

A STUDY OF EFFECTS OF PRELIMINARY EXERCISE AND PROCEDURES
ON PERFORMANCE IN VARIOUS TYPES OF ACTIVITIES

by 1264

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B. S., Kansas State University, 1963

A MASTER'S REPORT

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Physical Education

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1970

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INTRODUCTION

In the academic field of physical education and the actual performance of physical activities for competitive games, whether the activities are individual oriented or group oriented, there exists a common practice that is being continued based on a minimum amount of scientific research. The practice is that of using a preliminary exercise or procedure before the actual activity is to begin. This activity is most commonly called "the warm-up".

The concept that a warm-up period is necessary to achieve the best possible performance is held by a majority of ex-athletes who are now professional and amateur coaches. This traditional practice has been passed from generation to generation of coaches. Most coaches support the practice so student after student follow these practices. In the future, their students will probably concur with the tradition until significant research is provided to prove otherwise or to modify the practice.

However, with the relatively recent increase of the science of research into physical education, the concept for the necessity of the warm-up is beginning to be more closely scrutinized. Physiologists are beginning to inspect the physiological changes that occur as a result of warm-up activities.

Since the temperature of the muscle is the key to performance efficiency it has been generally thought that by "pre-heating" the muscle, or groups of muscles, by some activity it

would result in a greater efficiency of muscle use or work load. In other words, if the time between the beginning of an activity and the beginning of maximum work load could be eliminated or reduced it would result in a better performance.¹ For example, if it took three seconds to raise the temperature of the muscle to an efficient work load then it would seem beneficial to raise the temperature before the actual performance, thus beginning the performance at a level above the "cold" starting level and therefore resulting in better performances. "Muscle contraction efficiency depends on the degree of temperature within the muscle. In the human being, the lowering of the muscle temperature below normal decreases muscle irritability and work capacity. The reverse is also true. During physical activity the muscle temperature rises. These two physiological observations put together have led to the practice of indiscriminate warming-up before athletic contests."²

Recent studies, published in the late 50's and early 60's, along with some conducted in the mid 40's, have begun to refute this traditional concept of the validity of the warm-up. However, one should not dismiss the validity of warm-up on the conclusions of the few studies that have been conducted and published. The problem is too complex to say either that warm-up is necessary to efficient performance or that it is not. Doctor Peter V. Karpovich admits that the "job of summarizing the available results of warm-up studies will leave the researcher sitting on the

fence with results on both sides and some even hanging on the fence itself".³

Purpose of Study

This research study was undertaken to categorize the effects of warming-up on various activities which have been scientifically researched and published. There is no "yes" or "no" answer to the question of whether the warm-up is beneficial to performance. Such factors as the type of activity, nature of the warm-up, extent and intensity of the warm-up, physiological make-up of the individual, and attitudes toward warming-up must all be considered. Like the results of much of the scientific research today, the studies of warm-up activities unveils new and probing questions as to the nature and effects of preliminary exercise or procedures.

Method of Study

The Research Quarterly published by the American Association of Health, Physical Education and Recreation was the source from which these studies were taken and is located in Farrell Library on the Kansas State University campus and the Department of Physical Education at the University. This publication has long been recognized as the leading publication of research in the field of Physical Education.

The fifteen studies were published between 1957 and 1964 and were catagorized as to subject matter tested. The studies were

listed in the reference index of the Research Quarterly for Health, Physical Education and Recreation: 1930-60.⁴ These areas were speed, distance, strength and endurance, muscle fatigue, accuracy and jumping.

The following historical information about warm-up studies comes from Dr. P. V. Karpovich.

"---In 1945, two Danish investigators, Asmussen and Bøje, reported that, while preliminary exercise, short-wave diathermy, and hot showers were beneficial for sprints and one-mile rides on a bicycle ergometer, massage had no effect whatsoever."⁵

"---In 1947, however, a report came from Czechoslovakia stating that massage was beneficial as a warming-up modality."⁶

"---Intrigued by the disagreement, Creighton Hale and the author (Dr. P. V. Karpovich) decided to conduct experiments similar to those of Asmussen and Bøje."⁷

"---during the past ten years (1956-66) hundreds of tests have been performed in the author's laboratory (Dr. P. V. Karpovich) some with but most without warming-up."⁸

Many other studies have been done by Dr. P. V. Karpovich relating to the injury rate of no warm-up with overwhelming evidence that no serious injuries have resulted from activities without the warm-up.

Limitations of Study

Although Dr. Karpovich has done many studies on warm-up he has very few published. Not until 1955 did the Research Quarterly for Health, Physical Education and Recreation begin to publish many studies on the subject.

Only sixteen studies were published on the subject between 1955 and 1964. The lack of published material is not due to the lack of interest in the subject but rather to the complexity of the problem. There are, of course, a number of factors to be isolated in researching the subject of warm-up.

Definitions of Terms

All scientific research fields of study have a special language of their own. The studies involved with warm-up activities have a number of words and phrases that need explanation. The following is a list and brief explanation of each.

- | | |
|--------------------|--|
| Formal warm-up: | Using the actual skill as a warm-up that will later be used as the test activity. |
| Related warm-up: | Used interchangeably with the phrase formal warm-up. The term is being used more in recent publications than is the term formal. |
| General warm-up: | Usually consists of exercising the entire body prior to performance. |
| Unrelated warm-up: | Used interchangeably with general. It |

is being used more in recent publications than is the term general.

Positive results: The activity tested correlated positively or that a warm-up activity resulted in better performance results. In mathematical terms, it means that the correlation had a plus .50 or better.

Negative results: The activity tested correlated negatively or that a warm-up activity resulted in inferior performance results. In mathematical terms, it means that the correlation has a minus .50 or less.

Correlation: A relationship between variables. Correlation is stated from a -1 through 0 to a +1. Any correlation from a -.50 to a +.50 is generally not considered to be significant.

Passive activity: An activity that is done to a participant such as a massage. It does not involve any physical activity on the participants part.

Active activity: An activity that is done by the participant and involves some physical

creation of work load.

Violent activity: A very heavy resistance or long time period is placed on the participant when he creates a work load through some physical activity.

Short-wave diathermy: A machine that creates heat internally in the muscle cells by sound waves.

Isometric: Creation of a work load by contracting muscles with the movement of distance almost non-existent.

Isotonic: A work load created by moving resistance.

Bicycle ergometer: An apparatus used to determine foot pounds of work load. It is a one wheeled bicycle with adjustable friction for resistance.

Leg dynamometer: An apparatus used to determine strength and endurance. It consists of a chain attachment to a very heavy spring with a measuring device attached to measure the distance the spring is moved in foot-pounds of work.

Catagorization of Warm-up Activities

The warm-up activities used in the studies varied in intensity from passive to violent. The following is a catagorization with the type of classification of the activity.

Monetary reward-----	Psychological
Hot showers-----	Passive
Short-wave diathermy-----	Passive
Massage-----	Passive
Free throws-----	Semi-active related
Bowling-----	Semi-active related
Finger exercises-----	Semi-active related
Isometric-----	Active
Isotonic-----	Active
Bicycle crank attached to wall-----	Active
Swimming-----	Active
Calisthenics-----	Active
Running-----	Active
Stool stepping-----	Violent
Bicycle ergometer-----	Violent
Leg dynamometer-----	Violent

STUDY BRIEFS

Speed

Vera Skubic and Jean Hodgkins reported on a study they conducted on thirty-one physical education college women. The women were tested on a bicycle ride at top speed for one-tenth of a mile, three tries at throwing a softball for distance, and ten free throws. The general warm-up was twelve jumping jacks and the related warm-up was throwing a softball. The bicycle ride test resulted in no significant difference among the three warm-up methods. The same results were reported for the softball distance throw. In the basketball accuracy toss there was some statistically significant tendencies for higher scores to result on tests following the related warm-up.⁹

Thompson conducted a second study on warm-up, speed and endurance to swimming, accuracy in basketball foul shooting, accuracy in bowling, and the strength of softball players. Related and unrelated warm-up activities were used. Results of the basketball foul shooting accuracy, bowling accuracy, and strength will be discussed under their respective areas. For the swimming study Thompson used a swimming class of eighty-five males with ages ranging from 17-28. The warm-up activity was attendance in a regular swimming class with the tests being given after the class was dismissed. The first four weeks they used the related warm-up; weeks five and six the class used calisthenics (an unrelated warm-up); the last week no warm-ups

were used. The test was a sprint for speed of 30-yards, laps for endurance for five minutes and a grade and monetary reward for the best performances.

It was found that related warm-up did improve speed in swimming thirty yards. The unrelated warm-up did not improve the swimming speed. The related warm-up increased the number of laps that could be swum whereas the unrelated warm-up showed no improvement.¹⁰

A third study on the relationship between warm-up and speed by DeVries showed both positive and negative results. The warm-up activities consisted of hot showers, calisthenics, massage and swimming. DeVries tested thirteen highly skilled competitive male swimmers of a university swimming team. For an unrelated warm-up the subjects swam 500-yards slowly and continuously. The calisthenics consisted of 25 repetitions of rib and back stretching; 15 repetitions of chest, abdominal and lower back exercises; 100 repetitions of abdominal and hip joint movements; two repetitions of strengthening extensor muscles; 20 repetitions of the lower back and hip; 100 repetitions of all back muscles and 40 repetitions of strengthening the abdominal and hip muscles. They also had ten minutes of massage and some had six minutes under the hottest shower temperature they could stand. The subjects were tested for a 100-yard timed swim for fifteen trials. Each swimmer had three trials as a control or no warm-up activity. Only one time trial

was held per day for three days a week for five weeks. Considering all swimmers in one group regardless of strokes swum, it was found that warming up by swimming 500-yards was effective in reducing the subsequent 100-yard time trial by a mean difference of .44 seconds. This study concluded that swimming performance at the level of the highly skilled competitive swimmer could be improved by the proper warm-up procedure. Also, that if the improper warm-up procedure was employed it could be detrimental to the performance.¹¹

A fourth study by Lotter on speed showed a negative result. Lotter used four minutes of preliminary exercise of running and rotating the arms in a complete circle for his warm-up activity. He used a bicycle crank attached to the wall, using both hands for movement for his testing apparatus. There was no significant resistance attached to it. The subjects were twenty male university students between the ages of 19-34 years. They were tested twice with a week interval to control training. There was no evidence that the warm-up exercise improved performance in the experiment. There was a retest reliability of .509 for the first section of the test and .822 for the remaining parts of the test.¹²

The fifth study on speed was conducted by Mathews. Quite extensive warm-ups were used for Mathews study. The warm-ups consisted of jogging, six push-ups, six leg pulls (knees to chest) with each leg, ten toe touches, six sit-ups, three ten-

yard wind sprints and 5-10 minute rest. Fifty-four male students in a 10th grade physical education class were used as subjects. They were tested during two consecutive class periods for a month. Their times were recorded to a tenth of a second. The testing resulted in two general conclusions: (1) Warming-up prior to performing the 440-yard dash did not significantly improve the time over running the same distance without a preliminary warm-up. (2) No injuries were observed or reported during the testing period.¹³

The most intensive study was reported by Massey, Johnson and Kramer. The subjects were 15 males between 21 and 32 years of age. All were athletes or physical education majors. The subjects were put under a deep hypnosis prior to all tests. The warm-up activity was of an over-all bodily exercise and intensive. The study attempted to control through hypnosis the following conditions found in previous studies. (1) Environmental conditions when using as the criterion some type of competitive athletic performance. (2) Limited number of subjects studied to the point that statistically significant findings, in some instances, were virtually impossible. (3) Inadequate psychological control of the subjects in terms of the popular belief that warm-up is beneficial. (4) The limited number of repeated observations made upon each subject. The control of the first three conditions was attained by having the study done under laboratory conditions, using a sufficient number of subjects,

and using hypnosis and keeping them ignorant of the nature and purpose of the research.

The subjects were tested on four different days; two with warm-up and two without warm-up. A friction type bicycle ergometer was pedaled 100 revolutions as rapidly as possible with a constant resistance load of 26 pounds. Prior to the test the subjects were hypnotized. When no warm-up was used water was sprinkled on their head to simulate perspiration. The warm-up activity consisted of ten minutes of moderate exercise in which two minutes was jogging in a 30 foot diameter, one minute of side straddle hops, one minute of running in place, one minute jogging again in a circle, one minute of 30-foot wind sprints, one-half minute alternate toe touch, one-half minute running in place and a two minute rest. The subjects were then aroused from the hypnotic state and given the bicycle ergometer test.

The test-retest-reliability for test 1 and 2 was .66. Tests 2 and 3 was .82 and test 3 and 4 was .93. The performances steadily improved. The fastest time occurred following a no warm-up test. It was concluded that in no way does warm-up by over-all bodily activity improve subsequent muscular performance of a type similar to that found in sprint running.¹⁴

The final study of warm-up on speed was conducted by Phillips. The warm-up consisted of stool-stepping and arm action. The study was concerned with the influence of very large amounts of warm-up exercises, severe enough to cause considerable fatigue, on the speed of performance of a standardized limb movement. Seventy-five male college students

were tested. A single horizontal circular clockwise movement 63 centimeters in circumference, continuing without pause into a horizontal movement of 28 centimeters, was used as a criteria movement. The related warm-up exercise was turning a vertical two hand low friction arm crank as rapidly as possible for two and one-half minutes. The unrelated warm-up was stepping up and down on a 45 centimeter high stool at a rate of one per second for ten minutes. The moderate related warm-up showed no statistically significant advantage in speed of the criterion movement. The results of the heavy unrelated warm-up exercises showed an improvement in speed. It was concluded that warm-up exercises of the unrelated type improve performance in arm movements emphasizing speed when these exercises involve sufficiently heavy work. It was also concluded that related warm-up exercises involving moderate amounts of physical work evidently tend to be ineffective in improving the performance of fast arm movement.¹⁵

Distance

There were two studies reporting the relationship between warm-up and distance activities. The first was a study by Rochelle, Skubic and Michael. The study used both related and unrelated warm-up activities. The unrelated warm-up consisted of calisthenics, sprint running, jumping jacks, and toe touching. The related warm-up was throwing a ball by playing catch

at different distances. Performance by seventy-seven males from 17-20 years old were used in this study. There was no significant difference between the warm-up and the no warm-up activities. The retest-reliability was .87 for the no warm-up tests and .90 for the warm-up tests. With the related warm-up the subjects did improve 5.9 feet with a standard deviation of 1.75 feet. On the unrelated warm-ups the subjects improved their throws by 7.0 feet with a standard deviation of 2.17 feet.¹⁶

The second test was conducted by the same group. The study used a semi-active related warm-up, however, it was predominantly psychological. The testers promised a monetary reward for each throw greater than the subjects pre-established average. Forty-six male students, ranging in age from 18-22 were used as subjects. They threw a softball for distance without a warm-up and with a five minute related warm-up of playing catch. They were divided into groups which alternated and none of the subjects were varsity athletes. The results showed that the monetary incentive was beneficial. No significant difference was found between trials when throwing was preceded by a related five minute warm-up of playing catch.¹⁷

Strength and Endurance

There were three studies reported on in the area of strength and endurance and warm-up. Two of the studies in this area were

studies that were also reported on in other areas.

The first study with a relationship between warm-up and strength and endurance was in the study reported on by Skubic and Hodgkins, (page 9).¹⁸

The second study was reported by Thompson, (page 9). In this portion of Thompson's study he tested twenty male subjects from 18-23 years of age for strength on a leg dynamometer for leg extensor strength. All subjects were active softball players. They used a set of vigorous calisthenics for an unrelated warm-up. They were then tested three times with the warm-up and three times with no warm-up. The results showed that strength was not improved with unrelated warm-up on the leg dynamometer.¹⁹

The third study in the strength and endurance series was reported in Sedgwich and Whalen. The subjects were twenty male students 18-48 years of age. There was no physical warm-up used in this study but rather a passive heating procedure. One arm was heated for ten minutes and tested for strength thirty seconds after heating. Then the other arm was tested without heat. The arms were switched from test to test as control and experiment arms. A short-wave diathermy was used as the heating procedure. It was found that the effect of passive heating administered at an intensity to raise muscular temperature about five degrees centigrade decreased muscular strength slightly. When passive heating was administered at an intensity sufficient

enough to raise muscle temperature between two and four degrees centigrade there was no significant effect on local muscular endurance.²⁰

Muscle Fatigue

There were only two studies reporting on muscle fatigue and warm-up. One of the studies had been mentioned in the studies in regard to warm-up and speed.

The first study was reported by Grose. The warm-up used in this study was placing the forearm in hot water of 48 degrees centigrade for eight minutes and then in cold water of 10 degrees centigrade for eight minutes. There were twelve males from 18-34 years of age tested. The order of treatment was rotated from control (no treatment) to heat to cold to massage. Before the control subjects were tested they rested for eight minutes. The others had eight minutes heat, then eight minutes cold followed by four minutes of moderate massage. The work period was on an ergometer for six minutes with maximal contractions. The results of the test showed that with the heat treatment there was substantial and significant reduction in the amount of work accomplished. The cold treatment results were reduced by 12.2% in comparison to the control group. With the massage there was no significant difference.²¹

The second study on muscle fatigue and warm-up was reported by Phillips, (page 13).²²

Accuracy

There were three studies published on the relationship of warm-up to accuracy.

The first study was by Skubic and Hodgkins, (page 9). For the warm-up, Skubic and Hodgkins used a bicycle ride at top speed for one-tenth of a mile, three tries at throwing a softball for distance, and ten free throws. In the basketball accuracy toss there was some statistically significant tendencies for higher scores to results on tests following the related warm-up.²³

The second study by Thompson on the relationship between warm-up and accuracy was conducted in two testing situations.

Basketball foul shooting: Thompson tested twenty freshmen basketball players ranging from age 18-23. The players took no warm-ups and shot twenty tosses eight times for 160 tries to determine consistency. Then the unrelated warm-up was used for ten minutes of unrelated floor shooting, three minutes of passing, and ten foul shots. The results showed that related warm-up before foul shooting did improve accuracy.

Bowling: Thompson tested sixty men in a bowling league for accuracy. Their ages ranged from 22-56 years old. They used no warm-up and scored the first game of three to be bowled. The warm-up was the first game. They then took the score of the last game to determine if the warm-up of the first two had improved it. The results showed that the accuracy in bowling

was improved when using the related warm-up activity of bowling.²⁴

The third study in regard to warm-up and accuracy was by Witte. The warm-up activities used were the jumping jack and distance running. The subjects selected were 103 junior high school girls. They were chosen and placed into skilled and unskilled groups depending on their accuracy by tossing a softball into a target area. The jumping jacks were conducted at 120 beats per minute and the distance running was conducted by running between a square 44 feet and 6 inches long and 3 feet wide. They had to touch each corner as they ran. They then performed their underhanded accuracy ball throwing test. The study was designed to answer two questions. The first, does accuracy measure change in relationship to the amount and intensity of exercise and the second, is the change, if any, more evident in skilled performers or in unskilled performers? It was found that there is no difference in the effects of light exercise as compared with moderate or heavy exercise in either the skilled or unskilled. The unskilled subjects showed a higher degree of accuracy following exercise at each of the three levels. The skilled subjects showed no change in accuracy following light and moderate exercise. They did show a decrease in accuracy following heavy exercise.²⁵

Jumping

Pacheco reported on a study she conducted on 166 girls in a junior high school physical education class. The warm-up was

running in place. The classes consisted of grades eight and nine. They met on two separate days at the same hour with an interval of one week. The girls ran three minutes in place as the warm-up, then did five vertical jumps with one-half minute rest between each jump. The average daily gain due to warm-up was 1.56 centimeters or 4.52% improvement for the entire group. The eighth graders improved 1.42 centimeters or 3.48% in height and the ninth graders improved 1.82 centimeters or 2.87% in height. The retest reliability was .858 for the eighth graders and .879 for the ninth graders.

Merlino conducted the second study on jumping performance. The only warm-up activity used was a massage. The test used Henry's vertical jump apparatus. The test was given to thirty-six male university students between the ages of 17-39. They were all tested the same time of day. They had six trials with minute and a half rest in between. The subjects had the ordinary controls, a psychological control of pseudo-high frequency cellular massage and a ten minute vigorous manual massage. The near performance under massage conditions was 49.44 centimeters. This was significantly higher than the performance of the same subjects utilizing the pseudo control which was 48.17 centimeters. The increase performance from the massage was 1.27 centimeters better which was a 2.6% increase in improvement. Trial 1-4 was an increase of 1.8% and trials 5 and 6 showed a 4.2% improvement. This indicated that a delay in the massage stimulus which was

probably due to lactic acid accumulation. The test-retest-reliability for the control tests was .9277. The correlation between the scores for the experimental versus the control was .9535. The average correlation for the thirty-six subjects was .941. There was no significant correlation between either heights or weight and vertical jumping ability.²⁷

The third test conducted on jumping was conducted by Pacheco. Isometric stretching exercises were used as the warm-up activity along with isotonic exercises and a combination of the two (knee bends). Pacheco used Henry's vertical jump apparatus with nine males and one female as subjects. The subjects were tested on six jumps each separated by 1.5 minutes rest. The deep knee bends improved the jumps over no warm-up. Preliminary stretching improved jumps over no warm-up as well as did stationary running. The test-retest-reliability was .975. It was concluded that preliminary isometric stretching exercises, as well as exercises emphasizing isotonic work, improve vertical jumping performance. It was also concluded that an increase in the amount of preliminary exercise is reflected by improved performance.²⁸

ANALYSIS OF SPECIFIC FACTS

Number of Studies

The analysis of fifteen studies does represent a good cross section of research done in the subject matter. The most important criteria is not the number of studies reported but the quality of the studies and their test-retest-reliability. Unless it is clearly demonstrated that a warm-up induces physiological changes, and the degree to which those changes occur is indicated, experiments intended to show the effects of warm-up are of negligible value, at least from a physiological point of view.

Reliability

Six of the fifteen studies had a test-retest-reliability factor. This was 40% of the studies published with 33% of the participants involved in the test-retest studies, 293 out of 882 participants. The studies with the retest reliability results were:

Lotter, Willard S.; Effects of Fatigue and Warm-up on Circle Speed of Arm Movements: March, 1959. Page 11.

Massey, Benjamin H.; Johnson, Warren R.; and Kramer, George F.; Effect of Warm-up Exercise Upon Muscular Performance Using Hypnosis to Control the Psychological Variable: March, 1961.

Page 12

Merlino, Lawrence V.; Effects of Massage on Jumping Per-

formance: March, 1959. Page 19.

Pacheco, Betty A.; Effectiveness of Warm-up Exercise in Junior High School Girls: March, 1957. Page 19.

Pacheco, Betty A.; Improvement in Jumping Performance Due to Preliminary Exercise: May, 1959. Page 20.

Michael, Ernest; Skubic, Vera; and Rochelle, Rene; Effect of Warm-up on Softball Throw for Distance: December, 1957. Page 14.

Male and Female Participants

Of the 882 total participants, 562 or 63.5% were male. Three hundred and twenty or 36.5% were female. Of the 320 females tested, 269 were tested in just two different studies. The differentiation between the number of males and females tested does not seem to have any significant bearing on the results of the studies. More males participated because there are more male researchers than female in the field of physical education research.

Range of the Number of Participants

The range of the number of participants in the studies was from 10 to 161 participants tested in a single study. The median number was 58 participants. This represents a reliable number of participants per study.

The age range was from 13 years to 43 years old. The two predominant age group areas tested were the junior high school girls and the college age student bracket.

TABLE 1

Retest-Reliability of Thirteen Individual Parts of the Six
Studies That Had a Retest Coefficient

AUTHOR	TITLE OF STUDY	SECTION OF STUDY RETESTED	RELIABILITY COEFFICIENT
Pacheco	Improvement in Jump- ing Performance Due to Preliminary Exer- cise	Entire Test	.9750
Merlino	Effects of Massage on Jumping Perform- ance	Experimental Versus Control Group	.9535
Merlino	Effects of Massage on Jumping Perform- ance	Average	.9410
Massey, Johnson, and Kramer	Effect of Warm-up Exercise Upon Mus- cular Performance Using Hypnosis to Control the Psycho- logical Variable	Test 3 & 4	.9300
Merlino	Effects of Massage on Jumping Perform- ance	Control Tests	.9277
Michael, Skubic, and Rochelle	Effect of Warm-up on Softball Throw for Distance	Warm-up	.9000
Pacheco	Effectiveness of Warm-up Exercise in Junior High School Girls	Ninth Graders	.8790
Michael, Skubic, and Rochelle	Effect of Warm-up on Softball Throw for Distance	No Warm-up	.8700
Pacheco	Effectiveness of Warm-up Exercise in Junior High School Girls	Eighth Graders	.8580

TABLE 1 (Continued)

Retest-Reliability of Thirteen Individual Parts of the Six
Studies That Had a Retest Coefficient

ARTHOR	TITLE OF STUDY	SECTION OF STUDY RETESTED	RELIABILITY COEFFICIENT
Lotter	Effects of Fatigue and Warm-up on Cir- cle Speed of Arm Movements	Section 2	.8220
Massey, Johnson, and Kramer	Effect of Warm-up Exercise Upon Mus- cular Performance Using Hypnosis to Control the Psycho- logical Variable	Test 2 & 3	.8200
Massey, Johnson, and Kramer	Effect of Warm-up Exercise Upon Mus- cular Performance Using Hypnosis to Control the Psycho- logical Variable	Test 1 & 2	.6600
Lotter	Effects of Fatigue and Warm-up on Cir- cle Speed of Arm Movements	Section 1	.5090

GENERAL RESULTS OF THE STUDIES

Four of the fifteen studies showed that warm-up had a positive effect on the performance tested. These were Effect of Warm-up on Softball Throw for Distance (page 14), Effectiveness of Warm-up Exercise in Junior High School Girls (page 19), Influence of Massage on Jumping Performance (page 19), and Improvement in Jumping Performance Due to Preliminary Exercise (page 20). Seven studies showed that warm-up had no effect on performances tested. They were Effect of Warm-up Activities on Speed, Strength, and Accuracy (page 9), Effects of Fatigue and Warm-up on Circle Speed of Arm Movements (page 11), Effect of Warm-up on 440-Yard Dash Times (page 12), Effects of Warm-up Exercises Upon Muscular Performance Using Hypnosis to Control the Psychological Variable (page 12), Effect of Passive Warm-up on Muscular Strength and Endurance (page 16), Depression of Muscle Fatigue Curves by Heat and Cold (page 17), and Effect of Participation in Light, Medium, and Heavy Exercise Upon Accuracy in Motor Performance of Junior High School Girls (page 19). The remaining four studies showed that within the performances tested there were both positive and negative results. These were Effects of Various Warm-up Procedures on 100-Yard Times of Competitive Swimmers (page 10), Effect of Warm-up Upon Physical Performance in Selected Activities (page 9), Influence of Fatiguing Warm-up Exercises on Speed of Movement and Reaction Latency (page 13), and Performance

as Affected by Incentive and Preliminary Warm-up (page 14).

In the four positive studies, 289 participants were tested or 32.7% of the total persons tested. In the negative results, 255 persons or 28.9% were tested. There were 38.4% or 338 persons tested in the studies resulting in mixed results. The studies resulting in mixed results had the highest number of participants in the four studies.

TABLE II

General Results of the Fifteen Studies Rated as Positive Effects.

Negative Effects, and Positive-Negative Effects

AUTHOR	POSITIVE EFFECT	NEGATIVE EFFECT	POSITIVE & NEGATIVE
Pacheco	X		
Skubic and Hodgkins		X	
Michael, Skubic and Rochelle	X		
Grose		X	
Thompson			X
DeVries			X
Lotter		X	
Merlino	X		
Pacheco	X		
Mathews		X	
Rochelle, Skubic, and Michael			X
Massey, Johnson and Kramer		X	
Witte		X	
Phillips			X
Sedgwich and Whalen		X	

This table shows why it is difficult to generalize about the effect of warm-up. The answer to the question of the effect of warm-up seems to lie in the type of activity.

CONCLUSIONS

Warm-up Activities Involving Speed

The greatest number of studies were run on activities testing speed. Of the seven studies, four yielded results with a negative result. They were Effects of Fatigue and Warm-up on Circle Speed of Arm Movement (page 11), Effects of Warm-up Activities on Speed, Strength, and Accuracy (page 9), Effect of Warm-up on 440-Yard Dash Times (page 12), and Effect of Warm-up Exercises Upon Muscular Performance Using Hypnosis to Control the Psychological Variable (page 12). The other three studies showed mixed results. They were Effect of Warm-up Upon Physical Performance in Selected Activities (page 9), Effects of Various Warm-up Procedures on 100-Yard Times of Competitive Swimmers (page 10), and Influence of Fatiguing Warm-up Exercises on Speed of Movement and Reaction Latency (page 13). These studies involved the arm, swimming, entire body in general exercise, short-distance run and typing. The warm-up activities did not seem to effect those activities in which speed was the most important factor.

Warm-up Activities Involving Distance

Only two studies were involved with the testing of the relationship of warm-up to distance. One test had mixed results, Performance as Affected by Incentive and Preliminary Warm-up (page 14), and the other, Effect of Warm-up on Softball

Throw for Distance (page 14) had positive results. The warm-up activities seemed to have a positive effect upon those activities in which distance was the most important factor.

Warm-up Activities Involving Strength and Endurance

There were three studies reporting on the relationship between warm-up and strength and endurance. Two of the studies showed negative results. They were Effect of Warm-up Activities on Speed, Strength, and Accuracy (page 9) and Effect of Passive Warm-up on Muscular Strength and Endurance (page 16). The other study, Effect of Warm-up Upon Physical Performance in Selected Activities (page 9) showed mixed results. The warm-up activities did not seem to have a positive effect upon those activities in which strength and endurance were the primary factors.

Warm-up Activities Involving Muscle Fatigue

There were only two studies reported on in the relationship between warm-up and muscle fatigue. One study, Depression of Muscle Fatigue Curves by Heat and Cold (page 17) showed negative results while the other study, Influence of Fatiguing Warm-up Exercises on Speed of Movement and Reaction Latency (page 13) showed mixed results. The warm-up activities seemed to point to negative results where muscle fatigue was involved and a predominant factor.

Warm-up Activities Involving Accuracy

There were three studies reported on testing the relationship between warm-up and accuracy. Effect of Warm-up Activities on Speed, Strength, and Accuracy (page 9) and Effect of Participation in Light, Medium, and Heavy Exercise Upon Accuracy in Motor Performance of Junior High School Girls (page 19), showed negative results. Mixed results were found in Effect of Warm-up Upon Physical Performance in Selected Activities (page 9). The warm-up activities seemed to point to negative results where accuracy was the paramount factor.

Warm-up Activities Involving Jumping

The reports of the jumping tests were the only group of studies that showed positive effects of warm-up being beneficial to all three studies. They were Effectiveness of Warm-up Exercise in Junior High School Girls (page 19), Influence of Massage on Jumping Performance (page 19), and Improvement in Jumping Performance Due to Preliminary Exercise (page 20). The warm-up activities did benefit performances in which vertical jumping was the factor tested.

The evidence and analysis of these fifteen studies tend to show that "the theory that 'warm-up' is indispensable for good performance"²⁹ is not a valid theory in all cases. There are no studies available explaining why the warm-up is beneficial for vertical jumping and distance but not for speed, accuracy, strength and endurance, and muscle fatigue.

FOOTNOTES

1. Along with this idea is the hope that the warm-up would also eliminate or reduce the possibilities of injury to the muscle or muscle group involved.
2. Karpovich, Peter V., M. C.; Physiology of Muscular Activity; 6th Edition, 1965; Copyright, 1959; W. B. Saunders Company, Philadelphia and London; page 11.
3. Ibid., page 13
4. Pearson, George, and Whalin, Jacqueline; Reference Index of the Research Quarterly for the American Association of Health, Physical Education, and Recreation; All American Products and Publishers, San Diego, California; 1964.
5. Op. cit., Karpovich, P. V., M. D.; page 15.
6. Ibid., page 15, statement refers to studies done by A. L. Schmid of Moscow, Russia.
7. Ibid., page 15, statement refers to the Masters Thesis of Creighton J. Hale, "The Effect of Preliminary Massage on the 440-Yard Run"; Springfield College, 1949.
8. Ibid., page 16.
9. Skubic, Vera and Hodgkins, Jean; "Effect of Warm-up Activities on Speed, Strength, and Accuracy"; Research Quarterly for the American Association of Health, Physical Education, and Recreation; 28:147; May, 1957.
10. Thompson, Hugh; "Effect of Warm-up Upon Physical Performance in Selected Activities"; Research Quarterly for the American Association of Health, Physical Education, and Recreation; 29:231; May, 1958.
11. DeVries, Herbert A.; "Effects of Various Warm-up Procedures on 100-Yard Times of Competitive Swimmers"; Research Quarterly for the American Association of Health, Physical Education, and Recreation; 30:11, March, 1959.
12. Lotter, Willard S. "Effects of Fatigue and Warm-up on Circle Speed of Arm Movement". Research Quarterly; 30:57, March, 1959.
13. Mathews, Donald K. "Effect of Warm-up on 440-Yard Dash Time". Research Quarterly; 30:446, December, 1959.

14. Massey, Benjamin H.; Johnson, Warren R.; and Kramer, George F.; "Effect of Warm-up Exercise Upon Muscular Performance Using Hypnosis to Control the Psychological Variable". Research Quarterly; 32:186, March, 1962.
15. Phillips, William H.; "Influence of Fatiguing Warm-up Exercises on Speed of Movement and Reaction Latency". Research Quarterly; 34:87, October, 1963.
16. Rochelle, R. H.; Skubic, Vera, and Michael, E. D.; "Performance as Affected by Incentive and Preliminary Warm-up". Research Quarterly; 28:357, October, 1960.
17. Michael, Ernest, Skubic, Vera, and Rochelle, Rene; "Effect of Warm-up on Softball Throw for Distance"; Research Quarterly; 28:46 257, December, 1957.
18. Op. cit., Skubic, Vera and Hodgkins, Jean. Footnote #9.
19. Op. cit., Thompson, Hugh. Footnote #10.
20. Sedgwich, A. W. and Whalen, H. R.; "Effect of Passive Warm-up on Muscular Strength and Endurance"; Research Quarterly; 35:201, March, 1964.
21. Grose, Joel E.; "Depression of Muscle Fatigue Curves by Heat and Cold"; Research Quarterly; 29:128, March, 1958.
22. Op. cit., Phillips, William H. Footnote #15.
23. Op. cit., Skubic, Vera and Hodgkins, Jean. Footnotes #9 and #18.
24. Op. cit., Thompson, Hugh; Footnotes #10 and #19.
25. Phillips, William H.; "Effect of Participation in Light, Medium, and Heavy Exercise Upon Accuracy in Motor Performance of Junior High School Girls"; Research Quarterly; 33:34, May, 1962.
26. Pacheco, Betty; "Effectiveness of Warm-up Exercise in Junior High School Girls"; Research Quarterly; 28:55, March, 1957.
27. Merlino, Lawrence V.; "Influence of Massage on Jumping Performance"; Research Quarterly; 30:66, March, 1959.
28. Pacheco, Betty; "Improvement in Jumping Performance Due to Preliminary Exercise"; Research Quarterly; 30:202, May, 1959.
29. Op. cit., Karpovich, Peter V., M. D. Footnote #2.

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ACKNOWLEDGMENTS

The author extends his appreciation and gratitude to the following persons: Professor Thomas M. Evans, Assistant Professor Raymond W. Wauthier and to the Department of Physical Education, Kansas State University.

APPENDIX

Chronological Listing of Studies From the Research Quarterly

- March, 1957-----Pacheco, Betty A., Effectiveness of Warm-up Exercise in Junior High School Girls.
- May, 1957-----Skubic, Vera and Hodgkins, Jean, Effect of Warm-up Activities on Speed, Strength, and Accuracy.
- December, 1957---Michael, Ernest; Skubic, Vera; Rochelle, Rene; Effect of Warm-up on Softball Throw for Distance.
- March, 1958-----Grose, Joel E., Depression of Muscle Fatigue Curves by Heat and Cold.
- May, 1958-----Thompson, Hugh, Effect of Warm-up Upon Physical Performance in Selected Activities.
- March, 1959-----DeVries, Herbert A., Effects of Various Warm-up Procedures on 100-Yard Times of Competitive Swimmers.
- March, 1959-----Lotter, Willard S., Effects of Fatigue and Warm-up on Circle Speed of Arm Movement.
- March, 1959-----Merlino, Lawrence V., Influence of Massage on Jumping Performance.
- May, 1959-----Pacheco, Betty, Improvement in Jumping Performance Due to Preliminary Exercise.
- December, 1959---Mathews, Donald K., Effect of Warm-up on 440-Yard Dash Time.
- October, 1960----Rochelle, R. H.; Skubic, Vera; and Michael, E. D., Performance as Affected by Incentive and Preliminary Warm-up.
- March, 1961-----Massey, Benjamin H.; Johnson, Warren R.; and Kramer, George F., Effect of Warm-up Exercise Upon Muscular Performance Using Hypnosis to Control the Psychological Variable.
- May, 1962-----Witte, Fay, Effect of Participation in Light, Medium, and Heavy Exercise Upon Accuracy in Motor Performance of Junior High School Girls.

October, 1963----Phillips, William H., Influence of Fatiguing Warm-up Exercises on Speed of Movement and Reaction Latency.

March, 1964-----Sedgwich, A. W.; and Whalen, H. R., Effect of Passive Warm-up on Muscular Strength and Endurance.

A STUDY OF EFFECTS OF PRELIMINARY EXERCISE AND PROCEDURE
ON PERFORMANCE IN VARIOUS TYPES OF ACTIVITIES

by

ROYER KENT ULRICH

B. S., Kansas State University, 1963

AN ABSTRACT OF A MASTER'S REPORT

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Physical Education

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1970

The purpose of this investigation was to study the effects of different types of warm-up exercises on performance in various types of sports and activities. A common belief that is held by many individuals and coaches is that performance efficiency will be improved through "preheating" of the muscle, or muscle groups, and thus improving the work load of an individual's performance. In other words, does warm-up increase one's performance in the categories of speed, distance, strength and endurance, muscle fatigue, accuracy, and jumping ability.

The method of study was done through library research of all of the Research Quarterlies published by the American Association of Health, Physical Education, and Recreation during the period from 1957 through 1964. Fifteen studies were published on the subject of the effects of warm-up during this span than throughout any other ten year period.

In two studies done by Pacheco it was found that warm-up did have a positive effect on performance in activities involving vertical jumping. It was found in a study by Merlino that warm-up by massage had a positive effect on activities of vertical jumping while in a study by Michael, Skubic and Rochelle it was found that there was positive effects of warm-up on performance activities involving distance. Only two activities reported on vertical jumping and distance, were there found to be only positive effects of warm-up upon the activities tested.

In a study by Thompson it was found that when he tested

selected activities a negative and positive effect resulted. This same result was reported by DeVries in a study of speed and by Rochelle, Skubic and Michael in a study consisting of entirely motivation. Also, the same results were found, negative and positive effects, in a study by Phillips of warm-up upon performance in relation to maximum fatigue. There were four studies that showed that warm-up had both a negative and positive effect upon performance.

Seven of the studies showed that warm-up had a negative effect upon performance. Skubic and Hodgkins, found only negative results in a study on speed, accuracy and strength. Also, Grose found only negative effects in his study of muscle fatigue and warm-up as did Mathews in a study of short dash times. In a complicated study involving hypnosis and warm-up, Massey, Johnson, and Kramer found only negative results.

In total, two articles relating to activities studied, distance and vertical jumping, were the only ones that showed a positive effect of warm-up upon performance. In other words, only vertical jumping and distance performance were improved by a warm-up activity. Speed, accuracy, strength and endurance performances were either unimproved or were hindered, by a warm-up activity.

In many studies mixed results were indicated. Some parts of the tests showed effects of warm-up different than others.

It seems evident that such factors as the type of activity, nature of the warm-up, extent and intensity of the warm-up physiological make-up of the individual, and attitudes toward the warm-up were the factors to be isolated in researching warm-up activities.