THE EFFECTS OF PACING ON HEART RATES DURING ROPE JUMPING

By

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*This does not include the Style Group Jumpers

CHAPTER I

INTRODUCTION

In 1964, rope jumping was included in a battery of five test items for physical fitness in the program for secondary girls in the Tulsa Public School.

These tests included the following:

Test Item	Purpose
1. Sit and Reach	Flexibility
2. Bent Arm Hang	Arm and Shoulder
3. Sit-ups	Abdominal Muscle Strength
4. Obstacle Course	Speed and Agility
5. Jump Rope	Coordination

The investigator was a physical education teacher at Gilcrease Junior High School during 1964 to 1969 and administered these tests. The investigator's interest and concern, in this study, was the rope jumping test. The rope jumping test was one of two minutes duration. The students were instructed to jump on two feet, as many times as possible, until the two minutes had expired. During this four year period, the investigator observed that the rope jumping test caused quick exhaustion, boredom, or irregular jumping, on the part of the students. This caused their scores to be lower than they might have been, had they been paced for the two minute testing period.

The investigator became interested in this particular test because

students seemed to jump irregularly and to reach fatigue before the time limit was attained. The stated purpose of this rope jumping test was to test coordination. However, the investigator felt that rope jumping was a test of endurance, just as much as it was a test of coordination. Most girls in junior high school do have the skill to jump rope in some manner, depending upon how they learned this skill earlier.

In the different schools in Tulsa, it seemed to be felt among physical education teachers, that testing procedures were not standardized. Ropes were made of different materials, making some jump rope lighter in weight, than others. Scores, means, comparisons, and data concerning the tests were not made available for use, to the instructor. Therefore, there was no knowledge gained, as far as meaning to the instructor, for future use.

It was felt that if the students could learn to pace themselves, they could increase their length of jumping time and thereby score higher. The investigator also wanted to determine the relationship of rope jumping to heart rates.

Statement of the Problem

The purposes of this study were:

1. to determine if pacing by use of a metronome, would change the heart rate in rope jumping.
2. to determine if any one style of jumping was more strenuous than another, as judged by heart rate.
3. to compare skilled and non-skilled jumpers of normal weight, to those considered to be overweight or underweight in jumping

skill.

4. to compare skilled jumpers with joggers and non-jumpers, on mile run times, as a test of cardiovascular fitness.

Hypotheses of the Study

This study was based on five hypotheses.

1. Heart rates during rope jumping are increased more without some method of pacing, than with pacing.
2. Highly skilled jumpers have lower heart rates during jumping than do non-skilled jumpers.
3. Styles of jumping will influence the heart rate of the jumper, while jumping.
4. Weight and age have no influence on the skill of jumping rope.
5. Skilled jumpers are no different than the joggers, in endurance, as measured by mile run times.

Importance of the Study

This study will be important to the testing program in the Tulsa Public Schools, if it can show that higher scores can be made on the rope jumping test by some method of pacing. This would improve physical fitness and physical fitness scores, and also, improve the students' skill in rope jumping.

It is essential that those concerned with exercise programs have knowledge as to the values, benefits, and shortcomings of numerous forms of physical activity that contribute to improved circulatory fitness.

Recent evidence on fitness seems to indicate, that there is a

need for people to participate in the type of physical activity, which will promote the improvement of cardiovascular efficiency.[1,2,3]

Cureton indicated the best method of improving cardiovascular fitness was through endurance programs such as jogging, swimming, and cycling.[4]

Bowerman and Harris indicate that jogging will gradually increase the level of physical fitness.[5]

Kenneth H. Cooper explains fitness as getting enough oxygen to all areas of the body, where the food is stored, so that the two can combine to produce energy.[6]

John A. Baker did a research study on rope skipping and jogging and its effects upon cardiovascular efficiency. He recommended that a daily 10 minute program of rope skipping will significantly improve cardiovascular efficiency. After concluding that rope jumping was efficient and beneficial to cardiovascular fitness, he recommended it as a valuable phase of physical education programs that include

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[1]Thomas K. Cureton, "The Relative Value of Various Exercise Conditioning Programs, to Improve Cardiovascular Status and to Prevent Heart Disease," Journal of Sports Medicine and Physical Fitness, (1965).

[2]William J. Bowerman and W. E. Harris, M.D., Jogging, (1967).

[3]Kenneth H. Cooper, M.D., Aerobics, (1968).

[4]Cureton, pp. 54-55.

[5]Bowerman and Harris, pp. 7.

[6]Cooper, pp. 9.

endurance-type activities.[7]

Limitations of the Study

There are several limitations in this study. Teacher judgement was used in selecting student leaders to assist in obtaining heart rates of jumpers and joggers.

Because of limited equipment and regularly scheduled class activities, it was necessary to test before and after school hours; thus, testing operations were quite time consuming. After selecting the highly skilled jumpers and the non-skilled jumpers, the testing was started.

The number of non-jumpers was limited for motivational and psychological reasons. The non-jumpers were requested to run a mile for this study.

Assumptions of the Study

Five assumptions were made in this study. First, rope jumping is likely to be irregular in rhythm, without some method of pacing. This was observed by the investigator over the four years of administering these tests. Second, all subjects possessed some skill in rope jumping. Third, the investigator and the selected student leaders were capable of obtaining valid heart rates with a stethoscope. Fourth, that the testing procedures and instructional operations would be comprehensive and easily understood. Fifth, that the subjects' hearts

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[7] John A. Baker, "Comparison of Rope Skipping and Jogging as Methods of Improving Cardiovascular Efficiency of College Men," Research Quarterly, XXXIX, p. 241.

were without malfunction and disease.

During the first few weeks of the fall semester, seventh graders were tested through what is called, "clinic." This was a program set up to test each girl and boy for any physical deficiencies or abnormalities, that might hinder his or her participation in physical education classes. It was conducted by medical doctors, nurses, the school nurse, and volunteer mothers from the Parent-Teacher Association.

CHAPTER II

REVIEW OF RELATED LITERATURE

Physical fitness is a matter of concern to all who are involved in the development of health and welfare of the nation's youth. Methods of assessing physical condition have been devised by physical educators throughout the United States and testing programs are conducted through the year from coast to coast. However, one aspect of physical fitness which, until recently, has received relatively little attention is that of cardiovascular efficiency. Batteries of tests in common use do not generally include items which measure adaptation of the heart to exercise.

The American Heart Association accepts as normal pulse rate, a range of 50 to 100 beats per minute.[8] The round figures limiting this range, are arbitrary. However, the great majority of normal pulse rates will fall within these limits. Rates outside this range should be carefully re-examined before they can be accepted as normal and not exceptional.[9] Pulse rates for women, in basal condition are from seven to eight beats higher than for men. The pulse rate in healthy persons is affected by age, body size, body position, food intake, time of the day, emotions, and physical activity.

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[8]Peter V. Karpovich, Physiology of Muscular Activity, (1965),pp.163.

[9]Karpovich, pp. 163-164.

Because emotions accelerate the pulse rate, it is sometimes very difficult and even impossible to obtain a normal resting pulse rate. The subject may appear relaxed, while his pulse rate tells a different story. Variations in the emotional state affect the pulse rate much more than postural changes. A seemingly simple thing like waiting for a test may greatly affect the rate of the pulse. This has been well demonstrated by Brouha on a group of college students in one of his experiments.[10] Obtaining a reliable resting pulse in children is much more difficult than obtaining a reliable count in adults. Besides being more excitable, children are usually restless while waiting for examinations.

At the beginning of muscular exercise, the pulse rate increases rapidly. The greatest rise takes place within one minute. Gradually a plateau is reached. As one may expect, the change in pulse rate depends on the individual. For equal intensity of work, one subject may have a pulse rate of 160, while another's may reach 220. Excitement may also affect the work pulse rate. For the same intensity of work as judged by the amount of oxygen used, more physically fit persons have lower pulse rates. The time required for the pulse rate to return to normal after exercise depends upon the intensity of the exercise and upon the condition of the individual. Increasing the intensity of exercise increases the time required for recovery. On the other hand, better physical condition tends to shorten the period

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[10] L. Brouha, "Physiological Reactions of Men and Women During Muscular Activity and Recovery in Various Environments," Journal of Applied Physiology, (1961), XVI, pp. 133.

of recovery.[11]

It is a common belief that, in a group of subjects after a standard exercise, pulse rates will be higher in those individuals whose resting pulse rates are also higher.[12]

Resting, exercise, and postexercise heart rates are significantly higher for females at all ages. Pre-exercise heart rate decreases from age 10 to about age 25 in males and females, and shows little age change thereafter.[13]

Rope jumping, as with other traditional games, can be traced both into ancient cultures and around the world. Whether used for special festivals or done to the turn of common rhymes, it is basically the same everywhere in execution from the simplest form of running and jumping over a rope held by two others, to an intricate and difficult routine using two ropes swinging simultaneously at right angles while the jumpers has his own rope to manipulate-all going at once.[14]

There are few other activities which contribute as greatly toward agility, coordination, rhythm, and endurance in such a simple and direct manner. Rope jumping also challenges the ingenuity and skill of the performer. Once basic timing has been mastered, there are no limits to the variety of routines possible.[15]

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[11]Karpovich, pp. 167-168

[12]Karpovich, pp. 173.

[13]Karpovich, pp. 164.

[14]Betty van der Smissen and Helen Knierim, Fitness and Fun through Recreational Sports and Games, (1964), pp. 115.

[15]Smissen and Knierim, pp. 115.

Information concerning rope jumping skills of junior high school girls was not found in this research study. However rope skipping speeds and comparisons of skipping rope and jogging were evaluated in an article by John A. Baker.

This study by Baker was conducted to determine the effects upon cardiovascular efficiency that result from programs of rope skipping and jogging. The Harvard step test was administered to 92 male students in order to determine their level of cardiovascular efficiency. The subjects were then randomly divided into two groups; group I skipped rope 10 minutes daily for six weeks and group II jogged 30 minutes daily for six weeks. Upon completion of the conditioning programs the subjects again were administered the Harvard step test and comparisons were made from the pre-exercise and postexercise data.[16]

Baker concluded and recommended the following:

"1. A daily 10 minute program of rope skipping will significantly improve cardiovascular efficiency.

2. A daily 30 minute program of jogging will significantly improve cardiovascular efficiency.

3. A 10 minute daily program of rope skipping is as efficient as a 30 minute daily program of jogging for improving cardiovascular efficiency." [17]

It is therefore recommended that rope skipping, being less time-consuming than jogging, can be a valuable phase of any physical education program that includes endurance-type activities. Rope skipping should also be attractive to adults who were motivated toward endurance training but, were unable to participate in jogging programs because

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[16]Baker, pp. 240.

[17]Baker, pp. 243.

of time and/or facility factors.[18]

The results of a study by Cascino indicate that a program of rope skipping would improve the cardiovascular fitness of adult males.[19]

Curtis found that a rope skipping program for elementary schoool children resulted in no significant changes in endurance, leg power, agility, and coordination.[20]

Jones, Squires, and Rodahl, in a study on rope skipping and physical work capacity used seven untrained, nonathletic women. These women, ages 19 to 42, participated in a daily five-minute rope skipping program during a four week period. As a result of this training program, there was a significant improvement in physical work capacity as judged by pulse response to a standardized submaximal work load, or by the estimated maximal oxygen uptake based upon the pulse response to submaximal ergometer work according to the Astrand nomogram. It is suggested that rope skipping can be adopted as a simple method of improving the physical work capacity of a large segment of our population.[21]

In Baker's study, the group that was skipping rope was to jump or skip with a cadence or some kind of pace, or speed. The beginning

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[18]Baker, pp. 243.

[19]Joseph A. Cascino, "The Effects of a Program of Progressive Rope Skipping on the Cardiovascular Fitness of Adult Men," (unpub. master's thesis, Temple University, 1964).

[20]Delores M. Curtis, "Rope Skipping and the Endurance, Leg Power, Agility, and Coordination of Children," (unpub. doctoral dissertation, University of Illinois, 1963).

[21]D. Marritt Jones, Chadwick Squires, and Kaare Rodahl, "Effect of Rope Skipping on Physical Work Capacity," Research Quarterly, XXXIII, (1962), pp. 236.

skipping speed was 125 turns of the rope per minute. In this study, as the investigation progressed, subjects were allowed to gradually increase skipping speed in accordance with the Prentup table of skipping speeds.[22]

The rope skipping speeds suggested by Prentup are as follows:

1.	Slow skipping	125 to 130 turns per min.
2.	Medium skipping	135 to 145 turns per min.
3.	Fast skipping	150 to 160 turns per min.
4.	Speed skipping	165 to 170 turns per min.[23]

The investigator felt that pacing or a constant rhythm was needed to improve the scores of the students' scores on their physical fitness test.

In a study by Adams and Bernauer, variations of pacing are discussed in relationship to running.

It is generally accepted physiological principle that the maximum speed at which one can perform middle distance and distance races is limited by the rate at which the runner is able to supply oxygen to the muscles, (0_2 intake), and the energy his body is capable of furnishing through anaerobic metabolism during the time of the work. Track coaches differ markedly in their choice of the optimal method of pace during a middle distance race.[24]

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[22] Baker, pp. 241.

[23] Frank B. Prentup, Skipping the Rope for Fun and Fitness, (1963).

[24] William C. Adams and Edmund M. Bernauer, "The Effect of Selected Pace Variance on the Oxygen Requirement of Running a 4:37 Mile," Research Quarterly, XXXIX, pp. 837.

Nine experienced middle distance runners completed three experimental runs of equal distance and duration on a motor driven treadmill. Each run varied according to pace (steady, fast-slow-fast, and slow-fast), with the individual order of runs rotated to prevent bias in this respect. Heart rate and oxygen consumption measures were taken during rest, exercise and a 30 minute recovery period. Oxygen consumption values for the 30-90 minute recovery period were extrapolated from earlier measured recovery values. Analysis of data indicated that there were no significant differences among the three pace plans in net oxygen intake during the runs. However, the total oxygen debt value for the steady pace was lower than that for either the fast-slow-fast or the slow-fast paces. The total net oxygen requirement for the steady pace was found to be significantly less than that for the other two paces with no significant difference between the fast-slow-fast and slow-fast paces. It was concluded that a steady pace is most efficient for achieving best time in the mile run. Several reasons for individual differences in the oxygen requirement for running a specified effort were discussed.[25]

Several studies revealed changes in physical performance while subjects were listening to music. Scripture reported that thumb and finger grip pressure increased with stimulating music and decreased with the slow music.[26]

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[25]Adams and Bernauer, pp. 837.

[26]E. W. Scripture, Thinking, Feeling, and Doing, (New York, 1907).

Ayres, in a study of riders in a six-day bicycle rate, found that the average times were faster when the band was playing than when the band was silent. However, he observed that when the music was played, the audience was stimulated to applaud and encourage the riders. Thus, the faster riding may have been a direct result of the music, or it may have resulted indirectly from the encouragement of the spectators, who were aroused by the music.[27]

Of the studies concerned with circulatory changes in response to music, the study conducted by Dogiel was the first to be reported. He found that pulse rate and blood pressure reacted to musical sounds depending on the pitch and the intensity of the sound.[28]

Weld found an acceleration of the heart rate during a period of music, but he found no correlation between the tempo of the music and the change in the heart rate. He concluded that the circulatory changes were functions of attention and no products of emotional variations.[29]

Warthin found rather profound changes in pulse rate and respiration rate as a result of music when his subjects were in the hypnotic state, but very little change in their normal waking state.[30]

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[27]Leonard P. Ayre, "The Influence of Music on Speeds in the Six-day Bicycle Race," American Physical Education Review, (1911), XVI, pp. 321-324.

[28]J. Dogiel, "Ueber den Einflue der Music auf den Blutkreislauf," Arch. fur Physiol., (1880), pp. 416-428.

[29]Harry P. Weld, "An Experimental Study of Musical Enjoyment," American Journal of Psychology, (1912), XXIII, pp. 245-308.

[30]Alfred S. Warthin, "Some Physiological Effects of Music in Hypnotized Subjects," Medical News, (1894), LXV, pp. 89-92.

Wascho, with 61 high school students as subjects, reported that the most dramatic change in pulse rate occurred with "Stars and Stripes Forever" by Sousa (average increase of 8.9 beats per minute) and "Serenade" from Madame Butterfly by Puccini (average decrease of 8.0 beats per minute).[31]

Ellis and Brighouse reported significant changes in pulse rate and respiration rate during a period of music, but found that these changes were not maintained after the music stopped.[32]

Rope jumping makes excellent contributions to physical fitness. The space requirements are small and the cost of materials negligible. The activity is enhanced by the addition of suitable music.[33]

The jumper should develop a sense of rhythm. The rope should turn at a constant rhythem. The rope should be turned with centrifugal force with a quick easy motion of the hands.[34]

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[31]Alec Wascho, Jr., "The Effects of Music upon Pulse Rate, Blood Pressure, and Mental Imagery," (unpub. E.D. thesis, Temple University, 1933).

[32]Douglas S. Ellis and Gilbert Brighouse, "Effects of Music on Respiration and Heart Rate," American Journal of Psychology, (1952), LXV, pp. 39-47.

[33]Victor P. Dauer, Fitness for Elementary School Children through Physical Education, (1962), pp. 229.

[34]Dauer, pp. 229.

CHAPTER III

RESEARCH PROCEDURES

The subjects who participated in this study in the school year of 1968-69, were secondary school girls at Gilcrease Junior High School in Tulsa, Oklahoma. These girls were enrolled in the investigators' physical education classes. Their ages ranged from twelve to fifteen years. They were all classified as seventh graders, eighth graders, or ninth graders.

The purposes of this study were:

1. To determine if pacing by a metronome would affect the heart rate in rope jumping
2. to determine if any one style of jumping was more strenuous than another, as judged by heart rate
3. to compare skilled and non-skilled jumpers of normal weight, to those considered to be overweight or underweight, on jumping skill
4. to compare skilled jumpers with joggers and non-jumpers on the mile run time, as a test of cardiovascular fitness.

The testing was begun in early fall, as this was the designated time set up to administer physical fitness tests by the Tulsa Public Schools. The investigator tested all of the girls enrolled in physical education classes, which was 248. For this study, the investigator was concerned primarily with the rope jumping test.

Before the testing procedures began, student leaders were selected to listen to heart rates. These student leaders practiced obtaining heart rates with each other and also, with the investigator. For a test of reliability, all selected student leaders were asked to obtain a heart rate on a particular subject, before and after the subject engaged in an exercise. They were asked to do this three times; each time on a different subject. When the investigator felt that valid scores were being recorded, these particular girls were selected as having the capability of obtaining heart rates, for this study. They used a stethoscope and a stopwatch.

The selected student leaders and the investigator obtained resting heart rates on all girls enrolled in the investigators' physical education classes. Also, age, weight and height were recorded as personal data for each subject.

The subjects were then tested. The instructions were to jump rope on two feet for two minutes, jumping as many times as possible in this time limit. This test was not paced and no specific directions as to tempo or rhythm were given. Heart rates were obtained immediately after jumping, for 15 seconds by either the investigator or by the selected student leaders. This was done using a stopwatch and a stethoscope. Heart rates for the runners were obtained for 30 seconds immediately after running.

The investigator defines this first test, the Tulsa Public Schools physical fitness rope jumping test, as the "initial" test. The test given secondly, that was administered the same way, except for the pacing factor, the investigator defines, as the "re-test". This test was paced at 120 counts per minute, with a metronome.

In the re-test, 51 subjects were tested. A total of 187 girls were used in this research study. Subjects were chosen at random, from among those available, for the re-test, for participation in this research study, as the investigator had to consider class structure and organization. The investigator defines this group as the "rope jumpers." Also, some girls rode buses and some girls had parents, who picked them up after school. Therefore, due to the transportation situations, it was necessary to test whenever subjects were available.

During the period of time for the testing, none of the girls were permitted to practice rope jumping. The only difference in the initial test and the re-test, was the pacing factor. Therefore, it was assumed that the subjects' skill in rope jumping was not greatly improved from one testing period to another.

A group of 30 girls was selected by the investigator, from scores made on their initial test, as the skilled jumpers. This group was represented equally with seventh, eighth, and ninth graders. This same method of grouping was used to select 30 girls, as the non-skilled jumpers. Also, from the personal data collected at the beginning of this study, overweight and underweight subjects were classified likewise. Thus, the investigator used 30 girls, who were skilled jumpers, 30 girls, who were non-skilled jumpers, and 30 girls who were overweight and underweight jumpers combined.

A group of 20 girls was selected at random to jump rope using two styles of jumping. These styles were a one foot jump and a one foot jump crossing the rope in front of the body on alternate jumps. The subjects jumped rope for two minutes paced and not paced, performing the one foot jump and one foot jump cross-handed,

This same group, the style group, performed the re-test, but jumped rope for four minutes, instead of two minutes.

During the first three weeks of the school term, 18 girls joined the jogging club, instigated by the investigator. These girls ran one-half mile, once a week, for nine weeks. In the next four weeks, they ran one mile, once a week. A slow steady pace was used, as a jogging speed. At the end of this training period, the joggers were requested to run a mile as fast as they could, with cautionary instructions about beginning too fast. At the completion of the mile run, the subjects' time was recorded. Also, their heart rates were obtained immediately after the run, for 30 seconds and recorded.

In obtaining mile times for the non-jumpers, the investigator asked for volunteers. As one can readily understand, this was not the most appealing assignment for most girls this age. However, 11 girls did consent to perform this activity. Again, cautionary instructions were given as to pace. Also, these volunteer non-jumpers were instructed to quit, if it became necessary, before the mile run was completed. Thus, three girls did quit, leaving eight girls completing the mile run. The eight girls were timed on their mile run and heart rates were obtained immediately after the run for 30 seconds.

The skilled jumpers were requested to run in the same manner, voluntarily and with caution to pace. Fourteen of this group consented to run the mile. Again, after all fourteen had completed the mile run, their mile run times were recorded and their heart rates were obtained, by a selected student leader, with a stethoscope and stopwatch, for 30 seconds.

The data was organized to show the following:

1. Change in heart rate after two minutes of rope jumping without pacing.
2. Change in heart rate after two minutes of rope jumping with pacing.
3. Change in heart rate after four minutes of rope jumping without pacing.
4. Change in heart rates after four minutes of rope jumping with pacing.
5. Change in heart rates after jogging for one mile.
6. Change in heart rates after jumping for two minutes, using a one foot jump.
7. Change in heart rates after jumping for two minutes, using a cross-handed alternating jump.
8. Change in heart rates after jumping for two minutes, without pacing, for the non-skilled jumper.
9. Change in heart rates after jumping for two minutes, with pacing, for the non-skilled jumper.
10. Change in heart rates after jumping for two minutes, without pacing for the skilled jumper.
11. Change in heart rates after jumping for two minutes, with pacing for the skilled jumper.
12. Change in heart rates after jumping for two minutes, without pacing, for the underweight and overweight jumper.
13. Change in heart rates after jumping for two minutes, with pacing, for the underweight and overweight jumper.

14. Find group means of heart rates, in all cases of the above; numbers one through thirteen.

15. t-ratios were computed to determine the significance of difference between the means of the heart rates of the rope jumpers, with and without a pacer, and for the following groups.

    A. styles of jumping

        (1) a four minute test

        (2) a one foot jump test

        (3) a cross-handed one foot jump test

    B. weight problem jumpers

    C. skilled jumpers

    D. non-skilled jumpers

16. t-ratios were computed to determine if there were any significant differences in the means of the heart rates of skilled rope jumpers, as compared with those of the joggers and non-jumpers.

17. t-ratios were computed to determine if there were any significant differences, in the mean mile run times of skilled rope jumpers, as compared with those of the joggers and the non-jumpers.

CHAPTER IV

RESULTS

In evaluating the seven different groups, the means for the following conditions were computed:

1. the paced rope jumping scores after jumping
2. the unpaced rope jumping scores after jumping
3. the paced rope jumping heart rates immediately after rope jumping
4. the unpaced rope jumping heart rates immediately after rope jumping
5. the mile run times immediately after running
6. the mile run heart rate immediately after the mile run

Through the results wherever heart rates are referred to, this means they were measured immediately after jumping or running. The heart rates of rope jumpers were taken for 15 seconds and multiplied by four to obtain minute heart rates. The heart rates of runners were taken for 30 seconds and multiplied by two for minute heart rates.

The means of the heart rates after jumping and running are found in Table I and II. The group possessing the lowest mean heart rate on the initial test, was the rope jumpers, with a mean of 175.58. The group possessing the highest mean heart rate was the weight problem jumpers, with a mean of 235.86. On the retest, again, the weight problem jumpers had the highest heart rate, which was 229.26. It was

the investigator's observation, from heart rate scores, that the overweight subjects' heart rates seemed to influence the mean of this group, more than did the underweight rope jumpers' heart rates. However, the skilled jumpers showed the lowest heart rate on the retest, with a heart rate of 152.2.

The mean rope jumping skill socres made on the initial test ranged from 80.6 for the non-skilled jumpers to 182.5 for the skilled jumpers.

TABLE I

GROUP MEANS OF HEART RATES AND SKILL SCORES FOR ALL SUBJECTS

Groups	N =	unpaced Initial Test		paced Retest		Mile Run Times min.	Post Mile Run Heart Rates
		s	hr	s	hr		
Weight Jumpers	30	104.83	235.86	122.26	229.26		
Non-Skilled Jumpers	30	80.6	222.26	116.5	205.06		
Skilled Jumpers	30	182.5	186.93	199.96	152.2	13.32 (N=14)	217.42
Rope Jumpers	51	123.00	156.	172.27			
Joggers	18					9.7	193.66
Non-Jumpers	8					19.81	241.25

[s] rope jumping skill score - no. of jumps in 2 min.

[hr] heart rate, beats per min. after jumping

TABLE II

GROUP MEANS OF HEART RATES AND SCORES

FOR STYLE GROUP JUMPERS (N=20)

Test	Style Group Jumpers			
	Skill Scores		Post Jumping Heart Rates	
	np**	p*	np	p
The 4 minute test	291.95	313.00	224.00	211.80
	Scores		Heart Rates	
	np	p	np	p
The one foot jump test	193.80	226.00	193.80	186.20
	Scores		Heart Rates	
	np	p	np	p
The cross-handed test	106.45	116.65	177.2	170.50

*paced

**not paced

These rope jumping skill scores for jumping and running are found in Table I and II. Skill scores are explained by the following analysis:

Jumps in two minutes	Evaluation
170 and over	Excellent
155 to 169	Good
130 to 154	Average
111 to 129	Fair
0 to 110	Poor

On the retest, the range of rope jumping skill scores was 116.5 to 199.96. The non-skilled jumpers made the lowest mean skill score, while the skilled jumpers made the highest mean score. The mean rope jumping scores did improve on all groups, from the initial test to the retest. The improvement skill scores ranged from 17.46 for the skilled jumpers to 36.1 improvement for the non-skilled jumpers.

In bringing together personal data, group means were computed for age, weight, height and resting heart rate, for all groups. The resulting means of these groups are found in Table III.

The group possessing the lowest resting heart rate was the non-jumpers. This heart rate was 75.5 compared to 80,73 for the weight problem jumpers, which was the highest resting heart rate.

The combined rope jumpers consisted of the non-skilled jumpers, the weight problem jumpers, the skilled jumpers, and the rope jumpers. This group was compared, by means of a t-ratio, on paced and unpaced skill socres, and paced and unpaced heart rates. The mean of the paced skill scores was 143.71, compared to 124.56 on the unpaced skill

TABLE III

GROUP MEANS OF RESTING HEART RATES AND PERSONAL DATA

Group	N =	Resting Heart Rate	Age yrs.	Height in.	Weight lbs.
Rope Jumpers	51	76.54	13.19	62.47	110.52
Skilled Jumpers	30	76.26	13.13	63.06	119.00
Non-Skilled Jumpers	30	79.80	13.2	62.66	117.76
Weight Prob. Jumpers	30	80.73	13.16	64.1	132.7
Style Group Jumpers	20	76.9	13.5	63.7	119.95
Joggers	18	76.22	13.5	63.83	119.44
Non-Jumpers	8	75.5	14.0	63.87	122.25

*14 of these subjects ran the mile

scores. The mean of the paced heart rates was 189.69, compared to 205.15 on the unpaced heart rates.

The average age of all the subjects was 13.38 years. The average height and weight of all of the subjects was 63.38 inches and 120.23 pounds.

The classification and number of students involved in this research study are found in Table III. A total of 187 subjects was used in this study. These girls were represented in the seven different participating groups.

Using Dwyer's Single Computational Formula and the Traditional t-ratio Formula, the following t-ratios were obtained.

Skilled Jumpers Compared to Joggers

1. The joggers were significantly superior on mile run times, to the skilled jumpers with a t-ratio of 6.68. This was significant at the 1% level of confidence.
2. The joggers had significantly lower heart rates immediately after the mile run, to the skilled jumpers, with a t-ratio of 4.58. This was significant at the 1% level of confidence.

Skilled Jumpers Compared to Non-Jumpers

1. The skilled jumpers were significantly superior on mile run times, to the non-jumpers with a t-ratio of 4.72. This was significant at the 1% level of confidence.
2. The skilled jumpers were significantly lower on mile run heart rates, over the non-jumpers with a t-ratio of 3.25. This was significant at the 5% level of confidence.

Combined Rope Jumpers Paced Compared to Combined Rope Jumpers Unpaced on Skill Scores

1. The skill scores of the combined rope jumpers on the paced test were higher than the skill scores of the combined rope jumpers on the unpaced test, with a t-ratio of 2.91. This was significant at the 5% level of confidence.

Combined Rope Jumpers Paced Compared to Combined Rope Jumpers Unpaced on Heart Rates

1. The heart rates of the combined rope jumpers on the paced test were lower than the heart rates of the combined rope jumpers on the unpaced test, with a t-ratio of 3.42. This was significant at the 5% level of confidence.

Rope Jumpers Paced Compared to Rope Jumpers Unpaced

1. The heart rates of the rope jumpers on the paced test were lower than the heart rates of the rope jumpers on the unpaced test, with a t-ratio of 2.26. This was significant at the 5% level of confidence.

Weight Problem Jumpers Paced Compared to Weight Problem Jumpers Unpaced

1. The heart rates of the weight problem jumpers on the paced test were lower than the heart rates of the weight problem jumpers on the unpaced test, with a t-ratio of 2.09. This was significant at the 5% level of confidence.

Skilled Jumpers Paced Compared to Skilled Jumpers Unpaced

1. The heart rates of the skilled jumper on the paced test, were significantly lower than the heart rates of the skilled jumper on the unpaced test, with a t-ratio of 11.95. This

was highly significant at the 1% level of confidence.

Non-Skilled Jumpers Paced Compared to Non-Skilled Jumpers Unpaced

1. The heart rates of the non-skilled jumpers on the paced test were not significantly lower, than the heart rates of the non-skilled jumpers on the unpaced test, with a t-ratio of .34. This was not significant.

Style Group Paced and Style Group Unpaced on the Four Minute Test

1. The heart rates of the style group paced was significantly lower, than the heart rates of the style group unpaced, with a t-ratio of 2.56. This was significant at the 5% level of confidence.

Style Group Paced and Style Group Unpaced on the One Foot Jump Test

1. The heart rates of the style group paced were not significantly lower, than the heart rates of the style group unpaced, with a t-ratio of 1.49. This was not significant.

Style Group Paced and Style Group Unpaced on the Cross-handed Test

1. The heart rates of the style group paced were significantly lower, than the heart rates of the style group unpaced, with a t-ratio of 2.31. This was significant at the 5% level of confidence.

DISCUSSION

In most groups, heart rates did stay lower after jumping on the retest, than on the initial test, and were significant. The exception, howerver, was the style group who jumped on one foot, and the non-

skilled jumpers. In these two cases, there was little or no difference.

According to the resulting findings and t-ratios, the first three stated hypotheses of this research were accepted.

1. The first hypothesis stated, "Heart rates during rope jumping are increased more, without some method of pacing, than with pacing." This hypotheses was accepted for all groups tested except for the non-skilled rope jumpers and the style group rope jumpers who jumped on one foot. For these groups this hypothesis was rejected.
2. The second hypothesis stated, "Highly skilled jumpers have lower heart rates during jumping than do non-skilled jumpers." It was found out of all the girls, who jumped rope in this study, one girl jumped rope 240 times on the retest without any misses, making a perfect score. This test, as has been stated, was for two minutes duration, and was paced by a metronome at 120 counts per minute.
3. The third hypothesis stated, "Styles of jumping will influence the heart rate of the jumper while jumping." The mean heart rate of the paced cross-handed jump test was 170.50, compared to 193.80 for the unpaced one foot jump test.

According to the resulting findings and t-ratios, the fourth and fifth hypotheses of this research were rejected.

1. The fourth hypothesis stated, "Weight and age have no influence on the skill of jumping rope." The weight problem jumpers had next to the lowest rope jumping scores, and the highest heart rates after jumping. The mean age in every group was approximately the same. Therefore, no statistical

test was made of this effect. However, it was the observation of the author, that age had no effect upon the rope jumping skill scores or the rope jumping heart rates.

2. The fifth hypothesis stated, "Skilled jumpers are no different than the joggers, in endurance, as measured by mile run times." The joggers were significantly superior on mile run times and on mile run heart rates after running. There was one skilled jumper, whose mile run time was close to that of the mean of the joggers' group mile run times. This individual skilled jumper's mile run time was nine minutes and fifty-seven seconds, as compared to the joggers' mean mile run times of nine minutes and forty-two seconds. This individual mile run raw score, can be found in Appendix J, subject number 28. The joggers were significantly faster than the skilled jumpers and their heart rates were significantly lower, indicating better cardiovascular fitness.

TABLE IV

COMPARISONS OF STANDARD DEVIATIONS, MEANS, AND t-RATIOS BETWEEN GROUPS

Groups	Combined Group		Combined Group		Skilled Jumpers		Non-Skilled Jumpers		Rope Jumpers		Weight Problem Jumpers		Style Group on 4 Minute Test		Style Group on 1 Foot Jump		Style Group on Cross-Handed Jump		Joggers and Skilled Jumpers				Non-Jumpers and Skilled Jumpers		
	Skill Scores																								
	np	p	np	p	np	p	np	p	np	p	np	p	np	p	np	p	np	p	t	t	h	h	t	t	h	h
Standard Deviation	18.9	32.71	26.58	33.04	9.03	8.85	77.22	101.1	9.0	7.64	11.13	14.5	14.4	14.9	15.1	16.2	8.93	8.94	*		*		*		*	
Mean	124.56	143.71	205.15	189.69	186.93	152.2	222.26	205.06	175.58	172.27	235.86	229.26	224.0	211.8	193.8	186.2	177.2	170.5	13.32	9.7	217.42	193.66	13.32	19.81	217.42	241.25
t-ratio	2.91**		3.42**		11.95**		.34ns		2.27**		2.09**		2.56**		1.49ns		2.31**		6.68***		4.5***		4.72***		3.25**	

*Dwyer's Single Computational Formula Used
**Sig. at 5% level of confidence
***Sig. at 1% level of confidence
^{p}paced
^{np}not paced
^{ns}not sig.

^{t}time in minutes
^{h}heat rate

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

The investigator wanted to learn about pacing effects on heart rates in rope jumping. It was felt that pacing would increase the skill scores made on a physical fitness rope jumping test. Also, the investigator wanted to compare certain skill level jumpers to girls who had been on a jogging training program, on a test of cardiovascular fitness. In doing this, the author compared mile run times and post mile run heart rates.

Within this study, these conclusions were drawn.

1. Pacing did have the effect of lowering heart rates after rope jumping for the combined group of rope jumpers; (N=141) (t-ratio of 3.42 significant at the 1% level of confidence).
2. Rope jumping skill scores were higher on the paced test, than on the unpaced test, for the combined group of rope jumpers; (N=141) (t-ratio of 2.91 significant at the 5% level of confidence).
3. Heart rates immediately after rope jumping were lower with pacing in all groups except, the non-skilled rope jumpers and the style group jumpers who jumped rope on one foot.
4. Rope jumping skill scores in all group were higher with pacing except, the non-skilled rope jumpers and the style group jumpers who jumped rope on one foot.

5. Skilled rope jumpers were not as high in cardiovascular fitness as measured by mile run times and post run heart rates as a group of girls who had been jogging for nine weeks.
6. Rope jumping on one foot as judged by heart rate, was more strenuous than jumping a cross-handed jump, for the same amount of time.

As a result of this study, the investigator recommends that rope jumping tests be paced for higher scores, in a specific time limit, and for lower heart rates.

Also, different pacing agents might be used, such as music, a self-taught pace, or a metronome, as was used in this study.

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APPENDIX A

RAW SCORES FOR ROPE JUMPERS

Name	Age	Wt.	Ht. Inches	Resting Heart Rates	Scores Initial	Scores Retest	Heart Rates Initial	Heart Rates Retest
1.*P.A.	12	107	63	72	170	194	187	168
2. M.B.	12	106	62	80	63	105	176	172
3. G.B.	13	110	63	68	182	200	180	172
4. D.B.	14	112	63	72	108	145	176	168
5. S.B.	12	92	59	76	143	185	176	172
6. M.B.	13	117	64	76	90	111	180	176
7. L.D.	14	112	63	76	132	182	172	180
8. T.B.	14	128	65	72	157	175	172	164
9. L.C.	14	85	59	76	104	166	180	172
10. R.C.	13	94	59	80	107	150	188	180
11. V.C.	12	121	64	76	106	146	192	168
12. V.C.	12	119	64	72	100	110	188	184
13. G.C.	13	112	63	72	157	185	176	168
14. P.A.	14	109	63	76	124	188	164	168
15. R.C.	14	122	64	76	132	130	176	178
16. D.C.	13	131	65	80	169	165	176	176
17. D.C.	12	123	64	76	137	189	164	160
18. R.B.	12	135	66	80	149	161	176	172
19. P.D.	13	109	63	76	134	158	184	168
20. S.F.	15	102	62	72	121	175	184	180
21. L.G.	12	111	63	72	111	110	176	160
22. F.D.	12	101	62	76	125	128	172	172
23. J.F.	14	104	62	76	93	145	160	176
24. B.D.	12	111	62	76	143	185	168	160
25. S.G.	13	125	63	80	210	228	172	172
26. R.J.	13	136	65	76	136	150	172	164
27. C.L.	13	97	59	80	154	195	180	172
28. J.G.	13	129	65	80	113	127	164	176
29. J.J.	13	116	63	84	131	182	168	176
30. K.L.	12	91	59	72	108	165	168	160
31. B.M.	15	96	62	76	121	165	168	172
32. D.M.	15	103	64	72	83	75	168	180
33. J.M.	14	101	62	84	122	165	164	160
34. S.M.	13	106	62	80	122	130	176	176
35. T.M.	14	87	59	76	74	90	184	180
36. D.N.	13	96	58	80	108	138	160	152

APPENDIX A (CONT'D)

Name	Age	Wt.	Ht. Inches	Resting Heart Rates	Scores Initial	Scores Retest	Heart Rates Initial	Heart Rates Retest
37. M.P.	12	118	63	80	120	155	188	178
38. D.P.	13	100	59	72	132	130	200	184
39. M.F.	12	120	63	72	128	140	188	180
40. K.P.	13	124	64	76	108	168	176	180
41. J.P.	12	135	66	80	105	142	176	168
42. D.R.	12	110	63	88	120	168	172	172
43. D.N.	12	107	63	76	95	133	172	176
44. P.W.	12	127	66	88	167	198	164	184
45. L.R.	12	114	64	72	132	156	184	178
46. J.R.	13	103	62	76	134	180	168	180
47. W.C.	13	116	63	72	122	140	188	184
48. D.H.	14	81	58	80	94	110	184	168
49. C.V.	13	101	62	76	108	165	168	160
50. N.S.	13	115	61	72	113	158	164	164
51. K.W.	13	110	62	80	112	167	176	176

*Identifies the subject by roll call number

APPENDIX B

RAW SCORES FOR SKILLED JUMPERS

Name	Age	Wt.	Ht. Inches	Resting Heart Rates	Scores Initial	Scores Retest	Heart Rates Initial	Heart Rates Retest
1* S.S.[a]	15	123	64	76	180	194	196	152
2. M.H.	14	143	65	80	172	182	184	160
3. B.C.	14	117	63	72	210	240	180	146
4. D.L.	14	139	63	72	170	193	180	151
5. C.C.	15	151	62	72	192	198	300	148
6. J.W.	14	142	65	72	180	184	192	150
7. M.A.	14	116	65	80	174	198	184	162
8. M.G.	14	112	63	72	190	195	180	148
9. C.H.	15	132	63	76	191	202	192	164
10. K.N.	14	125	62	90	175	210	192	140
11. B.M.[b]	13	113	62	88	170	201	180	154
12. L.S.	14	121	64	80	180	196	184	154
13. L.W.	13	119	65	76	175	180	172	168
14. J.W.	13	108	61	72	182	180	188	150
15. M.S.	13	116	64	68	183	170	192	142
16. D.D.	13	127	66	76	170	175	192	144
17. P.W.	13	131	67	76	183	195	200	154
18. P.F.	13	122	64	80	175	200	192	158
19. N.S.	13	118	64	72	172	215	180	146
20. S.W.	13	110	63	68	192	213	188	162
21. K.C.[c]	12	108	64	72	183	199	180	150
22. K.S.	12	121	65	72	194	216	188	142
23. S.M.	13	115	64	64	186	204	188	144
24. L.P.	12	98	59	80	195	209	184	154
25. D.D.	12	101	59	80	180	215	180	136
26. M.M.	11	112	63	78	173	200	184	170
27. T.A.	12	106	62	88	194	222	192	154
28. D.T.	12	104	57	72	182	190	164	164
29. C.M.	12	117	64	76	176	205	200	136
30. T.N.	12	103	58	88	198	218	200	160

*Identifies the subject by roll call number

[a]Ninth graders

[b]Eighth graders

[c]Seventh graders

APPENDIX C

RAW SCORES FOR NON-SKILLED JUMPERS

Name	Age	Wt.	Ht. Inches	Resting Heart Rates	Scores Initial	Scores Retest	Heart Rates Initial	Heart Rates Retest
1* W.C.[b]	14	123	62	76	107	116	196	188
2. S.F.	13	113	65	80	106	116	202	184
3. P.T.	13	142	66	80	100	119	240	210
4. P.M.	13	131	66	80	42	45	232	190
5. R.H.	13	128	63	88	91	121	210	188
6. G.F.	14	112	63	80	95	118	220	192
7. D.H.	13	108	61	72	25	60	220	198
8. A.D.	13	119	63	80	82	112	220	204
9. C.H.	13	123	64	80	93	141	216	214
10. M.R.[c]	13	106	61	74	96	84	196	194
11. K.W.	12	101	61	72	69	140	232	180
12. M.B.	13	105	60	68	96	123	240	220
13. L.C.	12	103	62	88	93	132	250	214
14. V.C.	12	116	62	80	30	68	196	228
15. C.S.	12	97	57	88	73	117	224	192
16. V.C.	12	103	58	84	82	115	192	230
17. K.P.	12	86	57	84	92	60	240	204
18. R.C.	12	108	59	80	52	93	230	198
19. J.M.	13	114	65	90	48	147	226	224
20. J.W.[a]	12	125	65	88	86	120	214	200
21. C.P.	15	124	64	72	82	116	204	190
22. B.H.	14	117	64	88	48	149	230	184
23. J.D.	15	143	65	76	93	147	226	232
24. M.C.	14	136	65	72	94	148	232	230
25. J.M.	14	120	62	72	97	179	248	198
26. M.B.	14	113	62	72	84	142	216	190
27. S.S.	15	109	68	72	98	96	240	200
28. S.M.	14	139	65	80	75	126	232	228
29. D.S.	14	140	65	88	97	130	216	214
30. D.H.	14	129	66	80	92	115	228	234

*Identifies the student by roll call number

[a]Ninth graders

[b]Eighth graders

[c]Seventh graders

APPENDIX D

RAW SCORES FOR WEIGHT PROBLEM JUMPERS

Name	Age	Wt.	Ht. Inches	Resting Heart Rates	Scores Initial	Scores Retest	Heart Rates Initial	Heart Rates Retest
1* M.S.[a]	14	176	63	80	59	73	232	220
2. M.D.	14	164	65	90	64	84	240	214
3. S.S.	14	210	66	88	85	96	240	240
4. J.M.	15	198	65	78	31	92	240	248
5. S.A.	14	162	64	94	52	34	240	244
6. M.M.	14	102	65	88	131	114	232	232
7. K.M.	14	97	66	76	140	164	216	236
8. M.B.	14	104	65	88	115	132	240	210
9. M.S.	14	112	67	88	105	112	244	196
10. K.M.[b]	14	92	65	80	100	165	250	220
11. A.H.	14	179	64	80	75	80	236	244
12. J.H.	13	159	66	76	125	125	256	232
13. A.D.	13	148	64	72	92	112	216	232
14. P.M.	14	182	64	88	42	25	228	240
15. B.L.	13	184	65	84	43	60	240	220
16. M.B.	13	86	61	76	127	140	244	216
17. M.D.	13	101	62	76	130	135	240	240
18. S.A.	13	115	64	72	141	160	250	244
19. P.M.	14	117	65	80	140	155	216	248
20. S.F.[c]	13	107	64	76	166	192	244	210
21. C.C.	12	146	63	88	122	120	220	224
22. C.C.	12	142	62	90	105	114	232	196
23. M.S.	13	161	65	86	127	164	232	244
24. D.L.	12	148	64	84	138	142	248	236
25. B.C.	12	143	63	76	91	137	248	232
26. R.H.	12	95	64	72	88	151	212	232
27. J.H.	12	79	62	68	101	140	236	240
28. P.H.	12	86	63	76	110	105	228	228
29. J.D.	12	90	63	76	143	170	240	244
30. G.B.	12	96	64	76	157	175	236	216

*Identifies the student by roll call number

[a]Ninth graders

[b]Eighth graders

[c]Seventh graders

APPENDIX E

RAW SCORES FOR STYLE GROUP ON THE 4-MINUTE TEST

Name	Age	Wt.	Ht. Inches	Resting Heart Rates	Scores Initial	Scores Retest	Heart Rates Initial	Heart Rates Retest
1* J.B.	15	110	63	72	285	305	240	240
2. P.D.	15	117	65	78	290	294	232	224
3. D.S.	16	135	63	80	248	254	240	220
4. T.P.	16	129	65	76	325	343	236	212
5. C.F.	15	138	67	76	310	325	202	202
6. D.V.	14	134	65	76	280	310	212	192
7. T.B.	14	143	67	72	210	270	232	196
8. G.W.	14	107	63	72	382	400	212	196
9. J.W.	13	116	64	80	233	252	240	232
10. B.R.	13	120	64	80	270	281	236	212
11. L.R.	14	120	65	84	311	327	196	188
12. B.T.	13	126	64	72	304	310	228	220
13. B.B.	12	111	62	72	275	271	232	202
14. B.D.	13	124	64	76	317	315	310	210
15. D.S.	12	121	65	76	310	360	240	240
16. K.W.	12	102	61	80	261	294	232	202
17. K.M.	12	98	59	84	287	311	196	196
18. K.K.	12	107	62	72	301	329	220	210
19. M.T.	12	122	63	80	285	318	224	220
20. R.B.	13	119	63	80	355	391	220	220

*Identifies the student by roll call number

APPENDIX F

RAW SCORES FOR STYLE GROUP ON THE 1-FOOT JUMP TEST

Name	Age	Wt.	Ht, Inches	Resting Heart Rates	Scores Initial	Scores Retest	Heart Rates Initial	Heart Rates Retest
1.* J.B.	15	110	63	72	186	185	184	168
2. P.D.	15	117	65	78	161	175	192	164
3. D.S.	16	135	63	80	142	160	180	180
4. T.P.	16	129	65	76	196	190	196	176
5. C.F.	15	138	67	76	180	198	168	156
6. D.V.	14	134	65	76	165	210	196	188
7. T.B.	14	143	67	72	228	252	188	200
8. G.W.	14	107	63	72	315	335	196	212
9. J.W.	13	116	64	80	294	286	192	180
10. B.R.	13	120	64	80	305	310	192	196
11. L.R.	14	120	65	84	310	348	192	212
12. B.T.	13	126	64	72	194	284	202	180
13. B.B.	12	111	62	72	141	171	180	168
14. B.D.	13	124	64	76	182	198	172	172
15. D.S.	12	121	65	76	200	204	196	184
16. K.W.	12	102	61	80	173	180	180	180
17. K.M.	12	98	59	84	195	216	220	210
18. K.K.	12	107	62	72	167	204	232	202
19. M.T.	12	122	63	80	173	196	210	196
20. R.B.	13	119	63	80	210	235	208	200

*Identifies the student by roll call number

APPENDIX G

RAW SCORES FOR STYLE GROUP ON THE CROSS-HANDED TEST

Name	Age	Wt.	Ht. Inches	Resting Heart Rates	Scores Initial	Scores Retest	Heart Rates Initial	Heart Rates Retest
1* J.B.	15	110	63	72	84	110	180	176
2. P.D.	15	117	65	78	111	125	164	168
3. D.S.	16	135	63	80	104	133	186	180
4. T.P.	16	129	65	76	86	95	180	156
5. C.F.	15	138	67	76	109	154	172	168
6. D.V.	14	134	65	76	116	117	176	176
7. T.B.	14	143	67	72	102	141	172	180
8. G.W.	14	107	63	72	135	130	192	176
9. J.W.	13	116	64	80	107	115	180	164
10. B.R.	13	120	64	80	138	141	172	172
11. L.R.	14	120	65	84	90	82	184	180
12. B.T.	13	126	64	72	102	105	180	172
13. B.B.	12	111	62	72	81	64	164	150
14. B.D.	13	124	64	76	95	94	180	164
15. D.S.	12	121	65	76	83	96	192	180
16. K.W.	12	102	61	80	110	108	162	158
17. K.M.	12	98	59	84	141	155	168	162
18. K.K.	12	107	62	72	113	122	192	180
19. M.T.	12	122	63	80	137	145	176	168
20. R.B.	13	119	63	80	85	101	172	180

*Identifies the student by roll call number

APPENDIX H

RAW SCORES FOR JOGGERS

Name	Age	Wt.	Ht**	R.H.R.	Mile Run Time***	Mile Run H.R.
1* M.S.	15	146	64	84	10.88	180
2. J.W.	14	122	62	78	8.98	202
3. G.N.	14	110	63	72	9.01	206
4. D.D.	14	96	66	78	10.16	184
5. L.G.	14	131	67	80	8.85	196
6. S.S.	14	117	65	88	11.08	200
7. J.K.	13	121	63	72	10.18	200
8. V.N.	13	112	63	68	9.83	196
9. P.T.	14	109	63	68	9.33	204
10. D.N.	13	116	64	72	11.01	208
11. D.P.	12	98	61	76	8.96	200
12. D.M.	12	127	63	76	9.16	184
13. C.S.	13	123	66	72	9.75	180
14. S.H.	12	101	62	80	9.70	192
15. B.L.	12	131	63	76	10.15	180
16. M.A.	15	137	64	80	8.61	208
17. B.C.	15	119	66	80	8.8.	180
18. B.M.	14	134	64	72	9.28	186

*Identifies the student by roll call number

**Height in inches

***Mile run time in minutes

APPENDIX I

RAW SCORES FOR NON JUMPERS

Name	Age	Wt.	Ht**	R.H.R.	Mile Run Time***	Mile Run H.R.
1* D.W.	15	131	62	72	18.50	244
2. M.B.	15	121	64	68	15.80	232
3. D.V.	14	106	67	68	15.75	240
4. V.W.[a]	12	117	64	72		
5. L.G.	12	111	63	64	24.38	250
6. M.W.	13	141	63	80	21.13	238
7. B.M.[a]	12	112	60	72		
8. S.A.[a]	14	102	61	68		
9. D.H.	14	127	66	80	15.80	244
10. J.S.	15	122	64	84	26.65	236
11. J.D.	14	119	62	88	20.53	246

*Identifies the student by roll call number

**Height in inches

***Mile run time in minutes

[a]Subjects did not complete the mile run

APPENDIX J

RAW SCORES FOR SKILLED JUMPERS ON THE MILE

Name	Age	Wt.	Ht**	R.H.R.	Mile Run Time***	Mile Run H.R.
1* S.S.	15	123	64	76	16.53	240
2. M.H.	14	143	65	80	12.06	240
3. B.C.	14	117	63	72	9.95	212
4. C.C.	15	151	62	72	10.20	220
5. J.W.	14	142	65	72	14.51	216
6. M.A.	14	116	65	80	12.50	196
7. M.G.	14	112	65	72	18.81	240
8. D.L.	14	139	63	72	12.51	232
9. C.H.	15	132	63	76	11.16	196
10. K.N.	14	125	62	90	13.33	196
11. B.M.	13	113	62	88	12.18	200
12. L.S.	14	121	64	80	14.16	240
13. L.W.	13	119	65	76	15.66	196
14. J.W.	13	108	61	88	12.96	220

*Identifies the student by roll call number

**Height in inches

***Mile run time in minutes

APPENDIX K

FORMULA USED IN COMPUTATIONS FOR MILE RUN TIMES AND HEART RATES

t-ratio

1. $$t\text{-ratio} = \frac{(N_2\Sigma X_1 - N_1\Sigma X_2)^2 \ (N_1 + N_2 - 2)}{(N_2L_1 + N_1L_2) \ (N_1 + N_2)}$$ [35]

ΣX_1, ΣX_2 = Sum of measures in groups

N_1, N_2 = Number of subjects in groups

ΣX_1^2, ΣX_2^2 = Sum of squared measures

$L_1 = N_1\Sigma X_1^2 - (\Sigma X_1)^2$

$L_2 = N_2\Sigma X_2^2 - (\Sigma X_2)^2$

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[35] Dwyer's Single Computational Formula from "Computational Design for Evaluating the Significance of a Difference Between Means," A. T. Slater Hammel, Research Quarterly, May (1965), p. 213.

APPENDIX L

SAMPLE COMPUTATION OF t-RATIO FOR SKILLED JUMPERS' AND JOGGERS' MILE RUN TIMES

Dwyer's Formula:

$$t^2 = \frac{(N_2 X_1 - N_1 X_2)^2 (N_1 + N_2 - 2)}{(N_2 L_1 + N_1 L_2)(N_1 + N_2)}$$

$$t^2 = \frac{[18(186.577) - 14(174.777)]^2 (14 + 18 - 2)}{}$$

$$t^2 = \frac{(3358.386 - 2446.878)^2 (30)}{19696.734 + (-2276.82)(32)}$$

$$t^2 = \frac{(911.508)^2 (30)}{17419.914 (32)}$$

$$t^2 = \frac{830846.834 (30}{557437.2480}$$

$$t^2 = 44.7142$$

$$t = \boxed{6.68}$$

APPENDIX M

FORMULA USED IN COMPUTATION FOR JUMPERS

Standard Deviation

$$\sigma x = \sqrt{\frac{\Sigma x^2}{N} - M_x^2}$$

t-ratio

1. Standard error of each mean

$$\sigma M_1 = \frac{\sigma}{\sqrt{N-1}}$$

2. Standard error of the difference

$$\sigma \text{ difference} = \sqrt{\sigma M_1^2 + \sigma M_2^2}$$

3. $$\text{t-ratio} = \frac{M_1 - M_2}{\sigma \text{ difference}}$$[36]

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[36] Benton J. Underwood, Carl P. Duncan, Janet A. Taylor and John W. Cotton, Elementary Statistics, (1954), p. 121.

APPENDIX N

SAMPLE COMPUTATION OF TRADITIONAL t-RATIO FOR STYLE GROUP

1. Standard deviation of each mean.

   X_1 = Style Group cross jump without a pacer.

   X_2 = Style Group cross jump with a pacer.

   $M_1 = 177.2$ $\quad\quad$ $\sigma = 8.93$

   $M_2 = 170.5$ $\quad\quad$ $\sigma = 8.94$

2. Standard error of each mean,

$$\sigma M_1 = \frac{\sigma}{\sqrt{N-1}} = \frac{8.93}{\sqrt{19}} = \frac{8.93}{4.3588} = 2.0487$$

$$\sigma M_2 = \frac{\sigma}{\sqrt{N-1}} = \frac{8.94}{\sqrt{19}} = \frac{8.94}{4.3588} = 2.051$$

3. Standard error of the difference.

   σ difference $= \sqrt{\sigma M_1^2 + \sigma M_2^2}$

   σ difference $= \sqrt{2.0487 + 2.051}$

   σ difference $= \sqrt{8.403}$

   σ difference $= 2.8987$

4. t-ratio $= \dfrac{M_1 - M_2}{\text{difference}}$

$$\frac{6.7}{2.8987} = \boxed{2.311} = \text{t-ratio}$$

VITA

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Master of Science

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