THE ENERGY COST OF TRAMPOLINING

By

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Energy is a necessity for existence. Each individual has his own metabolic rate which is required to maintain life. "From 210 to 295 cc. of oxygen per minute are required to provide for the 'basal' metabolism of adults."[1] As more muscles are used and as the body engages in different activities, the demand for oxygen increases.

A significant amount of research has been done over the last twenty to thirty years dealing with the measuring of the amount of oxygen used in different physical activities. "The amount of energy used for an activity can be found by calculating it from the amounts of oxygen absorbed and carbon dioxide eliminated."[2]

Dr. Kenneth Cooper has completed an extensive amount of research measuring oxygen consumption. The Aerobics System, designed by Dr. Kenneth Cooper, is a fitness program that uses a variety of activities to improve one's health. The key to the whole program is oxygen.[3]

Exercise requires energy, consequently a certain amount of oxygen is needed. In the Aerobics program, oxygen consumption testing was

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[1]Peter V. Karpovich, M.D. M.P.E. and Wayne E. Sinning, Ph.D., Physiology of Muscular Activity (Philadelphia, 1971), p. 122.

[2]Ibid., p. 103.

[3]Kenneth Cooper, M.D., M.P.H., Aerobics (New York, 1968), p. 9.

done on numerous subjects in various activities. Some of these activities include: jogging, swimming, cycling, stationary running and cycling, walking, calisthenics, handball, racketball, squash, basketball, volleyball, football, aerobic dance, and tennis. Cooper devised a point system where these activities were assigned a certain number of points based on the amount of oxygen they required. The mile was used as a basic yardstick, running and walking at various speeds and correlating it with oxygen consumption.[4] From the research Cooper developed a chart for points and milliliters of oxygen per kilogram of body weight per minute. Cooper's system for assigning the points is done by multiples of seven. One point is assigned for each seven ml./kg./min. of oxygen. Thus, a person running a mile in six minutes and thirty seconds or less uses approximately 42 ml./kg./min. and would receive six points.[5]

The investigator in this study is a graduate assistant at Oral Roberts University where the Aerobics system has been adopted for the entire faculty and student body. The point system does allow for the development of an individualized fitness program because of its variety. At this point, oxygen consumption tests have not been conducted on the trampoline.

Trampolining did not become widespread until recently, but today it is well established as an interesting, beneficial, and enjoyable addition to the physical education program. Many elementary schools and high schools have now added it to their curriculum, because of its

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[4]Ibid., p. 49.

[5]Ibid.

exercise potential and carry-over value.

The investigator has taught the coed tumbling and trampoline classes at Oral Roberts University for the past two years. Interest has grown in the sport and many questions have been raised as to its aerobic value and its possible training effects on the cardiovascular system.

The purpose of this study was to determine the oxygen consumption of a person while straight jumping on the trampoline. Most of Cooper's work has been done on males only, but this study was conducted on males and females, skilled and unskilled, at two differnt heights of straight jumping on the apparatus. After oxygen consumpion was predicted from telemetered heart rates while on the trampoline and a Bruce treadmill test using a Beckman Metabolic Measurement Cart, aerobic points were predicted for the trampolining activity.

This study is a result of observing college men and women while jumping on the trampoline and personal experience with the apparatus.

Statement of Problem

The purposes of this study were:

1. To determine the energy cost of jumping on the trampoline.
2. To compare the heart rate and oxygen consumption of skilled, unskilled, males, and females while trampolining.
3. To compare the calorie cost of trampolining, in males, females, skilled, and unskilled subjects.
4. To compare oxygen consumption in mls./kg./min. for male, female, skilled, and unskilled trampolinists.
5. To determine the number of Aerobic Points earned while

trampolining at two different heights of bouncing.

Hypotheses of the Study

This study was based on four hypotheses:

1. Trampolining will not produce a training effect on the cardiovascular system.
2. There will be no significant difference in the energy cost of trampolining for male, female, skilled, and unskilled persons.
3. The height of bounce attained while trampolining will not affect oxygen consumption.
4. There will be no significant difference in the milliliters of oxygen per kilogram of body weight per minute consumed between males, females, skilled and unskilled while trampolining.

Delimitations

1. Those persons referred to as skilled jumpers had completed only one semester of trampoline class.
2. The unskilled persons were randomly selected out of aerobic classes at Oral Roberts University.
3. The test involved only straight jumping on the trampoline. No stunts or variation of jumping were allowed.
4. The oxygen consumption was measured directly with the Beckman Metabolic Measurement Cart on only seven tests. All other energy calculations were predicted from the regression equation for each individual.

Limitations

1. Environmental factors at ORU Aerobic Center may have been a factor that affected heart rates.
2. The height of bounce of the subjects was monitored, but subjectivity may have caused some error even though it was measured and a marker next to the trampoline was used.
3. All students are on a cardiovascular training program whether skilled or unskilled on the trampoline.

CHAPTER II

REVIEW OF RELATED LITERATURE

The study of related literature was divided into the following areas: literature on trampolining, oxygen consumption, and heart rate determination, measurement methods, and mechanical efficency.

Literature on Trampolining

Rebound tumbling, otherwise known as trampolining had its begining toward the end of the Medieval period. A frenchman named du Trampoline originated a springboard and also developed a bounding net for exhibition stunts by circus aerialists. This activity became so popular that both the apparatus and activity kept the originator's name.[1]

Trampolining did not become widespread until its equipment became adapted to a small portable frame. In the late 1930's, an American named George Nissen, standardized the apparatus and made it available to the public.[2] Today it consists of a bed, usually made of nylon, which is fastened to steel springs or rubber shock cords and then

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[1]Don Cash Seaton, Irene A. Clayton, Howard C. Leibee, and Lloyd L. Messersmith, Physical Education Handbook (New Jersey, 1969), pp. 187-189.

[2]Hollis F. Fait, John Shaw, and Katherine L. Ley, A Manual of Physical Education Activities (Philadelphia, 1967), p. 229.

fastened to a frame which is mounted on legs about three feet in height.

The stunts in trampolining are performed by bouncing on the bed of the trampoline and are built on a series of movements executed in a sequence between bounces. Sound jumping technique is essential to rapid progress and particularly to success in learning more advanced skills. The body should be in good alignment at all times with the head held erect. The jumper should not look at his feet for that causes the head to be brought forward, and the body will become off balance. A habit should be established of looking at the end of the frame of the trampoline.

The trampolinist's feet should be about shoulder width apart on the mat, and then the feet should be brought together after jumping in the air with his toes pointed. The arms should be bent with hands moving upward close to the body, until the height of the bounce. The shoulders should be lifted also.

When the body begins its descent toward the bed of the trampoline, the arms are brought down also, and the timing should be that the arms are at shoulder height when the feet contact the trampoline's bed. The arms continue downward as the bed is depressed. The jumper should never allow his arms to be moved behind the front half of his body. Only highly experienced persons should jump as high as they are able.[3]

Very little research has been done to determine whether trampolining facilitates cardiovascular fitness. Judith Bateman[4] studied

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[3]Fait, et. al., p. 192.

[4]Judith Bateman, "Effects of Trampoline Training and Tumbling on the Cardiovascular Efficiency of College Women" (Master's Thesis, 1972).

the effect of trampoline and tumbling training on cardiovascular efficiency of college women. Her study consisted of thirty-two college women randomly divided into four groups. One group trained on the trampoline for ten minutes a day for three days. The second group jumped on the trampoline five minutes a day, three days a week. The third group only attended the tumbling class every week and the fourth group was the control group that kept their regular routine. The study lasted for six weeks. Each of the subjects were tested using the Astrand test of maximal oxygen uptake and Cooper's twelve minute test. The t ration indicated significant increases at the .01 level of confidence in cardiovascular efficiency between the pre and post test given to the trampoline trained groups. No difference was found between the trampoline groups. Analysis of covariance for the Astrand test revealed significant differences at the .05 level between the trampoline groups and the group that only attended tumbling class. The other statistical work revealed no significant results.

Two unpublished studies, very similar in nature, by Bell[5] and Wright[6], were done with twelve boys between the ages of five and eleven. The subjects participated one day a week for eight months in a trampoline program. No statistical change in cardiovascular fitness was found. VanAnne[7] did a study on the effects of trampoline

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[5]Harry H. Bell, "The Effect of Gymnastics on the Cardiovascular Conditioning of Boys" (Unpublished Master's Thesis, 1958).

[6]James Wright, "The Effects of Gymnastics Training on the Heartgrams of Young Boys" (Unpublished Master's Thesis, 1954).

[7]Angela VanAnne, "The Effects of Trampoline Exercise on Selected Physical Capacities" (Unpublished Master's Thesis, 1953).

exercises on selected physical capacities. The researcher in the study pre and post tested balance, ankle flexibility, ankle extensor strength, and physical efficiency. Sixty-eight college women participated in a program of badminton, trampoline, body mechanics, and tumbling. The subjects time on the trampoline was not controlled. No significant gains were made or recorded.

Magnusson[8] used the time element as a controlling factor for his study. Each subject spent a total of twenty-nine minutes on the trampoline. Magnusson found a significant increase at the .05 level in ankle extensor strength and cardiovascular endurance.

Youngberg[9] did a study on the aerobic value of trampolining. Her study involved ten college women all enrolled in Beginning Tumbling and Trampoline at a university. The women were chosen randomly and tested twice each over a three week period. The treatment consisted of a progressive difficulty trampoline routine, monitored by heart rate telemetry. The trampoline routine was ordered as follows:

1. Five minutes of straight jumping six inches high.
2. Five minutes of straight jumping eighteen inches high.
3. Five minutes of straight jumping eighteen inches high interspersed with various beginning level stunts every ten bounces.

The routine was a continous fifteen minutes. Youngberg concluded from

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[8]Lucile Magnusson, "The Effects of Trampoline Exercise on Endurance and Ankle Strength" (Unpublished Master's Thesis, 1951).

[9]Linda Youngberg, "The Aerobic Value of Jumping on the Trampoline" (Sr. Paper, 1975).

the study the following things:

1. On the average, the activity was of sufficient intensity to cause a training effect when the second level of work was begun after the sixth minute.

2. Due to various levels of cardiovascular fitness, indicated by resting heart rate, recovery rates, and maximal rates, trampolining facilitated cardiovascular training between the fifth and twelfth minutes. The mean heart rate reached 150 or above in the sixth minute on both tests.

3. Trampolining is a beneficial aerobic activity according to this study for the mean heart rate was above 150 for ten minutes.

Fritz[10] also found significant improvement at the .05 level in balance and cardiovascular efficiency after a trampoline training program. College males were tested on balance, speed, strength of lower leg flexion, explosive power, agility and coordination. He tested on a standardized treadmill test before and after training.

Holzapful[11] stated that prolonged periods on the trampoline have tremendous effect on physical condition. The trampoline offers the opportunity to develop all-around skill and coordination by subjecting its pupils to a wide range of combinations and repetitive movement situations besides developing the cardiorespiratory system in a most enjoyable manner.

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[10] William Fritz, "Effect of a Trampoline Training Program on Selected Items of Motor Fitness (Unpublished Master's Thesis, 1965).

[11] N.R. Holzapful, "Elementary Trampoline Stunts" Athletic Journal (October, 1952), pp. 2-11.

The researcher observed that according to the studies done by Bateman, Magnussen, Youngberg, and Fritz, the comment made by Holzapful on the benefits of trampolining, was accurate. On the other hand the unpublished studies of Bell, Wright, and VanAnne showed no significant increases in cardiovascular fitness. It should be pointed out, though, that in Bell and Wright's studies, the subjects were only on the trampoline once a week. In VanAnne's study the time on the trampoline was not controlled. It would be questionable if any activity carried on for this amount of time and the given conditions would increase cardiovascular endurance.

Oxygen Consumption

When the body is resting it requires from 200-300 cc. of oxygen every minute, and during intensive exercise this may increase up to twenty times. Since muscles make up about forty percent of body weight their consumption may increase at least fifty times.[12] The oxygen that is taken in during a given exercise depends on the intensity of work and the size of the muscles involved. During exercise, the oxygen intake can be increased up to a maximum rate which is referred to as maximal oxygen consumption. It can be recorded as an absolute value in liters consumed per minute or as a relative value of milliliters per kilogram per minute. Milliliters per kilogram per minute (ml./kg./min.) is generally the better indicator of a subject's performance since a very large person may have a high intake just because of his size and greater muscle mass.[13]

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[12]Karpovich and Sinning, p. 90.

[13]Ibid.

There are several ways to measure maximum oxygen intake, but most involve some time of graded workload.

Balke[14] has designed a treadmill test that is quite well known. The subject walks on a treadmill at 3.5 m.p.h. while he is attached to air collection equipment. The treadmill starts out level, but at the beginning of the second minute the grade is raised two percent. Every minute after that the treadmill goes up one percent grade. During the last forty seconds of each period oxygen consumption is measured. The heart rate and blood pressure are also taken each minute. Balke used a heart rate of 180 beats per minute to determine cardiorespiratory capacity and the end of his test.[15] From his work he concluded that the attainment of a heart rate of 180 in exercise represents a physiological point at which cardiorespiratory limitations are manifest due to the observation that this was when a sudden rise in anaerobic work occurred.

Nagle and Bedecki[16] conducted a study that concurred with Balke's research. Forty-four subjects were given an all out run test on a treadmill. The correlation between heart rate and run times increased with heart rate, with a correlation of .85 calculated at 180 beats per minute. Between the rates of 170-180 beats per minute, the ventilation function increases out of proportion to the heart rate

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[14]B. Balke, "Correlation of Static and Physical Endurance" (1952).

[15]Karpovich and Sinning, p. 372.

[16]Francis Nagle and Thomas Bedecki, "Use of the 180 Heart Rate Response as a Measure of Cardiorespiratory Capacity," Research Quarterly (March, 1963).

increase, indicating some deterioration in cardiorespiratory efficiency above this heart rate. There is a tendency for the relationship to become asymptotic between 180 and the maximal rate. Balke found that the oxygen consumption curve did level off at the 180 heart rate. He concluded that this indicated the maximal oxygen consumption, because even though there was an increase in heart rate it was not accompanied by a proportionate increase in delivery of oxygen to the tissues.

Dill[17] described a bicycle ergometer test where the subjects pedaled at a rate of fifty revolutions per minute and the workload is increased 150 kilogram meters per minute after the first minute. The same technique for measuring oxygen was used. Newton[18] compared different approaches and found that those tests that were graded gave higher maximums than either running or bicycling to exhaustion. Hermanson and Saltin[19] also did a comparison of the measurement of maximal oxygen uptake and found that those tests involving the treadmill gave mean scores seven percent higher.

Dr. Kenneth Cooper has done extensive work with air force men in the area of oxygen consumption. The key to Cooper's aerobics program is based on the amount of oxygen consumed during exercise.[20]

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[17] D.B. Dill, Assessment of Work Performance (Philadelphia, 1966).

[18] J.L. Newton, "The Assessment of Maximum Oxygen Uptake," (1963), p. 164.

[19] L. Hermanson and B. Saltin, "Oxygen Uptake During Maximal Treadmill and Bicycle Exercise," (1969), p. 31.

[20] Cooper, p. 24.

Aerobics literally means "with oxygen". Aerobic exercises demand oxygen without producing an intolerable oxygen debt, so that they can be continued for long periods of time.[21] Applying the aerobic concept to fitness means following specific training guidelines. If pursued regularly aerobic activities would have the following effect according to Dr. Kenneth Cooper:

1. Increases the efficiency of the lungs.
2. Increases the efficiency of the heart.
3. Increases the number and size of the blood vessels.
4. Increases the total blood volume.
5. Improves the tone of the muscles.
6. Changes fat weight to lean weight.
7. Increase maximal oxygen consumption by increasing the efficiency of the means of supply and delivery.[22]

The main object of an aerobic exercise is to increase the maximum amount of oxygen that the body can process in a given time. That is aerobic capacity.[23]

Cooper's Aerobic training system is based on points. An activity is assigned a certain number of points based on the amount of oxygen required to perform that particular activity. One point is equivalent to seven milliliters of oxygen consumed a minute. For example: For

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[21]Ibid., p. 28.

[22]Ibid., p. 12.

[23]Ibid., p. 9.

a female to run a mile in seven minutes it would require about 35 ml./kg./min.[24] Thus, she would receive five points. Cooper has calculated that an average of thirty points per week should be earned to maintain cardiovascular fitness.

Heart Rate and Oxygen Consumption

A high maximum intake is dependent upon the optimal functioning of the respiratory and cardiovascular systems and transfer of oxygen and carbon dioxide between the blood and tissues. For this reason the most accurate assessment of oxygen intake is in an exercise physiology laboratory. In researching various types of activities sometimes staying in a physiology laboratory is not feasible.

Heart rate has long been used as a means for estimating intensity of training. Its linear relationship with oxygen intake during submaximal exercise and its relative ease of determination make it a frequently chosen method. Heart rates during exercise have been accurately assessed through ECG and biotelemetry systems.[25]

Following is a review of that literature related to the heart rate and oxygen consumption.

The evaluation of McArdle's[26] research was based on telemetered

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[24]Ibid., p. 49.

[25]Michael Pollock, "Validity of the Palpitation Techniques of Heart Rate Determination and Its Estimation of Training Heart Rate," Research Quarterly (March, 1972), pp. 78-88.

[26]William McArdle, "Aerobic Capacity, Heart Rate, and Estimated Energy Cost during Women's Competitive Basketball," Research Quarterly (May, 1971), pp. 178-185.

heart rates during a women's competitive basketball season. His study attempted to measure the energy expenditure in basketball by recording heart rate with the telemetry and then relating that heart rate during basketball to the subject's heart rate oxygen consumption curve that they established in the physiology lab. This study used six female players.

In a recent study by Morgan and Bennett[27] the heart rate and oxygen consumption were measured in four healthy male subjects during discontinuous and continuous exercise. With the exception of the responses of heart rate and oxygen uptake to low workloads, it was found that the relationship between heart rate and oxygen consumption was similar during steady and unsteady conditions in the discontinuous test. Furthermore, the slopes of the regressions of heart rate and oxygen consumption during discontinuous and continuous work were comparable. It appeared that for this group of subjects, the mean cardiovascular response to exercise, defined as the slope of the regression of the heart rate on oxygen consumption could be obtained by measurement made during discontinuous or continuous exercise.

Noble[28] conducted a study with three highly skilled gymnasts while competing on floor exercise, balance beam, and uneven parallel bars. With the use of telemetry, Noble concluded that compulsory routines were less stressful than optionals.

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[27] D. Brian Morgan and T. Bennett, "The Relation Between Heart Rate and Oxygen Consumption during Exercise," Journal of Sports Medicine and Physical Fitness (March, 1976), pp. 38-43.

[28] Larry Noble, "Heart Rate and Predicted VO_2 During Women's Competitive Gymnastics Routines," (June, 1975), pp. 151-157.

According to Higgs[29], assessment of maximal oxygen consumption for women using continuous and intermittent work capacity tests on a treadmill or bicycle ergometer have produced remarkably consistent findings.

Horvath and Michael[30] tested fourteen women subjects at the workload at which they reached their maximum oxygen consumption. They found that a woman performing at this severe workload would reach exhaustion within two to four minutes. However, men were able to continue for some time at most workloads after reaching their maximal oxygen uptake.

Analysis of the heart rate during submaximal work periods in a recent investigation[31] showed that the curve of the adjustment of the heart rate to the demands of suddenly increased energy output is not the same in arm and in leg exercise. While the heart rate in leg exercise reaches roughly the appropriate level within one to two minutes and continues to increase only slowly and asymptotically, the increase of the heart which follows the initial rise is much steeper in arm exercise and shows no tendency to level off in the course of six minutes of submaximal work. For this reason the degree of differences between the heart rates recorded at the same oxygen uptake

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[29]Susanne Higgs, "Maximal Oxygen Intake and Maximal Work Performance of Active College Women," Research Quarterly (May, 1973), pp. 125-131.

[30]Ibid.

[31]______________"Oxygen Uptake/Heart Rate Relationships in Leg and Arm Exercise, Sitting and Standing," Journal of Applied Physiology (July, 1975), pp. 54-59.

in arm and leg exercises depends also on the duration of work which preceded the measurement of the heart rate.

Wald[32] found the heart rates and oxygen consumption parameters were linearly correlated. For oxygen consumption the heart rate rise time for the light task was significantly shorter than for moderate and heavy tasks. For heart rate the reverse was true. Rise time was found to be significantly shorter as the task load increased. Fall time for heart rate decreased with increased task intensity. However, there was a statistically significant difference only between the light and heavy tasks.

Berggren and Christensen[33] have also used the pulse rate as an index of metabolic rate for work periods.

Astrand and Rodahl[34] have also determined in their studies that in many types of work, the increase in heart rate is linear with the increase in work load. There are exceptions, but they are more frequent among subjects who are untrained. The evaluation from submaximal work loads is based on recording the heart rate during the steady state then extrapolating the line to a fixed heart rate. For women, fifty percent oxygen uptake is attained at a heart rate of 140 beats per minute at twenty five years of age. The rates are generally higher for a given oxygen uptake when the work is per-

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[32]Alvini Wald, "Oxygen Consumption and Heart Rate Changes and Relationships in Static Work," Ergonomics (1975), pp. 299-309.

[33]Karpovich, p. 394.

[34]Per-Olaf Astrand and Kaare Rodahl, Textbook of Work Physiology (New York, 1970), pp. 166-167.

formed with the arms rather than the legs.

Bowles and Siggerseth[35] did a study with heart rate responses in different running efforts. Radio telemetry was used and the responses were used quite conveniently in the evaluation of the overall adaptation to exercise.

Holland[36] also conducted a study to examine the reliability of heart rate during a standardized submaximal oxygen test. Thirty-one men and thirty-two women were tested twice. Heart rates were taken the last fifteen seconds of every minute. The testing produced a significant curvilinear trend between heart rate and oxygen consumption.

It has been the view of the given investigators that a rectilinear relationship exists between heart rate and oxygen consumption through submaximal work only; this relationship not holding through high intensities of work. Submaximal work is that work which is performed at an average heart rate of 180 beats per minute or less.[37]

Sharkey and Halleman[38] tested sixteen college men and their re-

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[35]Charles Bowles and Peter Siggerseth, "Telemetered Heart Rate Responses to Pace Patterns in the One Mile Run," (1968), pp. 36-46.

[36]John C. Holland and Andrew Jackson, "Optimal Measurement Schedules for Submaximal Oxygen Consumption Tests when Heart Rate is the Criterion Measurement," Abstracts of Research Papers (1973).

[37]J.G. Wells and B. Balke, "Lactic Acid Accumulation During Work," Journal of Applied Physiology (1957), pp. 51-57.

[38]John P. Halleman and Sharkey, "Cardiorespiratory Adaption to Training at Specified Intensities," Research Quarterly (1967), pp. 698-703.

sults indicated that training should include intense activity as opposed to light or moderate. A high training pulse rate was necessary to obtain any major effects on training. A heart rate of at least 150 was suggested.

Cooper[39] has stated two basic principles:

1. If the exercise is vigorous enough to produce a sustained heart rate of 150 beats per minute or more, the training benefits will begin about five minutes after the exercise starts and continue as long as it is performed.
2. If the exercise is not vigorous enough to produce a heart rate of 150 beats per minute, but is still demanding oxygen, the exercise will have to be continued considerably longer.

Direct and Indirect Methods of Measuring Oxygen Consumption

Glassford and Baycraft[40] did a study with twenty-four male subjects from seventeen to twenty-three years of age. The subjects were given three direct tests of maximal oxygen uptake (Mitchell, Sproula, and Chapman treadmill, Taylor, Buskirk, and Henschet treadmill, and Astrand's bicycle ergometer test). The subjects were also given one indirect test--the Astrand Rhyming nomogram bicycle ergometer test. All four tests indicated improvement in maximum oxygen intake and intercorrelation between tests show the predicted test method to be as accurate as the direct methods.

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[39] Cooper, p. 30.

[40] R.G. Glassford and G.H.Y. Baycraft, "Comparison of Maximum Oxygen Consumption Values Determined by Predicted and Actual Methods," Journal of Applied Physiology (1960), pp. 509-513.

Astrand and Rhyming[41] have constructed a nomogram for predicting the aerobic capacity by simply measuring the heart rates. Best results are obtained during submaximal work. Terry[42] did a study on college males and the Astrand-Rhyming Nomogram did not accurately predict aerobic capacity. It underestimated their maximum oxygen consumption and the standard error of estimate was 24.2 percent. They recommended that:

1. Additional equations be developed for males and females.
2. Larger study populations.
3. Leg strength be studied in relation to performance on bicycle ergometer.

Astrand[43] constructed the nomogram by determining that fifty percent of the maximum would be reached in five to six minutes. One hundred and twelve well trained males and females were tested and a heart rate of 170 beats per minute was used as a maximum.

According to Karpovich and Sinning[44] there are several factors that determine the rate of oxygen intake. These must be properly coordinated and integrated with the muscles.

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[41]Karpovich, p. 39.

[42]James Wendell Terry, "The Development of a Regression Equation to Predict Workload for the Astrand Test,"

[43]Per Olaf Astrand, "Human Physical Fitness with Special References to Sex and Age," Physiological Reviews (1956), pp. 307-327.

[44]Karpovich, pp. 109.

1. Ventilation of the lungs. This ordinarily increases proportionately to the increase in the work load.
2. Oxygen carrying capacity of the blood, determined by the hemoglobin content of the blood.
3. The unloading of oxygen at the tissues.
4. The Minute Volume of the heart.

Mechanical Efficiency

Foster[45] conducted a study on trained runners and trained non-runners. The trained runners were more efficient in running than the trained non-runners. It seems reasonable to suspect that mechanical efficiency, equated in many studies with aerobic requirements, may be an important component. How much does training improve a person's ability to do that skill economically and reduce their aerobic requirements?

Pechar[46] did a study with sixty males, randomly selected and assigned them to three groups. One treadmill training, one bicycle ergometer, and one group as a control with no training program. The study concluded that:

1. For individual's without prior bicycle experience, there is a difference between maximum oxygen consumption values as measured by the treadmill and bicycle tests. Maximum oxygen

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[45]Carl C. Foster, "Maximum Aerobic Power and the Aerobic Requirements of Running in Trained Runners and Trained Non-Runners," (Unpublished Master's Thesis, 1972).

[46]Gary S. Pechar, "The Effects of Specific Training Upon the Difference in Maximum VO_2 Scores Between Treadmill and Bicycle Ergometer Tests of Cardiorespiratory Function," (Ph.D. Dissertation, 1973).

consumption as measured by the treadmill tests was significantly greater than maximum oxygen consumption by the bicycle tests.

2. A training program utilizing the bicycle as a means of exercise significantly reduced the difference between the maximum oxygen consumption values as measured by treadmill and bicycle tests.

Bransford and Howley[47] did a study to compare the oxygen cost of running in trained males and females and untrained males and females. Forty subjects were studied and they were divided ten into each group. This study supported the theory that there is a linear relationship between oxygen consumption and speed of treadmill running for a specific range of speeds. This relationship holds regardless of a person's sex or whether they are trained or untrained. There were differences though in the oxygen cost of running, not only between trained and untrained groups, but men and women.

[47]Donald R. Bransford and Edward T. Howley, "Oxygen Cost of Running in Trained and Untrained Men and Women," Medicine and Sport (Spring, 1977), pp. 41-44.

CHAPTER III

METHODS AND PROCEDURES

The subjects that participated in this study were students at Oral Roberts University. Their ages ranged from eighteen to twenty-four years of age. The purposes of the study were:

1. To determine the energy cost of jumping on the trampoline.
2. To compare the heart rate and oxygen consumption of skilled, unskilled, males, and females while trampolining.
3. To compare the calorie cost of trampolining in male, female, skilled, and unskilled subjects.
4. To compare oxygen consumption in mls./kg./min. for male, female, skilled, and unskilled trampolinists.
5. To determine the number of Aerobic Points earned while trampolining at two different heights of bouncing.

The administration of the testing took place between March 14, 1977, and May 6, 1977. There was a total of forty subjects involved in the study. Since males have been used predominantly in the past in oxygen consumption studies, the researcher chose to use twenty males and twenty females and compare their oxygen consumption in ml./kg./min. The males and females, were also broken down into two other groups. There were twenty females, ten skilled and ten unskilled, and twenty males, ten skilled and ten unskilled. Skilled subjects were randomly selected from those who had at least one semester of

HPE 032, Beginning Tumbling and Trampoline. Those defined as unskilled jumpers were randomly selected from HPE 041 Aerobic classes. Those randomly selected in the unskilled group were asked it they had received instruction on the trampoline, and if they had received instruction, they were dropped from the sample.

Each subject was tested on three different tests over the seven week period. The first two tests both involved jumping on the trampoline at different heights. The investigator chose two different heights in order that heart rates and oxygen consumption could be compared. The question had been raised whether a person, barely working the bed of the trampoline, could receive any cardiovascular benefits.

On the first test, subjects were allowed to jump only eight inches high. This was monitored with a marker on the side of the trampoline and an assistant that gave the jumper feedback during the test as to whether he was too low or too high. The eight inch test was given first to allow for those who were unskilled to get used to the new apparatus. On the second test the subjects were asked to jump eighteen inches high. This was again monitored by an assistant at the side of the trampoline and a marker so that it wasn't left up to his subjectivity. During both test one and test two the subject's heart rate was monitored by a Hewlett Packard 1500 EKG Machine. The trampoline tests were each 10 minutes in length.

The third test was a Bruce treadmill test. The Bruce test is a voluntary maximum test with no verbal encouragement from the Human Performance Laboratory technician nor from the investigator.

The subject starts the test at a ten percnet grade and 1.7 m.p.h. The protocol is given below:

Minutes	M.P.H.	Elevation
0-3:00	1.7	10
3:01-6:00	2.5	12
6:01-9:00	3.4	14
9:01-12:00	4.2	16
12:01-15:00	5.0	18
15:01-18:00	5.5	20
18:01-21:00	6.0	22

During the test the subjects metabolic respiratory measurements were recorded. The researcher did the testing in the Human Performance Laboratory at Oral Roberts University and the machine used to measure the gases was the Beckman cart, otherwise known as the Metabolic Measurement Cart. The oxygen was measured in the cart by a Beckman OM-11 Oxygen Analyzer, and the carbon dioxide was measured by a Beckman LB-2 Medical Gas Analyzer. Programmed automatic operations were controlled by a Monroe Model 1810, Programmable Printing Calculator. There additional transducers which measure volume, pressure, and temperature.[1]

The EKG electrode hookup on the treadmill was as follows. The right arm lead was placed on the sternum, the right leg lead was placed on the right side of the fifth intercostal space, the left arm lead was placed on the inferior side of the oblique angle of the right

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[1]Beckman, <u>Metabolic Measurement Cart Operating Instructions</u>, (1975), p. 1.

scapula, and the left leg lead was placed on the fifth intercostal space of the left side.

Source of Data

The data of this study was derived from the results of the EKG Machine which was used in both of the two trampoline tests. A heart rate ruler was used to determine the heart rate. After each subject took the two trampoline tests he was given a Bruce treadmill test because it is the standard treadmill test given at Oral Roberts University. Maximal oxygen consumption was determined by the use of the Beckman Metabolic Cart.

Administration of Tests

Sex, height, weight, date of tests, and skill level were recorded for each subject on a personal information sheet.

The following testing procedures were used for each test:

Test One

Each subject was first instructed to jump in the middle of the trampoline, where the colored webbing crosses. Then each jumper was instructed on how to jump on the trampoline so that the test was more uniform. The subjects feet were to land shoulder width apart on the trampoline and to come together in the air. Both arms were to move simultaneously in small circles in front of the subject. The arms were to rise until the body began its descent and they contined down until the body beganto rise.

1. Sitting heart rate was recorded.
2. Standing heart rate was recorded.
3. Ten minutes of straight jumping at a height of eight inches with the heart rate recorded at the end of every minute.
4. Three minute recovery heart rate.
5. Five minute recovery heart rate.

Test Two

The subjects were instructed to jump in the same manner that they had on the previous test with the same arm and leg movements.

1. Sitting heart rate recorded.
2. Standing heart rate recorded.
3. Ten minutes of straight jumping eighteen inches high.
4. Three minute recovery heart rate.
5. Five minute recovery heart rate.

On both of the first two tests the height of the bounce was monitored by an assistant who stood at the side of the trampoline. A marker measured the height and the assistant gave the subjects verbal feedback as to whether they were bouncing too high or too low. The subjects did not take the test immediately after each other due to the effect it may have on the heart rate of the second test.

Test Three

The subjects were brought to the preparation room first and the dead cells were rubbed off and alcohol was used to clean the skin in the four places so the EKG could be clearer. Every subject was instructed as to how to put the head gear on for the gas measurement and that it must be kept on throughout the entire test. They were all told that the Bruce test was a voluntary maximal test and when they had gone as far as they could go to grab the bar and the researcher would turn off the treadmill.

1. Blood pressure taken.
2. Sitting heart rate recorded.
3. Standing heart rate recorded.
4. Bruce treadmill test with oxygen consumption recorded automatically every minute, in liters and ml./kg./min.
5. Three minute recovery rate.
6. Five minute recovery rate.

Collection of Data

The data was organized as follows:

1. Mean heart rate for each minute was determined for each trampoline test for male, female, skilled, and unskilled subjects.
2. Mean calorie costs were determined for male, female, skilled, and unskilled subjects for each trampoline test.
3. Mean aerobic points per minute were determined for male, female, skilled, and unskilled subjects for both trampoline tests.
4. A chart was constructed for each person with the following information:
    (1) Treadmill Test
        a. heart rate per minute
        b. oxygen consumed in liters
        c. oxygen consumed in ml./kg./min.

(2) Trampoline Tests (low and high jumping)

a. heart rate per minute

b. columns for predicted O_2 consumption in liters and ml./kg./min.

c. calorie cost for each test

d. aerobic points per minute

5. Regression equations were computed for each person. These were determined by the heart rate and corresponding O_2 intake per minute by each subject on their Bruce treadmill test.

6. Oxygen consumption in liters and ml./kg./min. was predicted by using the regression equations for each heart rate on both the low and high jumping tests.

7. Calorie cost was determined by multiplying the total liters consumed for each test by subject.

8. Aerobic points were determined by graphing Dr. Kenneth Cooper's chart and predicting from mls./kg./min. of O_2 consumed.

9. Two way analysis of variance was run on the individual calorie cost of each subject for both low and high jumping tests.

10. Two way analysis of variance was run on the individual ml./kg./min. of each subject for both low and high jumping tests.

CHAPTER IV

ANALYSIS OF DATA

The administration of the testing for this study took place between March 14, 1977 and May 6, 1977. The subjects were classified in four different groups. There were twenty females, ten skilled and ten unskilled, and twenty males, ten skilled and ten unskilled. These subjects were randomly selected from activity classes at Oral Roberts University. Each person was tested on three different tests over the seven week period. The first two tests were given on the trampoline and the final test was a Bruce Treadmill Test using the Beckman Metabolic Measurement Cart for respiratory measurement.

The researcher will analyze the results of this study in the following manner: heart rate and maximal oxygen consumption, calorie cost of trampolining,, aerobic points, and the validity study.

Heart Rate and Maximal Oxygen Consumption

Each subject was instructed to jump in the middle of the trampoline bed. The jumper's feet were to land shoulder width apart on the trampoline and come together in the air. Their arms were to move simultaneously in small circles in front of them.

An Hewlett Packard 1500B EKG Machine was used to measure heart rate the last fifteen seconds of every minute. Four electrodes were used in the hookup. They were placed as follows: the right arm lead was placed on the sternum, the right leg lead was placed on the right side on the fifth intercostal space, the left arm lead was placed on the inferior side of the oblique angle of the right scapula, and the left leg lead was placed on the fifth intercostal space of the left side. On both trampoline tests a sitting rate was taken, ten minutes of straight jumping at the designated height of bounce, and then a five minute recovery rate was recorded.

The first test involved jumping at a height of 8 inches. The mean pretest heart rate for the forty subjects on this test was 86 beats per minute. The lowest group mean was the skilled males, which was 82 beats per minute. According to DeVries, the average heart rate is seventy beats per minute, which would imply that the mean in this study was a little high.[1] Heart rates can be affected by many factors such as: age, sex, size, eating, emotions, and environmental surroundings. The testing for this study took place in the Oral Roberts University Aerobics Center, where many activities are going on simultaneously. The researcher feels that the environmental factors, along with the newness and excitement of the testing may have caused this slight rise in heart rate.

Mean heart rates for males, skilled and unskilled, for the ten minute period, did not exceed 129 beats per minute on this 8 inch trampoline test. Cooper states that if an exercise is not vigorous enough to produce or sustain an heart rate of 150 beats per minute, the exercise must be continued considerably longer than five minutes,

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[1]Herbert A. DeVries, Physiology of Exercise(Dubuque, Iowa, 1974), p. 130.

the total period of time depending on the oxygen consumed.[2] There were two extremes among the unskilled males that the researcher would like to mention. Subject GMc, had an heart rate of 158 beats per minute by the third minute, and his heart rate stayed above 150 for the remainder of the test. Refer to Table V, The researcher feels that there were several possible reasons for this. GMc was the heaviest subject in this study weighing 209 pounds. His Bruce Treadmill test time was 12:00 minutes. Oral Roberts University has established mean times for it's students that have been tested over the last three years. The mean time for men is 13:30 minutes. Subject GMc's time was a minute and a half lower than the average. This subject's maximum oxygen consumption was 42 ml./kg./min., which according to Cooper's chart falls only in the fair category. Refer to Table I. GMc also had a pre-test heart rate of 100 beats per minute which was above the mean. It is a common belief that in a group of subjects after a standard exercise, that pulse rates will be higher in those individuals whose pretest rates were higher.

Subject JW, also an unskilled male, had a pretest heart rate of 66 beats per minute and a posttest rate of 55 beats per minute. A slow resting rate is characteristic of the trained individual.[3] JW never exceeded a heart rate of 100 beats per minute on this test. This subject's treadmill time was 18:25 minutes, five minutes above

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[2]Cooper, p. 39.

[3]Donald K. Matthews and Edward L. Fox, The Physiological Basis of Physical Education and Athletics (Philadelphia, 1971), p. 155.

the ORU average for males. His maximal oxygen consumption was 55.1 mls./kg./min., which is considered to be in the excellent category.

Mean heart rates per minute for females were slightly higher than the males. This is consistent with research, that sex is a factor that affects heart rate.[4] Eight of the twenty female subjects maintained heart rates over 150 beats per minute for longer than five minutes. If an exercise is vigorous enough to produce or sustain a heart rate of 150 beats per minute, the training effect benefits will begin about five minutes after the exercise starts and continue as long as it is performed.[5] Seven of these eight subjects had treadmill times below the University average for females of 10:15 minutes. They ranged from 8:15 to 10:10 minutes. Subjects CB, SMc, LJ, CH, and AM, also had maximum oxygen consumptions that fell in the fair to poor category. See Table IV for heart rates and refer to Table I for maximal oxygen consumption values. They ranged from 32.0-36.8 mls./kg./min. Maximum oxygen consumption depends upon the transport of oxygen from the atmosphere to the mitochondria of the muscle cells.[6] High maximum intake is dependent on the optimal functioning of the cardiovascular and respiratory systems and the transfer of gases between the blood and tissues and the blood and lungs.[7] Lower oxygen intake values may

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[4]DeVries, p. 104.

[5]Cooper, p. 39.

[6]DeVries, p. 183.

[7]Karpovich, p. 111.

TABLE I

MAXIMAL OXYGEN INTAKE*

MALES

CATEGORY		OXYGEN INTAKE (mls./kg./min.)
1.	Very Poor	25.0
II.	Poor	25.0 - 33.7
III.	Fair	33.8 - 42.5
IV.	Good	42.6 - 51.5
V.	Excellent	51.6 - 60.2
VI.	Superior	60.2+

FEMALES

CATEGORY		OXYGEN INTAKE (mls./kg./min.
I.	Very Poor	23.6
II.	Poor	23.6 - 30.1
III.	Fair	30.2 - 37.0
IV.	Good	37.1 - 47.9
V.	Excellent	48.0 - 55.2
VI.	Superior	55.2+

*Cooper

be due to an inefficient system. Cooper has stated that maximum oxygen consumption seems to be the best overall measure of fitness.[8] A training program would increase maximal oxygen consumption by increasing the efficiency of the heart, lungs, blood vessels, and body tissue.

The second trampoline test involved jumping at a set height of 18 inches. This test seemed more enjoyable for the subjects and a little more realistic, since even the unskilled wanted to jump higher on the first test after about six minutes.

The mean pretest heart rate for all subjects was again a little high - 85 beats per minute. There was no significant difference in the heart rates of the skilled and unskilled subjects. The females mean heart rate per minute was above 150 beats per minute for the entire test. Only one unskilled female did not maintain a heart rate of 150 beats per minute. Subject DM is a senior Physical Education major at ORU, and has been on the aerobics program for four years. Her maximum oxygen consumption was 46.6 mls./kg./min., indicating a good fitness level for females. Nine of the twenty females had heart rates that exceeded 180 beats per minute for longer than five minutes. Balke's research indicates that there is a linear relationship between heart rates and mean oxygen consumptions. It seems that there is some deterioration in the cardiorespiratory efficiency by the time a rate of 180 beats per minute is attained. With an increasing heart rate there is not a proportionate increase in delivery of oxygen to the

[8]Cooper, p. 9.

tissues.[9] The exercise becomes anaerobic.

The male subjects, skilled and unskilled, were on the trampoline three minutes before the mean heart rate reached 150 beats per minute. Only one unskilled male, subject GMc, exceeded a heart rate of 180 beats per minute, and this was for eight minutes of the test. This subject was discussed earlier because he was the only person to sustain a heart rate of 150 beats per minute on the first test for eight minutes also. Five of the male subjects maintained heart rates considerably lower than the mean. These subjects were, KE, JD, DR, TW, and JW. Refer to Table VII. Subject JW,an unskilled male, was also discussed previously, due to his heart rate never going above 100 beats per minute on the first test. Subject TW, also with a low heart rate on the first test, and with a pretest heart rate of 63 beats per minute, never exceeded a heart rate of 141 on this second test. This subject had a low maximal heart rate on the treadmill of only 180 beats per minute, and it was not until the ninth minute that it even reached 150 beats per minute. His maximum oxygen consumption was 49.6 mls./kg./min. Subject KE is on the cross country track team and has a maximum oxygen consumption of 57.4 mls./kg./min. The researcher feels it would be interesting to note here that subjects JD and DR were the most highly skilled trampolinists in any of the trampoline classes. The reason for having skilled and unskilled groups in this study was to determine whether mechanical efficiency would play

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[9]Francis Nagle and Thomas Bedecki, "Use of the 180 Heart Rate Response as a Measure of Cardiorespiratory Capacity," (March, 1963), pp. 361-369.

a very big role in the amount of oxygen consumed. Efficiency is defined as the ratio of work done to the amount of energy used.[10] The researcher feels that the mechanical efficiency of these two highly skilled trampolinists may have been a factor in their low heart rates. Their maximum oxygen uptakes were only 48.6 and 53.6 mls./kg./min., classifying them in the good and excellent categories. Another cross country runner in the study sustained an heart rate of 150 beats per minute and more, for nine minutes of the test. This subject, unskilled male RS, had a maximum oxygen uptake of 60.3 mls./kg./min. Even though this subject's maximum oxygen uptake was superior, his cardiovascular system was trained while trampolining.

The mean treadmill times for subjects in this study was very close to the ORU average. For males it was 13:15 minutes and for females it was 10:35 minutes. The mean maximum oxygen consumption values for the females in this test was 41.9 mls./kg./min., and for the males it was 52.48 mls./kg./mim.

Calorie Cost

The energy cost of trampolining was etermined indirectly, Each subject took the Bruce Treadmill test and their metabolic respiratory measurements were calculated by using the Beckman Metabolic Measurement Cart. Regression equations were computed for each person on the basis of their heart rate and oxygen consumpion on the treadmill. The equation, Y=a+bx was used where (x) was the predictor - heart rate,

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[10] Karpovich, p. 113.

and (Y) was the criterion - liters of oxygen consumed. Correlation coefficients for the forty subjects ranged from .913 to .998, with a mean of .975. The mean standard deviation for the regression equations was .76 and the standard error of the estimate was .18.

After the regression equations were computed for each person, the oxygen consumption was predicted for each minute of jumping on the trampoline from the minute heart rate. This was done for both the 8 inch and the 18 inch trampoline tests. Liters of oxygen were totaled. Females on the 8 inch test consumed an average of 1.3 liters per minute and the males consumed an average of 1.46 liters per minute. Skilled subjects consumed an average of 1.3 liters per minute while unskilled persons consumed 1.48 liters of oxygen per minute. On the 18" test females consumed a mean of 1.86 liters per minute and males consumed 2.2 liters per minute. Skilled persons consumed an average of 1.95 liters per minute and unskilled subjects consumed 2.13. The total mean liters of oxygen consumed for the low jumping test was 13.85 and for the high test was 21 liters for the ten minute period. To determine the calorie cost the total number of liters of oxygen consumed were multiplied times five. Refer to Tables VIII and IX. Two way analysis of variance was done to determine any variance within or between groups. The F scores were as follows:

8" Trampoline Test	F Scores
male vs. female	1.82
skilled vs. unskilled	2.22
18" Trampoline Test	
male vs. female	14.63
skilled vs. unskilled	.43

There was a significant difference at the .01 level of confidence between males and females in the liters of oxygen consumed on the 18 inch trampoline test. The researcher felt that this was highly possible due to the physiological difference of size and greater muscle mass.

The mean calorie cost for females on the 8 inch test was 65 calories. This is 6.5 calories per minute. The mean on the 18 inch test for the females was 93.8 calories. For the males, the mean on the first test was 73.3 calories and on the second test it was 110 calories. The unskilled males had the highest calorie costs on both tests. They expended 82.5 calories on the first test and 121.1 calories on the second test. Those subjects that were the exceptions when heart rates were discussed were also the ones that expended more energy. Refer to Table VIII and IX. The total mean calorie cost for the 8 inch trampoline test was 69.25 calories, or 6.9 calories per minute. On the 18 inch test the mean total was 102.3 calories, or 10.2 calories per minute. This compares to sitting - 1.19 calories per minute and walking (2 mph) - 3.0 calories per minute.

The researcher decided to run two way analysis of variance on the four groups to determine whether there was any significant difference between mls./kg./min. of oxygen consumed, since there had been a difference between males and females in liters of oxygen consumed. The F scores were as follows:

8" Trampoline Test	F Scores
male vs. female	.57
skilled vs. unskilled	3.27
18" Trampoline Test	
male vs. female	.28
skilled vs. unskilled	2.20

The results showed that there was no significance between any of the four groups when compared by mls./kg./min. of oxygen consumed. There was a slight difference between skilled and unskilled subjects but it was not significant. The researcher feels that the raw scores of the unskilled males are what caused this small difference.

Aerobic Points

After two-way analysis of variance had been done on the mls./kg./min. of oxygen consumed, the researcher calculated the number of aerobic points one could earn by trampolining. Cooper has a chart for the assessment of aerobic points and it is based on 7 mls./kg./min. of oxygen consumed being equivalent to one aerobic point.[11] The investigator graphed Cooper's chart and then predicted aerobic points per minute from the mls./per kg./min. of oxygen consumed. Refer to Table X and XI. The mean number of aerobic points per minute earned on the first trampoline test was .29. On the second test the mean was .59 points per minute. Since there was no significant difference in the mls./kg./min. of oxygen consumed, only one chart was made for aerobic points. Refer to Table II. The aerobic points are rather low on the 8 inch jumping test, but on the 18 inch test a person should receive 5 points for jumping between 9-10 minutes. This is the same number of points that a person would receive if he ran a mile in under eight minutes.[12]

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[11]Cooper, p. 49.

[12]Ibid.

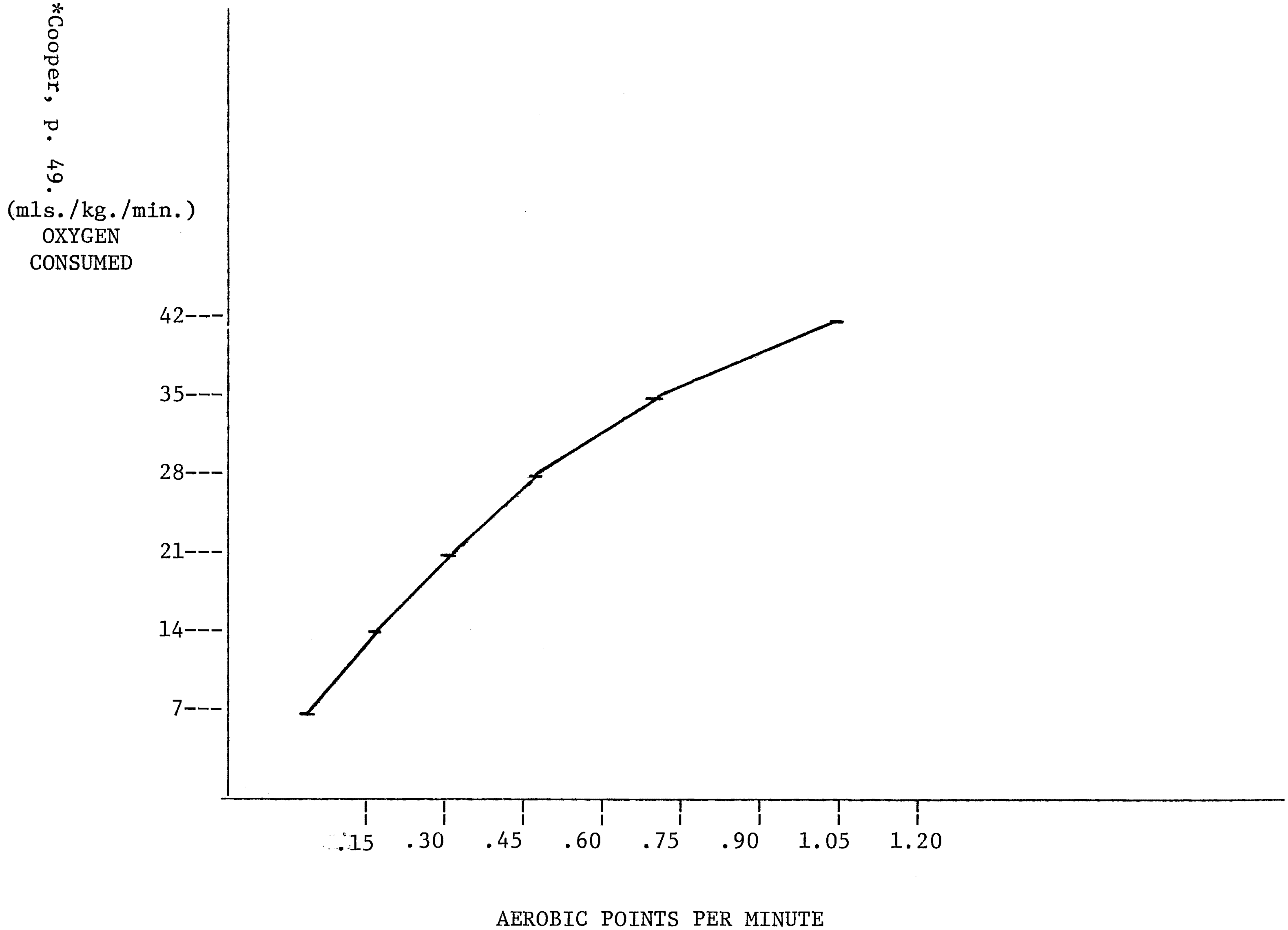

Figure 1.

*Cooper, p. 49.

TABLE II

AEROBIC POINTS FOR TRAMPOLINING

All males, females, skilled, and unskilled persons will receive the same number of aerobic points for trampolining.

8" Straight Jumping	
3-6 mins.	1 pt.
7-10 mins.	2 pts.
11-13 mins.	3 pts.
14-17 mins.	4 pts.
18" Straight Jumping	
2-3 mins.	1 pt.
4-5 mins.	2 pts.
6-8 mins.	4 pts.
9-10 mins.	5 pts.

TABLE III

SUMMARY OF DATA

MEAN HEART RATES FOR TRAMPOLINE TESTS		
8" Test		
males	122	
females	144	Low test combined mean
skilled	132	
unskilled	135	133
18" Test		
males	153	
females	172	High test combined mean
skilled	163	
unskilled	162	163
MEAN OXYGEN CONSUMPTION (LITERS/PER/MIN.)		
8" Test		
males	1.46	
females	1.30	Low test combined mean
skilled	1.30	
unskilled	1.48	1.38
18" Test		
males	2.20	
females	1.86	High test combined mean
skilled	1.95	
unskilled	2.10	2.03
MEAN CALORIE COST PER MINUTE		
8" Test		
males	7.30	
females	6.50	Low test combined mean
skilled	6.50	
unskilled	7.30	6.90

SUMMARY OF DATA
(CONTINUED)

<u>18" Test</u>		
males	11.1	
females	9.3	High test combined mean
skilled	9.7	
unskilled	10.6	10.2
MEAN AEROBIC POINTS PER MINUTE		
<u>8" Test</u>		
males	.27	
females	.30	Low test combined mean
skilled	.25	
unskilled	.32	.29
<u>18" Test</u>		
males	.60	
females	.575	High test combined mean
skilled	.555	
unskilled	.62	.59

Validity

The treadmill test was used in this study because it brings about a slightly better involvement of large muscles groups than any other device, since the arms and shoulders do enter into the activity. Pechar found that for an individual without bicycle experience, there is a difference between oxygen consumption values when measured on the treadmill and the bicycle ergometer.[13] Maximal oxygen consumption values were significantly higher when measured on the treadmill than the values attained from the ergometer test. In the trampoline tests the arms and shoulders were to have a small amount of movement, so the treadmill test seemed the best choise.

In order to determine the predictive validity of this study the researcher decided to directly measure the oxygen consumed while jumping on the trampoline. With the help of two members of the ORU Human Performance Laboratory staff, the Beckman Metabolic Cart was brought out to the trampoline and seven trampoline tests were measured directly. The subjects jumped with the head gear and nose clips on. An assistant held the hose that was attached to the head gear and the Beckman and the investigator ran the EKG machine. The results are graphed. See figures 2-5.

The researcher computed regression equations for the trampoline tests for the four subjects that were measured directly on the trampoline. Four of the subjects performed the 8 inch test and three of

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[13]Gary Pechar, "The Effects of Specific Training upon the Differences in Maximum O_2 Scores Between Treadmill and Bicycle Ergometer Tests of Cardiorespiratory Functions," (1973).

three of these performed the 18 inch test as well. The lines of best fit were drawn for the treadmill test and trampoline tests from the regression equations.

The four subjects represented the four different groups. Subject LF was a skilled female, AM was an unskilled female, GM was a skilled male, and RS was an unskilled male. The regression lines for the females seemed to indicate a high relationship between the treadmill and the trampoline tests. The lines for both the male subjects also followed a certain pattern. It seems that at the lower heart rates more oxygen was used on the trampoline than on the treadmill, and at the higher heart rates more oxygen was used on the treadmill than on the trampoline. The lines for female subject also indicated this trend. Raw data concurred with these findings.

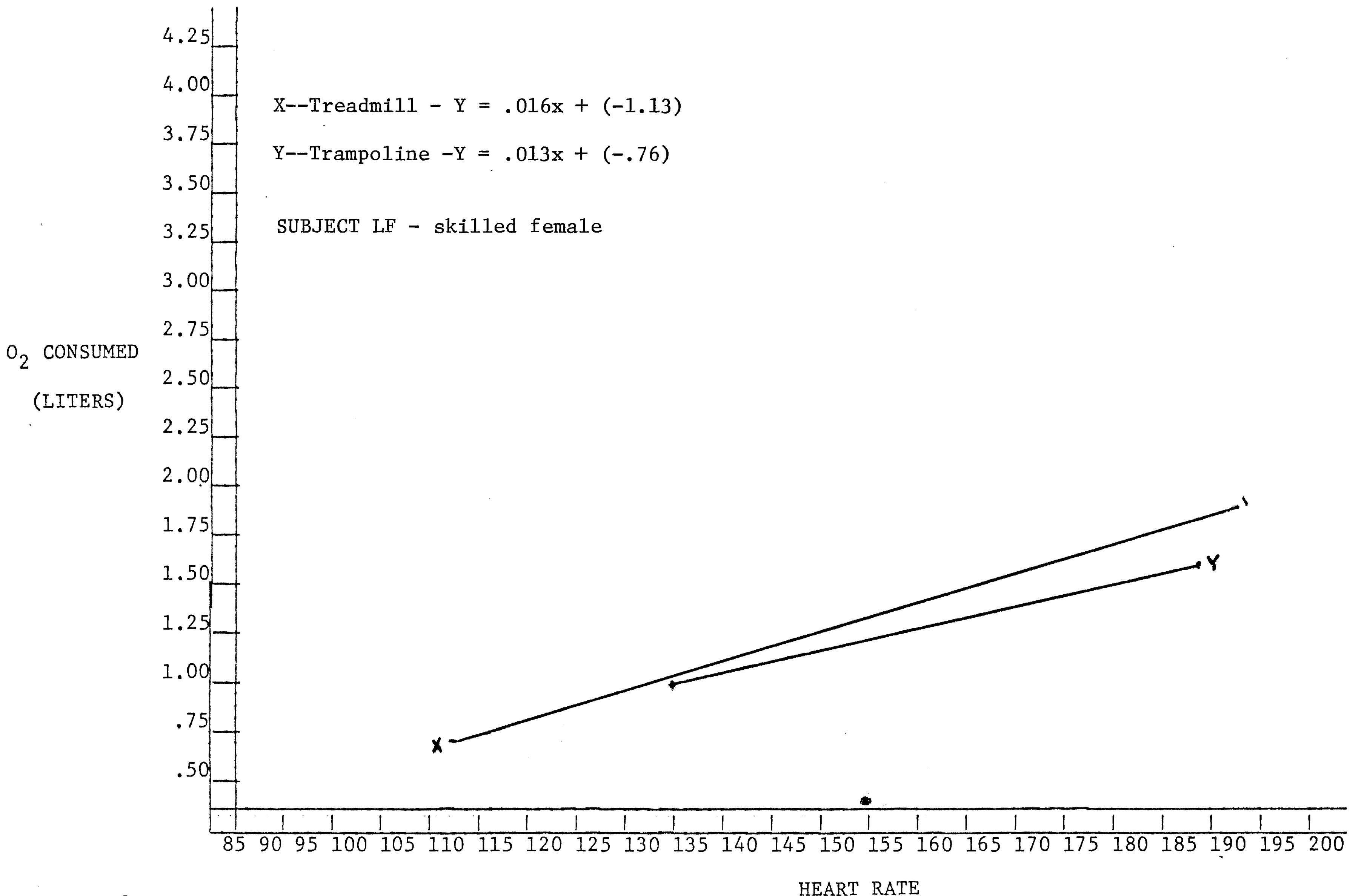

X--Treadmill - Y = .016x + (-1.13)
Y--Trampoline -Y = .013x + (-.76)
SUBJECT LF - skilled female
4.25
4.00
3.75
3.50
3.25
3.00
2.75
2.50
2.25
2.00
1.75
1.50
1.25
1.00
.75
.50
O2 CONSUMED
(LITERS)
X
Y
85 90 95 100 105 110 115 120 125 130 135 140 145 150 155 160 165 170 175 180 185 190 195 200
HEART RATE

Figure 2.

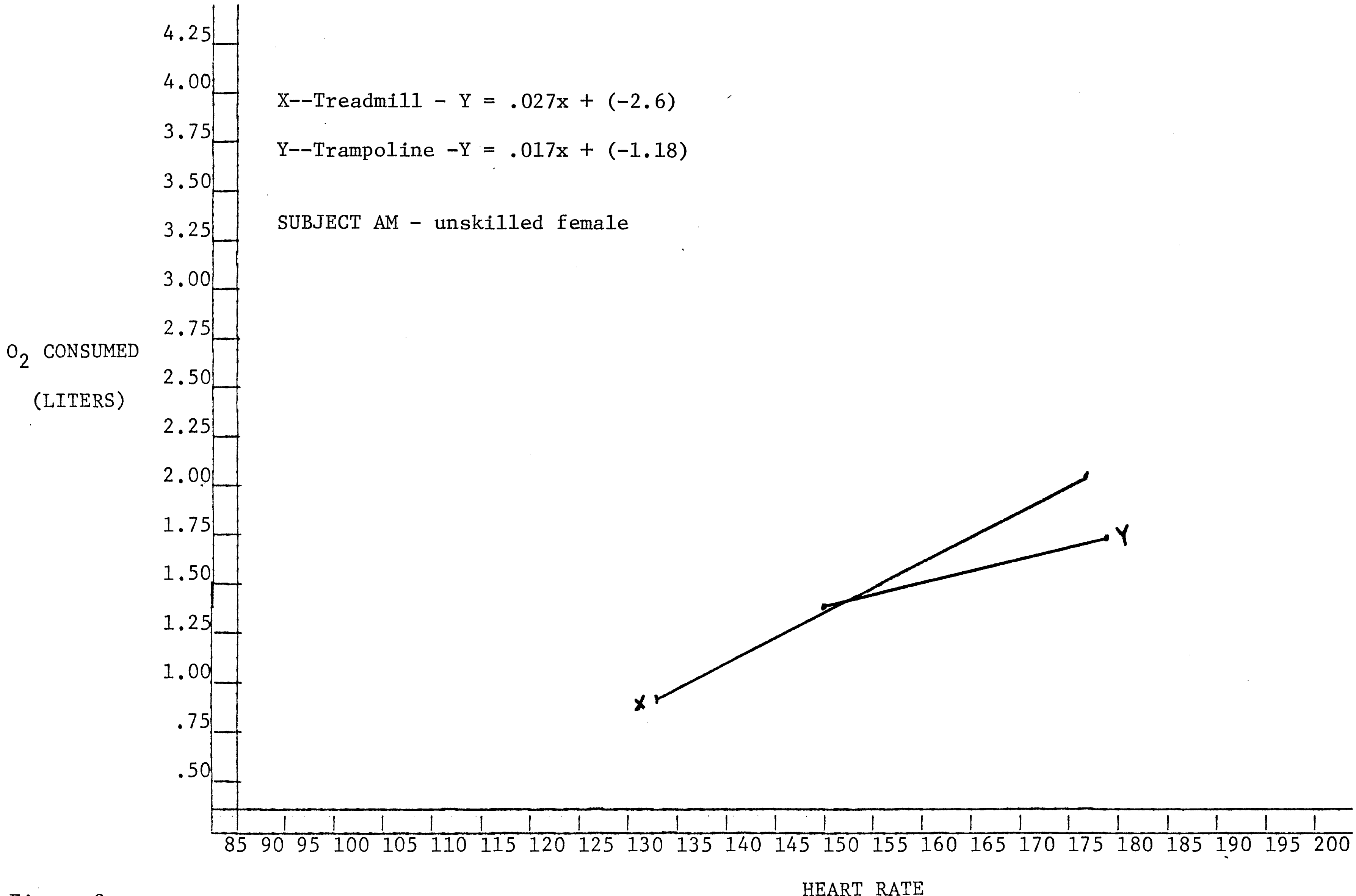

4.25
4.00
3.75
3.50
3.25
3.00
2.75
2.50
2.25
2.00
1.75
1.50
1.25
1.00
.75
.50
O_2 CONSUMED (LITERS)
X--Treadmill - Y = .027x + (-2.6)
Y--Trampoline -Y = .017x + (-1.18)
SUBJECT AM - unskilled female
X
Y
85 90 95 100 105 110 115 120 125 130 135 140 145 150 155 160 165 170 175 180 185 190 195 200
HEART RATE

Figure 3.

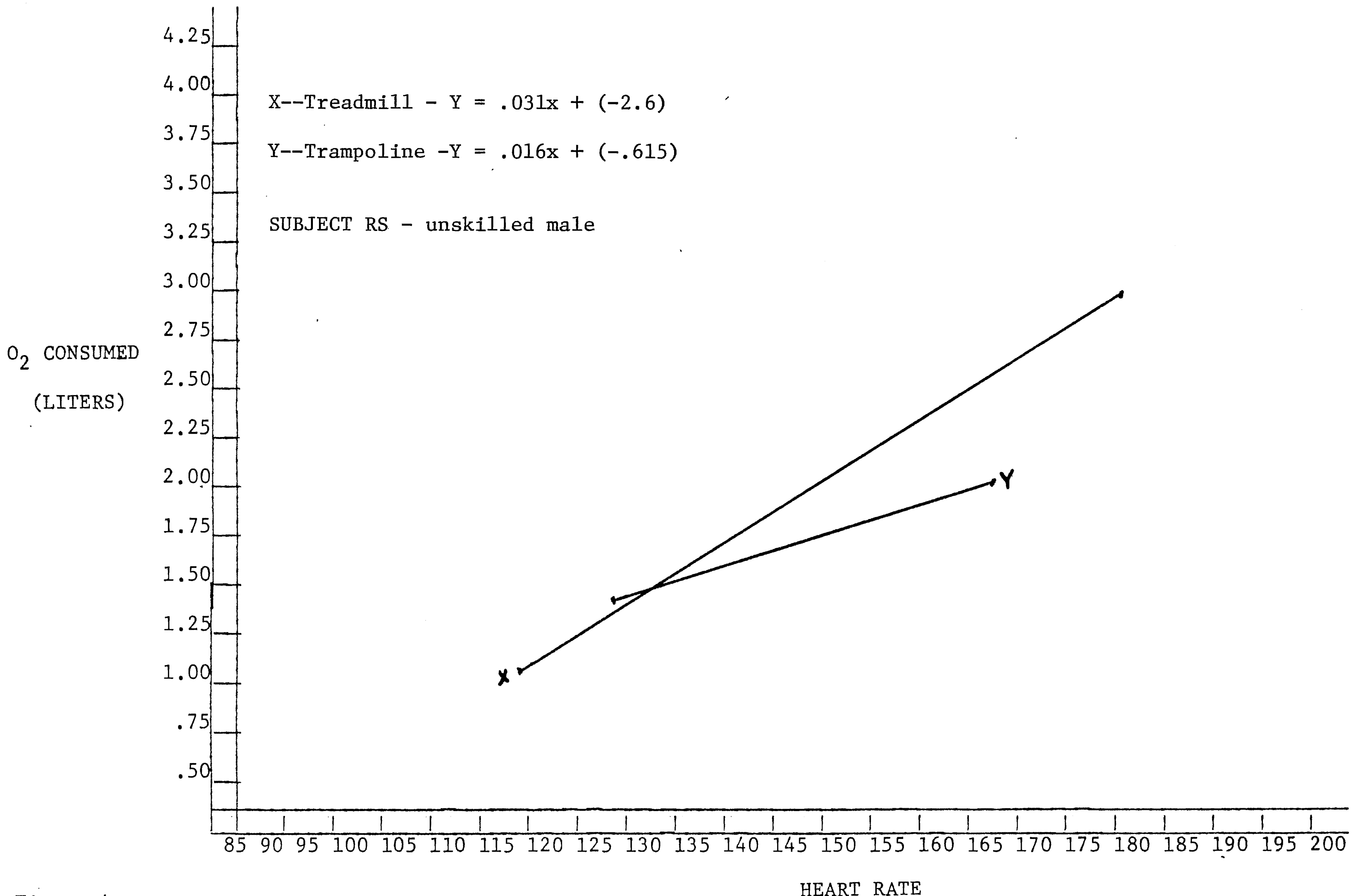
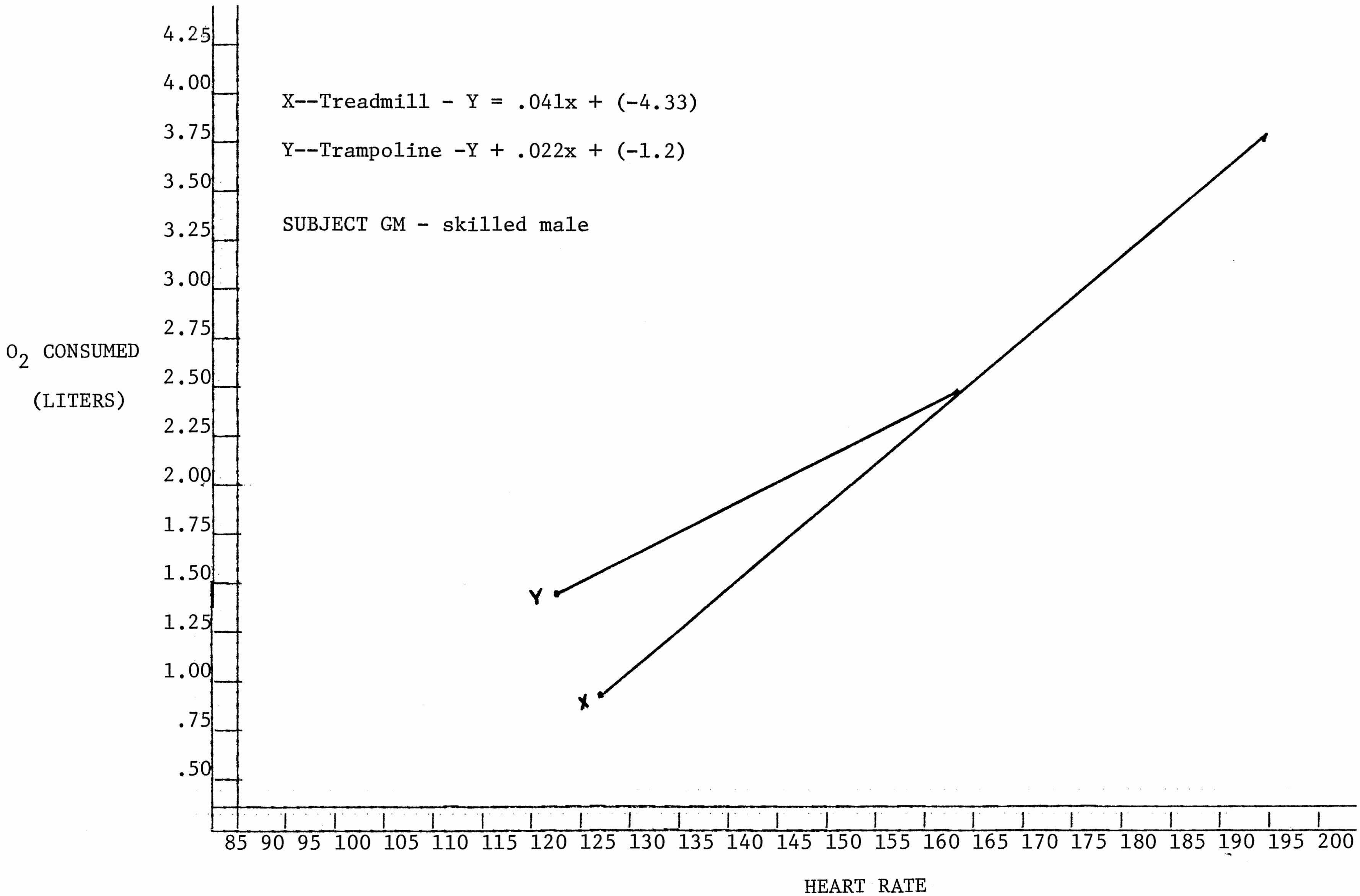

X--Treadmill - Y = .031x + (-2.6)
Y--Trampoline -Y = .016x + (-.615)
SUBJECT RS - unskilled male
O2 CONSUMED
(LITERS)
4.25
4.00
3.75
3.50
3.25
3.00
2.75
2.50
2.25
2.00
1.75
1.50
1.25
1.00
.75
.50
85 90 95 100 105 110 115 120 125 130 135 140 145 150 155 160 165 170 175 180 185 190 195 200
HEART RATE
X
Y

Figure 4.



4.25
4.00
3.75
3.50
3.25
3.00
2.75
2.50
2.25
2.00
1.75
1.50
1.25
1.00
.75
.50
X--Treadmill - Y = .041x + (-4.33)
Y--Trampoline -Y + .022x + (-1.2)
SUBJECT GM - skilled male
O_2 CONSUMED
(LITERS)
Y
X
85 90 95 100 105 110 115 120 125 130 135 140 145 150 155 160 165 170 175 180 185 190 195 200
HEART RATE

Figure 5.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

The investigator has taught the coed tumbling and trampoline classes at Oral Roberts University for the past two years. During that time interest has grown in trampolining, and questions have been raised as to its aerobic value and possible training effects on the cardiovascular system.

The purposes of this study were:

1. To determine the energy cost of trampolining.
2. To compare the heart rate and oxygen consumption of skilled and unskilled, male and female trampolinists.
3. To compare the calorie cost in trampoline of male, female, skilled, and unskilled subjects.
4. To compare oxygen consumption in mls./kg./min. of male, female, skilled, and unskilled subjects.
5. To determine the number of aerobic points earned while trampolining at two different heights of bouncing.

The research from this study indicated the following:

1. The mean energy cost of trampolining on the 8" test was 6.9 calories per minute. The mean energy cost of trampolining on the 18" test was 10.2 calories per minute.
2. On the 8" test, the skilled males had the lowest mean heart

rate for the test. The mean female heart rate for the test was 22 beats per minute higher than the males. The mean skilled subjects heart rate was three beats per minute lower than the unskilled. The males consumed an average of two liters of oxygen per test more than the females. The unskilled subjects also consumed two liters more per test than the skilled.

On the 18" test, the mean female heart rate for the test was 19 beats per minute more than the males, and the unskilled subjects mean heart rate was one beat less per minute than the skilled subjects. The females mean oxygen consumption was three liters less than the males and the unskilled subjects also consumed an average of two liters less than the skilled subjects.

3. On the 8" test, skilled males and females and unskilled females expended 1.7 calories per minute less than the unskilled males. On the eighteen inch test the unskilled males, expended two calories per minute more than any other group. The difference between males and females on the eighteen inch test was significant at the .01 level of confidence.
4. There was no significant difference in ml./kg./min. of oxygen consumed between the four groups.
5. Since there was no significant difference in ml./kg./min. of oxygen consumed the investigator was able to make one chart for the aerobic points. If a person were to jump only eight

inches high he would receive .29 points per minute. If a person bounced at the height of eighteen inches he would receive .59 points per minute.

6. Direct measurement of oxygen consumed on the trampoline showed high predictive validity of the regression equation for females. At the lower heart rates males seemed to consume more oxygen on the trampoline and at higher heart rates they consumed more on the treadmill.

According to the results of this study the first three stated hypotheses were rejected.

1. The first hypothesis stated, "Trampolining will not produce a training effect on the cardiovascular system." This hypothesis was rejected due to the results that indicated that the heart rates attained and the oxygen consumed were of sufficient intensity and duration to train the cardiovascular and respiratory systems. The eighteen inch test was superior since mean heart rates stayed above 150 beats per minute for almost the entire ten minutes.
2. The second hypothesis stated, "There will be no significant difference in the energy cost of trampolining for males, females, skilled and unskilled persons while trampolining." Two-way analysis of variance was computed and there was a significant difference at the .01 level of confidence between males and females on the eighteen inch test only. There was no significant difference between any other group.
3. The third hypothesis stated, "The height of bounce attained

while trampolining will not effect oxygen consumption." This hypothesis was rejected because the mean liters and mls. of oxygen consumed on the eighteen inch test was almost twice the oxygen consumed on the eight inch test.

On the basis of this research the fourth hypothesis was accepted.

1. The fourth hypothesis stated, "There will be no significant difference in the milliliters per kilogram of body weight per minute consumed between males, females, skilled, and unskilled subjects." Two-way analysis of variance was computed and even though there was a slight difference in the means of the skilled and unskilled subjects, there was no significant difference between any of the groups.

The investigator feels from this research that trampolining at a bounce height of at least eighteen inches may be an excellent fitness activity and should be considered as an alternative activity in an aerobic fitness training program.

As a result of this study the researcher recommends the following:

1. Further direct testing be done on the trampoline.
2. A study be conducted with stunts interspersed between the bounces.

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APPENDIX

TABLE IV

8" TRAMPOLINE TEST

SKILLED FEMALES

Subject	ES	CB	JA	AM	DK	KH	LL	TM	EL	LF	Average
Resting Heart Rate	103	73	92	91	91	89	74	73	77	108	87
Minute 1	123	143	121	140	118	152	133	137	151	135	135
Minute 2	121	160	128	152	120	153	140	130	155	141	140
Minute 3	137	171	118	147	122	163	138	120	151	148	142
Minute 4	136	178	122	150	120	159	141	120	151	148	143
Minute 5	139	179	121	153	122	165	149	123	146	151	145
Minute 6	136	172	121	154	121	159	151	130	144	148	144
Minute 7	150	181	125	154	122	173	151	131	150	150	149
Minute 8	151	180	121	157	127	164	150	139	151	151	149
Minute 9	149	182	119	160	119	168	153	138	148	150	149
Minute 10	148	186	117	161	121	171	148	134	160	151	150
5 Minute Recovery	104	98	69	108	83	95	87	73	93	97	91

UNSKILLED FEMALES

Subject	DM	BM	SM	RH	LJ	PY	KW	CH	LL	AM	Average
Resting Heart Rate	84	111	84	104	92	55	68	104	81	75	86
Minute 1	111	125	142	150	140	107	137	139	119	151	132
Minute 2	116	138	152	160	145	123	141	150	127	152	140
Minute 3	120	138	160	168	152	120	142	158	121	150	143
Minute 4	122	136	165	160	154	116	141	159	123	153	143
Minute 5	124	139	172	159	155	119	149	159	121	151	145
Minute 6	128	139	179	155	159	120	147	160	122	155	146
Minute 7	131	140	179	150	160	126	147	160	119	155	147
Minute 8	127	144	180	150	156	116	149	159	122	160	146
Minute 9	122	140	179	155	155	120	148	159	123	160	146
Minute 10	128	140	175	154	162	122	155	160	121	155	147
5 Minute Recovery	76	108	95	86	93	60	73	89	77	88	85

TABLE V

8" TRAMPOLINE TEST

SKILLED MALES

Subject	JM	KE	BC	GC	JD	DR	GW	RC	LC	GM	Average
Resting Heart Rate	107	91	90	66	88	102	74	67	65	66	82
Minute 1	105	112	119	105	112	121	125	101	108	110	112
Minute 2	132	121	118	111	113	122	120	113	116	122	119
Minute 3	128	119	118	115	108	123	121	112	112	119	117
Minute 4	132	122	127	120	111	119	121	119	114	115	120
Minute 5	119	122	116	111	109	122	122	116	113	121	117
Minute 6	132	121	116	120	110	124	121	120	114	128	122
Minute 7	135	129	116	112	106	125	122	124	113	129	122
Minute 8	125	128	114	119	107	127	122	125	113	129	121
Minute 9	123	131	118	118	110	124	121	126	116	130	122
Minute 10	130	122	112	121	105	124	118	128	117	126	120
5 Minute Recovery	93	97	73	68	72	110	90	72	68	65	81

UNSKILLED MALES

Subject	JW	FH	BG	TW	ST	NG	MR	JC	GMc	RS	Average
Resting Heart Rate	66	97	71	53	98	101	103	111	100	76	88
Minute 1	98	136	106	104	125	100	121	138	140	128	120
Minute 2	100	139	102	108	129	111	114	140	148	128	122
Minute 3	100	140	102	109	131	120	115	148	158	129	123
Minute 4	98	131	97	106	128	119	113	148	159	130	125
Minute 5	98	139	95	101	134	120	119	147	165	130	124
Minute 6	97	140	89	102	132	131	112	149	162	129	126
Minute 7	100	137	95	100	139	132	116	149	163	132	126
Minute 8	97	132	89	105	138	133	118	148	171	132	126
Minute 9	98	134	97	108	139	134	117	149	172	130	129
Minute 10	98	134	97	109	134	129	114	149	169	131	126
5 Minute Recovery	55	94	57	67	89	95	67	106	93	85	81

TABLE VI

18" TRAMPOLINE TEST

SKILLED FEMALES

Subject	ES	CB	JA	AM	DK	KH	LL	TM	EL	LF	Average
Resting Heart Rate	96	81	77	112	85	83	75	93	85	100	89
Minute 1	161	150	130	151	141	185	152	140	162	153	153
Minute 2	182	178	165	175	155	183	169	150	178	159	169
Minute 3	181	185	170	178	157	177	171	153	175	169	172
Minute 4	183	183	171	183	151	182	169	165	182	169	174
Minute 5	181	191	168	181	160	188	173	169	185	178	177
Minute 6	184	192	165	181	154	186	170	172	187	178	177
Minute 7	186	189	162	182	155	182	178	175	188	182	178
Minute 8	185	196	170	181	154	182	173	178	188	190	180
Minute 9	186	199	168	182	148	188	181	180	189	191	181
Minute 10	186	195	172	181	152	187	184	179	189	193	182
5 Minute Recovery	116	108	93	108	81	95	83	94	104	97	98

UNSKILLED FEMALES

Subject	DM	BM	SM	RH	LJ	PY	KW	CH	LL	AM	Average
Resting Heart Rate	81	101	82	82	93	76	73	93	75	107	86
Minute 1	135	166	171	165	179	148	151	160	141	154	157
Minute 2	145	179	180	171	183	152	161	171	158	162	166
Minute 3	139	181	188	172	188	155	155	169	156	160	166
Minute 4	137	185	183	178	191	155	165	171	161	164	169
Minute 5	148	188	183	173	189	158	169	175	158	165	171
Minute 6	148	188	185	173	189	167	168	179	159	170	173
Minute 7	146	185	185	178	193	171	169	170	158	172	173
Minute 8	148	188	181	178	195	175	173	172	160	179	175
Minute 9	148	189	183	179	195	171	173	178	159	178	175
Minute 10	151	194	183	182	196	173	174	180	160	175	177
5 Minute Recovery	76	117	93	104	95	76	89	122	88	94	95

TABLE VII

18" TRAMPOLINE TEST

SKILLED MALES

Subject	JM	KE	BC	GC	JD	DR	GW	RC	LC	GM	Average
Resting Heart Rate	73	111	79	71	76	97	93	98	76	69	84
Minute 1	141	129	147	131	135	128	131	132	145	148	137
Minute 2	150	136	145	139	135	139	149	149	138	153	143
Minute 3	160	138	159	148	137	142	149	155	147	152	149
Minute 4	171	138	166	151	136	137	150	162	161	150	152
Minute 5	167	136	156	148	135	139	160	167	163	159	153
Minute 6	159	141	159	152	134	139	155	171	162	160	153
Minute 7	158	142	159	151	136	138	155	172	170	160	154
Minute 8	170	144	156	158	135	147	153	172	174	165	157
Minute 9	172	142	154	168	137	149	153	171	171	171	159
Minute 10	172	145	155	170	134	144	154	178	169	170	159
5 Minute Recovery	107	107	99	88	88	95	95	106	80	86	95

UNSKILLED MALES

Subject	JW	FH	BG	TW	ST	NG	MR	JC	GM	RS	Average
Resting Heart Rate	56	85	68	63	81	95	69	110	95	99	83
Minute 1	126	141	143	135	139	129	143	150	168	139	141
Minute 2	130	150	157	138	145	140	145	153	179	155	149
Minute 3	138	145	157	141	151	135	152	152	181	152	150
Minute 4	141	151	154	139	153	147	153	158	183	159	154
Minute 5	142	149	154	140	154	148	149	167	188	155	155
Minute 6	142	155	151	135	158	150	148	171	189	159	156
Minute 7	138	150	153	138	161	149	149	171	189	162	156
Minute 8	142	165	149	134	164	151	147	171	188	168	158
Minute 9	140	159	156	139	169	152	151	172	191	163	159
Minute 10	140	163	159	139	170	160	149	180	190	169	163
5 Minute Recovery	60	68	63	66	110	88	87	112	106	95	86

TABLE VIII

CALORIE COST

8" TRAMPOLINE TEST

FEMALES

SKILLED		UNSKILLED	
Subjects	Calories	Subjects	Calories
ES	63.85	DM	64.5
CB	84.85	BM	36.4
JA	42.45	SM	76.6
AM	68.5	RH	91.75
DK	47.9	LJ	51.4
KH	83.8	PY	57.15
LL	73.85	KW	86.45
TM	69.05	CH	64.4
EL	60.45	LL	49.8
LF	55.6	AM	74.15

MALES

SKILLED		UNSKILLED	
Subjects	Calories	Subjects	Calories
JM	43.8	JW	23.75
KE	62.5	FH	79.3
BC	63.7	BG	48.25
GC	53	TW	72.6
JD	75.8	ST	87.6
DR	107.9	NG	90.9
GW	60.5	MR	113.05
RC	56.65	JC	117.35
LC	41.35	GM	144.9
GM	77.25	RS	76.8

TABLE IX

CALORIE COST

18" TRAMPOLINE TEST

FEMALES

SKILLED		UNSKILLED	
Subjects	Calories	Subjects	Calories
ES	104.1	DM	85.1
CB	94.95	BM	80.4
JA	100	SM	87.05
AM	97.65	RH	114.2
DK	77.8	LJ	85.6
KH	104.05	PY	102.9
LL	107.35	KW	108.65
TM	101.35	CH	77.35
EL	85.65	LL	85
LF	78.65	AM	96.45

MALES

SKILLED		UNSKILLED	
Subjects	Calories	Subjects	Calories
JM	101.65	JW	87
KE	86.5	FH	103.35
BC	111.35	BG	127.4
GC	127.45	TW	116.9
JD	121.8	ST	114.65
DR	136.1	NG	120
GW	100.55	MR	114.65
RC	116.65	JC	147.95
LC	84.75	GM	184.35
GM	119.3	RS	95

TABLE X

AEROBIC POINTS

8" TRAMPOLINE TEST

FEMALES

SKILLED		UNSKILLED	
Subjects	Points per/min	Subjects	Points per/min
ES	.25	DM	.31
CB	.45	BM	.15
JA	.13	SM	.35
AM	.27	RH	.41
DK	.22	LJ	.22
KH	.46	PY	.21
LL	.29	KW	.67
TM	.25	CH	.26
EL	.28	LL	.2
LF	.32	AM	.35

MALES

SKILLED		UNSKILLED	
Subjects	Points per/min	Subjects	Points per/min
JM	.12	JW	.06
KE	.23	FH	.28
BC	.23	BG	.14
GC	.16	TW	.24
JD	.2	ST	.5
DR	.38	NG	.4
GW	.19	MR	.65
RC	.19	JC	.47
LC	.15	GM	.52
GM	.23	RS	.43

TABLE XI

AEROBIC POINTS

18" TRAMPOLINE TEST

FEMALES

SKILLED		UNSKILLED	
Subjects	Points per/min.	Subjects	Points per/min.
ES	.63	DM	.53
CB	.55	BM	.57
JA	.52	SM	.45
AM	.57	RH	.62
DK	.57	LJ	.53
KH	.70	PY	.57
LL	.58	KW	1.06
TM	.49	CH	.35
EL	.54	LL	.50
LF	.64	AM	.56

MALES

SKILLED		UNSKILLED	
Subjects	Points per/min.	Subjects	Points per/min.
JM	.45	JW	.36
KE	.43	FH	.46
BC	.59	BG	.70
GC	.75	TW	.55
JD	.43	ST	.85
DR	.61	NG	.90
GW	.44	MR	.68
RC	.64	JC	.74
LC	.47	GM	.85
GM	.50	RS	.60

DATA SHEET NUMBER ONE NAME______________

TRAMPOLINE TEST NUMBER ONE AND TWO

TEST ONE	TEST TWO
Sitting Rate________	Sitting Rate__________
Standing Rate________	Standing Rate__________
MIN 1______________	MIN 1______________
MIN 2______________	MIN 2______________
MIN 3______________	MIN 3______________
MIN 4______________	MIN 4______________
MIN 5______________	MIN 5______________
MIN 6______________	MIN 6______________
MIN 7______________	MIN 7______________
MIN 8______________	MIN 8______________
MIN 9______________	MIN 9______________
MIN 10_____________	MIN 10_____________
MIN 11_____________	MIN 11_____________
MIN 12_____________	MIN 12_____________
MIN 13_____________	MIN 13_____________
MIN 14_____________	MIN 14_____________
MIN 15_____________	MIN 15_____________
MAXIMUM RATE________	MAXIMUM RATE________
MIN 3 RECOVERY_______	MIN 3 RECOVERY_______
MIN 5 RECOVERY_______	MIN 5 RECOVERY_______

DATA SHEET NUMBER TWO

Protocol_______________
Date___________________

Subject_______________________ ID#_____________________ Sex: M F

Ht.:_______in._______cm. Wt._______lb._______kg. P_B__________DBT____WBT____

Pre-Ex: HR_____________BP______/________ VO_2_________L/min._______ml/kg/min

Exercise Test Time	HR	BP	$\dot{V}_E$ (L/min) (BTPS)	VO_2 (STPD) L/min	VO_2 (STPD) ml/kg/min	VCO_2 (STPD) L/min	RQ
0:00-0:30							
0:30-1:00							
1:00-1:30							
1:30-2:00							
2:00-2:30							
2:30-3:00							
3:00-3:30							
3:30-4:00							
4:00-4:30							
4:30-5:00							
5:00-5:30							
5:30-6:00							
6:00-6:30							
6:30-7:00							
7:00-7:30							
7:30-8:00							
8:00-8:30							
8:30-9:00							
9:00-9:30							
9:30-10:00							
10:00-10:30							
10:30-11:00							
11:00-11:30							
11:30-12:00							
12:00-12:30							
12:30-13:00							
13:00-13:30							
13:30-14:00							
14:00-14:30							
14:30-15:00							

Test Duration: ______:______ __________min. Apparent Motiviation:___

DATA SHEET NUMBER THREE

NAME________________________ WEIGHT__________________ SEX_________________ _____________________________

TREADMILL				TRAMPOLINE				
	H.R	VO_2 (Liters)	(ml/kg/min)		H.R.	VO_2	ml/kg/ min	CALORIE COST
1				1				
2				2				
3				3				
4				4				
5				5				
6				6				
7				7				
8				8				
9				9				
10				10				
11				11				
12				12				
13				13				
14				14				
15				15				
5 min				5 min.				

Low_______

High______

VITA

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