhalation as an ergogenic aid, an elite group was needed to understand the interaction between ammonia inhalation and additional factors such as training status and competition.

Summary and Conclusion

The use of ammonia inhalation as an ergogenic aid was investigated in the present study. Previous research investigating the topic has been limited. The findings of the present study were in conflict with previous research. The sample size and experimental procedures used in the present study may have influenced the existing differences between the present study and previous research. No precise answer has been found concerning the use of ammonia inhalation as an ergogenic aid in events requiring muscular strength, anaerobic power, and speed. The present study did indicate that the use of ammonia inhalation prior to events requiring muscular and anaerobic power may be beneficial if the events emphasize gross muscle mass movements rather than technique. The present researcher recommends that future research including a larger sample size, untrained, trained, and elite weight lifters be completed before ammonia inhalation is suggested as an effective ergogenic aid for events requiring muscular strength, anaerobic capacity, power, or speed.

REFERENCES

Astrand, P. O. and Rodahl, K. (1977). Textbook of work physiology (2nd ed.). New York: McGraw-Hill.

Burks, T. F. (1981). Drug use in athletics: Introduction to symposium. Federation Proceedings, 40(12), 2680-2681.

Brubaker, C. E. (1968). The ergogenic effects of sound reinforcement. Unpublished master's thesis, University of Orgeon, Eugene, Oregon.

Chandler, J. V. and Blair, S. N. (1980). The effect of amphetamines in selected physiological components related to athletic success. Medicine and Science in Sports and Exercise, 12(1), 65-69.

Christian, V. K. and Johnson, R. (1981). Laboratory Experiences in Exercise Physiology: Measurement, Evaluation, Application, Center for Instructional Development at Appalachian State University: Boone, NC.

Christian, V. K. (1983). Studies of anaerobic bikework power. Unpublished study. Appalachian State University, Boone, NC.

Coppin, E. G., Livingstone, S. P., and Kuehn, L. A. (1978). Effects on handgrip strength due to arm immersion in a 10° C water bath. Aviation Space and Environmental Medicine, 49 (July-December), 1322-1326.

Cratty, B. J. (1968). Movement behavior and motor learning. New Jersey: Prentice-Hall.

Falls, H. B. (1969). Circulatory responses to cold showers: Effect of varied time lapses before exercise. Research Quarterly, 40(1), 45-49.

Falls, H. B. (1972). Heat and cold applications. In W. P. Morgan (Ed.), Environmental stress: Individual human adaptations (pp. 119-154). New York: Academic Press.

Falls, H. B. and Humphrey, L. D. (1970). Effect of length of cold showers on skin temperatures and exercise heart rate. Research Quarterly, 41(3), 353-360.

Horvath, S. M. (1982). Exercise in a cold environment. In D. I. Miller (Ed.), Exercise and sport sciences reviews: Vol. 9. USA: The Franklin Institute.

Ikai, M., and Steinhaus, A. H. (1961). Some factors modifying the expression of human strength. Journal of Applied Physiology, 16, 157-163.

Inbar, O. (1982). Unpublished description of the Wingate Anaerobic Test, Wingate Institute for Physical Education and Sport, Tel Aviv, Israel.

Johnson, B. L. and Nelson, J. K. (1979). Practical measurements for evaluation in physical education. Minneapolis: Burgess.

Johnson, D. J. and Leider, F. E. (1977). Influence of cold bath on maximum handgrip strength. Perceptual and Motor Skills, 44, 323-326.

Laties, V. B. and Weiss, B. (1981). The amphetamine margin in sports [symposium]. Federation Proceedings, 40(12), 2689-2692.

Mandell, A. J., Stewart, K. D., and Russo, P. V. (1981). [symposium]. The Sunday syndrome: From kinetics to altered consciousness. Federation Proceedings, 40(12), 2693-2698.

Mathews, D. K. and Fox, E. L. (1976). The physiological basis of physical education and athletics. Philadelphia: Saunders.

McArdle, W. D., Katch, F. I., and Katch, V. L. (1981). Exercise physiology: Energy, nutrition, and human performance. Philadelphia: Lea and Febiger.

Moody, G. and O'Bryant, H. (1984a). The efficacy of ammonia inhalation as an ergogenic aid for weight lifting. Unpublished manuscript, Appalachian State University, Boone, NC.

Moody, G and O'Bryant, H. (1984b). [The efficacy of ammonia inhalation as an ergogenic aid for untrained and trained males]. Unpublished raw data.

Morgan, W. P. (1972). Ergogenic aids and muscular performance. New York: Academic Press.

Nicklin, R. (1983). Bikework. American Journal of Physics, 51, 423-429.

O'Bryant, H. S. (1982). Periodization: A hypothetical training model for strength and power. Unpublished doctoral dissertation, Louisiana State University, Louisiana.

O'Shea, P. Effects of selected weight training programs on the development of strength and muscle hypertrophy. Research Quarterly, 37, 95-102.

Oxendine, J. B. (1968). Pyschology of motor learning. New York: Appleton-Century-Crofts.

Oxendine, J. B. (1976). Emotional arousal and motor performance. In A. C. Fisher (Ed.), Psychology of sport (pp. 124-136), California: Mayfield.

Rosen, M. (1952). The effect of a cold abdominal spray upon a repeat performance in the 440-yard run. Research Quarterly, 23, 226-230.

Sills, F. D. and O'Riley, V. E. (1956). Research Quarterly, 27, 217-219.

Simonson, E. (Ed.). (1971). Physiology of work capacity and fatigue. Illinois: Thomas.

Smith, G. M. and Beecher, H. K. (1959). Amphetamine sulfate and athletic performance. Journal of American Medical Association, 170, 542-561.

Stone, M. and O'Bryant, H. (1984). Weight training: A scientific approach. Minnesota: Burgess Publishing.

Stone, M. H., O'Bryant, H. and Garhammer, J. (1981). A hypothetical model for strength training. Journal of Sports Medicine and Physical Fitness, 21, 342-351.

Stone, M. H., O'Bryant, H., Garhammer, J., McMillan, J. and Rozenek, R. (1982). A theoretical model of strength training. National Strength and Conditioning Association Journal, 4, 36-39.

Withers, R. T. (1970). Effect of varied weight training loads on the strength of university freshmen. Research Quarterly, 41, 110.

APPENDIX A

Study Outline and Signed Consent Form for: Effects of Ammonia Inhalation on Anaerobic Power, Muscular Strength, and Peformance

Study Outline and Signed Consent Form for: Effects of Ammonia Inhalation on Anaerobic Power, Muscular Strength and Performance

The purpose of the study is to investigate the use of ammonia inhalation as an ergogenic aid in five various strength, power, and performance tasks. Ammonia inhalation has been used by powerlifters and Olympic weightlifters before lifting in competition events. The effects of ammonia inhalation is not known due to lack of research on the topic.

For each strength measure, power test, and performance task, each subject will be required to inhale vapor from liquid ammonia during the testing session and perform the test at another time without inhaling ammonia. The subject will be required to be tested twice for each test at different times. All measurements will be made prior to and after the training program.

The performance task is a 40 yard dash and requires the subject to run 40 yards in a maximal effort. The test should take no more than 10 minutes (includes stretching time). Two tests will be used to measure power. The first test is a vertical jump test and is also a course requirement. The subject will be required to jump as high as possible four times. The second test is a bike power test and requires the subject to ride a cycle ergometer in an 'all-out' effort for twenty seconds. The two tests are done at the same testing session and should take no more than 10 to 15 minutes (includes stretching time). The strength measurements will be done in class and are course requirements. 1RM of a parallel squat and supine bench press will be performed. A 1RM is a lift in which a person lifts as much weight as possible at one time. All subjects will be given time to work on proper technique prior to the strength measurements.

Maximum effort and class attendance are very important to the success of the study. Attending class is also of great importance to your personal development and goals to improve your physical condition. It is also important that you train twice a week and only during the class time to avoid problems with the training schedule and study. Your help would be greatly appreciated.

Thanks!!

Paula Green

I ______________________ agree to participate in Paula Green's research study. I understand the study requires each subject to inhale ammonia and perform in a maximal effort. After the instructor and assistants have explained all testing procedures prior to the testing sessions, and I have read the study outline, I assume full responsibilities for any possible injuries and/or discomforts caused by participation in the study. I agree to give maximum effort during the training and testing sessions. I agree to lift weights twice a week during the designated class time for duration of the study.

Signature__________________________________

APPENDIX B

Information/Result Sheet

Information/Result Sheet
(Circle One): Pre-Test Post-Test

Paula Green | Name______________________

Research Study | Subject #____________

Thesis, Spring, 1985 | Class Sect.____________

Preliminary Measures | Order of Trt.______ ______

Age_____ Height _____ | w/A w/out

Sex_____ Body wt._____ lbs.

40-Yard Dash Results

w/out ammonia:

Date:_________ Time:_________

Testers:____________________

Time:_________ sec.

w/ammonia:

Date:_________ Time:_________

Testers:____________________

Time:_________ sec.

1RM Results

Parallel Squat

w/out ammonia:

Date:_________ Time:_________

Testers:____________________

Spotters:____________________

1RM:_________ lbs.

w/ammonia:

Date:_________ Time:_________

Testers:____________________

Spotters:____________________

1RM_________ lbs.

Supine Bench Press

w/out ammonia:	w/ammonia:
Date:__________ Time:_________	Date:__________ Time:_________
Testers:______________________	Testers:______________________
Spotters:_____________________	Spotters:_____________________
1RM:__________ lbs.	1RM:__________ lbs.

Vertical Jump Results

w/out ammonia:	w/ammonia:
Date:__________ Time:_________	Date:__________ Time:_________
Testers:______________________	Testers:______________________
Body weight:__________ lbs.	Body weight:__________ lbs.
Initial Reach:________ cm	Initial Reach:________ cm
Trial 1______ 2______ 3______	Trial 1______ 2______ 3______
Best________ cm ________ in	Best________ cm ________ in
Power__________ $kg{\cdot}m{\cdot}sec^{-1}$	Power__________ $kg{\cdot}m{\cdot}sec^{-1}$

Bike Power Results

w/out ammonia:	w/ammonia:
Date:__________ Time:_________	Date:__________ Time:_________
Testers:______________________	Testers:______________________
Body weight:__________ lbs.	Body weight:__________ lbs.
Resistance load:________ kp	Resistance load:________ kp
male: .083xBWT; female: .075xBWT	
Power______watts______ $kg{\cdot}m{\cdot}sec^{-1}$	Power______watts______ $kg{\cdot}m{\cdot}sec^{-1}$
Time to max power ______ sec.	Time to max power ______ sec.

APPENDIX C

Order of Testing Sessions

Order of Testing Sessions

Pre-Training Measurements

Order of Session	Testing Session
1	40 yard dash
2	* Vertical Jump
3	* Modified Wingate Anaerobic Power Test
4	+ Strength Measures (Supine bench press, parallel squat)

Post-Training Measurements

Order of Session	Testing Session
1	+ Strength measures (supine bench press, parallel squat)
2	40 yard dash
3	* Vertical Jump
4	* Modified Wingate Anaerobic Power Test

* Performed at the same testing session with enough rest between the two tests to allow adequate recovery time for the anerobic energy system (McArdle et al., 1981)

\+ The supine bench press and parallel squat measurements were counterbalanced for ammonia treatment and gender.

APPENDIX D

1RM Strength Measurements

1RM Strength Measurements

Reminders:

1. Stretch out properly before attempting a max.

2. Parallel squat - Requires you to position the top of the thighs horizontal to the floor.

3. Supine bench - Requires you to take the bar down slowly to your chest, lightly touch your chest and fully extend your arms. Avoid arching your back during the lift and keep your feet on the floor.

4. Max attempt - Requires light warmup and 3 max attempts, with the last attempt your maximal lift. Add on weight accordingly so that the last lift is a max attempt and you don't under- or over-shoot your true max.

Parallel squat-

Light warmup: 1x5 ____________ lbs.

1x3 ____________ lbs.

Max attempt: 1st ____________ lbs.

2nd ____________ lbs.

*3rd ____________ lbs.

+4th ____________ lbs.

+5th ____________ lbs.

*parallel squat max: ____________ lbs.

Supine bench-

Light warmup: 1x5 ____________ lbs.

1x3 ____________ lbs.

Max attempt: 1st ____________ lbs.

2nd ____________ lbs.

*3rd ____________ lbs.

+4th ____________ lbs.

+5th ____________ lbs.

*supine bench max: ____________ lbs.

+use only if needed

APPENDIX E

Example of a Computer Printout of the

Modified Wingate Anaerobic Power Test Data

Example of a Computer Printout of the

Modified Wingate Anaerobic Power Test Data

Name: MD
Timer Cycle Time = 8.31970564E-03 Sec
Number of Switch Cycles = 32

TIME(S)	POWER(W)	LOGPOWER
.24	595	6.38
.91	361	5.88
2.25	160	5.07
3.98	185	5.22
5.42	232	5.44
6.28	674	6.51
6.72	674	6.51
7.17	662	6.49
7.62	662	6.49
8.07	650	6.47
8.53	650	6.47
8.99	638	6.45
9.46	627	6.44
9.93	627	6.44
10.41	627	6.44
10.89	616	6.42
11.38	595	6.38
11.88	595	6.38
12.38	586	6.37
12.89	567	6.34
13.41	576	6.35
13.94	558	6.32
14.48	550	6.3
15.02	533	6.27
15.59	525	6.26
16.16	518	6.24
16.73	510	6.23
17.33	483	6.17
17.96	470	6.15
18.61	447	6.1
19.29	425	6.05
20.00	420	6.04

APPENDIX F

Example of Weight Training Program

Daily Workout Chart

Example of Weight Training Program

Daily Workout Chart

Name________________________

EXERCISES (5x10)	
Parallel Squats	
Supine Bench Press	
Bent-Knee Situps	
Mid-Thigh Pulls	
Leg Curls	
Bicep Curls	
Hyperextensions	
Date:	
EXERCISES (3x5)	
Parallel Squats	
Supine Bench Press	
Bent-Knee Situps	
Mid-Thigh Pulls	
Leg Curls	
Bicep Curls	
Hyperextensions	
Date:	
EXERCISES (3x2)	
Parallel Squats	
Supine Bench Press	
Bent-Knee Situps	
Mid-Thigh Pulls	
Leg Curls	
Bicep Curls	
Hyperextensions	
Date:	

Original 1RM Parallel Squats: ________ Final 1RM Parallel Squats: ________

Original 1RM Supine Bench Press: ________ Final 1RM Supine Bench Press: ________