THE EFFECTS OF DRY HEAT IN A SAUNA BATH UPON PERFORMANCE OF CERTAIN PHYSICAL AND MENTAL TASKS

DISSERTATION

Presented to the Graduate Council of the
North Texas State University in Partial
Fulfillment of the Requirements

For the Degree of

DOCTOR OF EDUCATION

By

Dick T. Dowell, B.S., M.T.A.

Denton, Texas

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This investigation is concerned with effect of dry heat in a sauna bath on leg power, agility, endurance, and mental alertness. Tests were conducted on forty-two subjects, with all the subjects taking a test following heat treatment and a test without heat treatment, for leg power, agility, endurance, and mental alertness.

The Fisher's t test for significance of difference between the means is the statistical technique for analyzing the data. The .05 level of significance is the level of acceptance for the stated hypotheses.

The purposes of the investigation were to determine and analyze the effects of dry heat upon the physical and mental performance tasks and to deduce implications for the improvement of educational practices.

The hypotheses state that exposure to heat treatment in the sauna bath will significantly increase the performance of leg power, agility, endurance, and mental alertness. The The hypotheses for leg power, agility, and endurance are rejected because the .05 level of significance was not obtained. The hypothesis for mental alertness is accepted at the .05 level of significance.

This study has five chapters, organized in the following manner: (1) Chapter I contains the introduction, statement of the problem, hypotheses, procedures for collecting the data, and procedures for treating the data; (2) Chapter II is concerned with the review of the literature and gives studies for passive warm-up, active warm-up, passive warm-up contrasted with active warm-up, and related and unrelated warm-up; (3) Chapter III gives a description of subjects and tests and the procedures for treating the data; (4) Chapter IV reports the statistical technique of the analysis and the findings related to the hypotheses; and (5) Chapter V gives the summary, findings, conclusions, and recommendations.

The conclusions of this study state that heat treatment does not cause great improvement in leg power or agility, and causes slower performance times in the endurance runs. It is concluded that heat treatment causes an improvement in mental alertness test performance when compared with mental alertness performances completed without heat treatment.

It is recommended that when mental alertness is the primary factor in performance tasks, the sauna bath be used for heat treatment prior to the performance. Further recommendations state that psychological factors which might influence studies of this type need to be determined and a method of control established, and the relationship between mental alertness and physical performance should be investigated in greater depth.

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CHAPTER I

INTRODUCTION

Physical educators, physiologists, and coaches have been concerned for many years about the value of warm-up prior to vigorous physical performance. Their concern varied from the "prevention of injuries" to "improvement of athletic performance." The research which has been conducted in the area of warm-up is also varied in types of warm-up exposure, and the testing of performance after exposure. It has been controversial, on the basis of the research data now available, whether warm-up does significantly affect the performance of individuals. This study was designed to provide experimental evidence concerning the effect of dry heat treatment upon performance of selected physical and mental tasks so that a method of possible improvement of physical education class performances might be found.

Statement of the Problem

The problem involved an investigation of the effect of dry heat in a sauna bath on leg power, agility, endurance, and mental alertness.

Purposes of the Study

The following purposes were formulated:

1. To determine the effect of dry heat upon physical performance tasks consisting of leg power, agility, and endurance.

2. To determine the effect of dry heat upon mental alertness.

3. To analyze the effects of dry heat upon the physical and mental performance tasks and to deduce implications for the improvement of educational practices.

Hypotheses

To carry out the purposes of the study, the following hypotheses were formulated:

I. Exposure to heat treatment will significantly increase the performance of leg power as measured by the "Sargent's Vertical Jump Test."

II. Exposure to heat treatment will significantly increase the performance of agility as measured by the zigzag run.

III. Exposure to heat treatment will significantly increase the performance of endurance as measured by the 440-yard run.

IV. Exposure to heat treatment will significantly increase the performance of mental alertness as measured by the Thurstone Mental Alertness Test.

Background and Significance of the Study

The question of the effectiveness of warm-up prior to an athletic performance has been debated for many years. Certainly, it would be of great value to teachers and coaches if it were established that warm-up does or does not affect performance. Unfortunately, all studies do not establish a statistical significance in favor of warm-up for physical performances.

Asmussen and Boje[1] concluded that work output was increased when the body was at a higher temperature. Their passive warm-up procedures included hot showers, radiodiathermy and massage. The active warm-up consisted of work with the bicycle ergometer. The types of work tested included power, endurance, and strength. The results indicated that all forms of warm-up except massage had a beneficial effect on work performance.

Pacheco[2] found that subjects showed significant improvement in vertical jumping ability after a warm-up exercise of running in place for three minutes. The vertical jumping test is a valid test for power.

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[1]E. Asmussen and O. Boje, "Body Temperature and Capacity for Work," Acta Physiological Scandinavica, X (1945), 1-22.

[2]B. A. Pacheco, "Improvement in Jumping Performance Due to Preliminary Exercise," Research Quarterly, XXVIII (March, 1957), 55-63.

Michael, Skubic, and Rochelle[3] supported the power study by Pacheco with a power test for the arms. Their warm-up consisted to toe touching, jumping jacks, sprint running, and throwing at various distances. They concluded that the warm-up improved the power performance.

Karpovich and Hale[4] performed three series of experiments. Seven subjects ran 440 yards after deep massage, exercise, and digital stroking. Three subjects took sprint rides on the bicycle ergometer after preliminary exercise and with warm-up. Five subjects ran 440 yards without warm-up after digital stroking. They concluded that none of the warm-up devices improved time in running the 440 yards or performance on the bicycle ergometer.

Skubic and Hodgkins[5] used physical education majors as subjects and tested for speed on the bicycle ergometer, for strength with the softball throw, and for accuracy with basketball free throws. Each test was performed with no warm-up, with a general warm-up of jumping jacks, and with a warm-up related to the test activity. They concluded that

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[3]E. D. Michael, V. Skubic, and R. H. Rochelle, "Effect of Warm-up on Softball Throw for Distance," Research Quarterly, XXVIII (December, 1957), 357-363.

[4]P. V. Karpovich and C. J. Hale, "Effect of Warm-up on Physical Performance," Journal of the American Medical Association, CLXII (November, 1956), 1117-1119.

[5]V. Skubic and J. Hodgkins, "Effect of Warm-up Activities on Speed, Strength, and Accuracy," Research Quarterly, XXVIII (May, 1957), 147-152.

warm-up had no significant effect on the performance of speed, power, and skill, thereby supporting the Karpovich and Hale study.

Very few studies have been published which used the sauna bath as a source of warm-up. Since many colleges now have sauna baths available, this source of heat for warm-up could prove valuable. An entire team of basketball players might warm up in the sauna bath prior to the game. Physical educators interested in improving individual and group performances may find the sauna bath helpful in reaching their goals.

The fact that power, agility, and endurance may be improved with the sauna bath warm-up would also suggest that physical fitness would be improved. If mental alertness is found to be significantly improved along with the physical aspects, then a person would have benefited more totally.

Definition of Terms

The terms used in this study are defined as follows:

1. Agility refers to the capacity for fast reaction in a controlled, nimble movement of action. The agile subject moves quickly, dexterously, and easily. Agility represents one of the highest types of neuromuscular training.

2. Endurance refers to the capacity for continuous exertion of the muscles against a moderate resistance for a long period of time and the effectiveness of the heart, blood

vessels, and lungs in obtaining and delivering oxygen. The subject running 440 yards uses muscles against the resistance offered by the wind and track and also must call upon a great amount of oxygen utilization.

3. Heat refers to a form of energy which produces an increase in temperature. Dry heat is the energy which increases the temperature at a relatively low percentage of humidity. For the purpose of this study, heat will refer to a temperature of 180° F. and a humidity of 20 percent.

4. Mental alertness refers to quickness in sizing up a situation. It also reflects the capacity of the subject to acquire new knowledge and skills and the ability to understand complex and subtle relationships.

5. Power emphasizes the capacity to release a great explosive force in order to execute fast or sudden efforts which move the entire body with maximum effort. Power is also defined as force times velocity. The subject participating in the vertical jump must use force and speed in order to demonstrate power.

Limitations of the Study

1. The study was limited to forty-two of the forty-eight college men who volunteered to participate in the study. All of the men were students of Midwestern University during the spring semester of 1970.

2. The study investigated only the effects of exposure to dry heat in a sauna bath upon the specified tasks of leg power, agility, endurance, and mental alertness.

Basic Assumptions

1. It was assumed that the subjects would be honest and would cooperate in their attempts to follow the prescribed testing programs.

2. It was assumed that acclimation to the dry heat would not be a factor which would influence the results, since the length of time for exposure was limited.

Procedures for Collecting the Data

During the spring semester of 1970, volunteers were sought from the physical education weight training classes of Midwestern University for participation in the study. From the forty-eight volunteers, a total of forty-two men completed all the tests involved in the study. Three testing periods were allowed for each of the following tests: the vertical jump test, the zigzag run test, and the 440-yard run test. Two periods were allowed for the test of mental alertness. The extra period provided for the tests of physical performances was used to test the persons who had missed one of the preceding periods allotted for the tests. An extra period was not needed for the test of mental alertness. On all tests, one-half of the subjects performed after exposure in the sauna bath at 180° F. at 20 percent humidity

for ten minutes. The rest of the subjects took the tests without heat treatment. The subjects who had performed after the heat treatment took the same test without heat treatment on the next testing period, while the rest of the subjects took the test after receiving the heat treatment.

Procedure for Treating the Data

The tenability of the hypotheses of this study was tested by Fisher's t test for significance of difference between the means for each of the four tests. The hypotheses were accepted at the .05 level of significance.

CHAPTER II

REVIEW OF THE LITERATURE

Research studies investigating the effect of warm-up on performance have reported contrasting results for years. Examination of these studies reveals many types of warm-up treatments, varied intensities and time permitted for warm-up, with many different activities being tested.

The investigator has classified warm-up procedures found in the review of the literature into four major categories. These major categories include passive warm-up, active warm-up, passive warm-up contrasted with active warm-up, related and unrelated warm-up.

Passive Warm-Up

A study using massage as a method of warm-up was reported by Merlino.[1] Thirty-six male subjects performed the vertical jump after receiving massage of various degrees. The improvement of the vertical jump after receiving a combination of deep stroking and kneading massage was statistically significant at the .01 level.

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[1] Lawrence U. Merlino, "Influence of Massage on Jumping Performance," Research Quarterly, XXX (March, 1959), 66-75.

A study by Karpovich and Hale[2] concluded that pre-exercise massage had no significant effect upon the performance of seven subjects running the 440-yard run.

Grose[3] administered pre-exercise massage of the forearm muscles on twelve subjects being tested with the hand dynamometer ergograph, and reported no significant effect upon total work output. Hot water and cold water treatments were also used and the investigator concluded that hot water treatment caused a decline in performance as compared to cold water treatment. This experiment utilized localized treatment and performance of the forearm muscle, instead of a more general treatment and performance of many groups of muscles working in a total body situation.

A study by Carlile[4] was conducted using eight-minute hot showers on a group of male subjects. These subjects showed an improvement in swimming performance in 40-yard time trials and the 220-yard swim. The investigator concluded that muscle temperature had a more important influence on performance than did blood temperature.

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[2]P. V. Karpovich and C. J. Hale, "Effect of Warm-up on Physical Performance," Journal of American Medical Association, CLXII (November, 1956), 1117-1119.

[3]J. E. Grose, "Depression of Muscle Fatigue Curves by Heat and Cold," Research Quarterly, XXLX (March, 1958), 19-31.

[4]Forbes Carlile, "Effect of Preliminary Passive Warming on Swimming Performance," Research Quarterly, XXX (March, 1959), 11-20.

In a study of grip strength, Robbins[5] used hot showers of 115° F. for ten minutes and cold showers of 65° F. for ten minutes as types of preparation for the grip dynamometer test. Strength decreased slightly following the hot shower and increased slightly following the cold shower. Neither treatment was statistically significant. The heat treatment conclusion was similar to what Grose later found, but the cold treatment findings for both studies were not in agreement.

Steinhaus, Kelso, and Reinhardt[6] reported that a cold hip bath resulted in temporary improvement in tapping rate, eye-to-eye muscle reaction time, and visual functions. Physical changes noticed in the subjects included (1) slowing of the resting pulse rate, (2) reduction of the pulse rate increase that normally occurs when a reclining person assumes the standing position, and (3) increase in the difference between the systolic blood pressure for reclining and standing.

In a test of muscular strength and endurance, Sedgwick and Whalen[7] studied the effects of short wave diathermy used

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[5]A. C. Robbins, "The Effects of Hot and Cold Shower Baths upon Adolescents Participating in Physical Education Classes," Research Quarterly, XIII (October, 1942), 373-380.

[6]A. H. Steinhaus, A. Kelso, and V. Reinhardt, "The Improvement of Visual and Other Functions by Cold Hip Baths," Research Quarterly, XII (December, 1943), 610-617.

[7]A. W. Sedgwick and H. R. Whalen, "Effects of Passive Warm-up on Muscular Strength and Endurance," Research Quarterly, XXXV (March, 1964), 45-59.

as a passive warm-up. The twenty male subjects were tested for strength on each arm a total of six times. Test results following the short wave diathermy warm-up of ten minutes were lower than the results obtained with no warm-up treatment. The test for endurance indicated that passive heating administered at an intensity sufficient to raise muscle temperature between two and four degrees centigrade, had no significant effect on local muscular endurance.

Active Warm-Up

Lotter[8] reported that warm-up was not significant; in fact, the subjects actually did worse, in his study of arm movement speed. The test consisted of turning a crank as fast as possible throughout the four minutes allotted. The two-minute warm-up exercise consisted of stationary running while simultaneously rotating both arms in a complete circle.

A study by Mathews and Snyder[9] to determine the effect of warm-up on the 440-yard dash, used fifty subjects and warm-up exercises of sit-ups, toe touches, push-ups, wind-sprints, leg pulls, and jogging 440 yards. It was reported that warming up prior to performing the 440-yard dash did

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[8]Willard S. Lotter, "Effects of Fatigue and Warm-up on Speed of Arm Movements," Research Quarterly, XXX (March, 1959), 57-65.

[9]Donald K. Mathews and H. Alan Snyder, "Effect of Warm-up on the 440 Yard Dash," Research Quarterly, XXX (December, 1959), 446-451.

not significantly improve the time over running the same distance without a preliminary warm-up.

Pacheco[10] studied the effectiveness of warm-up exercise on the vertical jump using junior high school girls as subjects. The exercise used for warm-up consisted of a three-minute run at a comfortable pace in which the subjects were urged to use their arms as well as their legs. A significant difference at the .01 level was found, and it was concluded that the preliminary warm-up exercises such as running improve the vertical jumping performance of girls of the junior high school age.

Another study by Pacheco[11] used college subjects doing the standardized vertical jump. It was found that deep knee bends as warm-up exercise improved performance 2.88 percent, isometric stretching improved performance 4.99 percent, and stationary running improved performance 7.80 percent. All of these differences were statistically significant. A further experiment with this study resulted in an improvement of the vertical jump of 3.27 percent after a warm-up of knee bends. This increased performance was significant at the .01 level.

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[10]Betty A. Pacheco, "Effectiveness of Warm-up Exercise in Junior High School Girls," Research Quarterly, XXX (May, 1959), 202-213.

[11]Betty A. Pacheco, "Improvement in Jumping Performance Due to Preliminary Exercise," Research Quarterly, XXVIII (March, 1957), 55-63.

Using eighty girls as subjects, Richards[12] studied the effect of warm-up exercises on the vertical jump. The exercises consisted of stepping on a stool fifteen and one-half inches high at the rate of twenty-five step-ups per minute for one-minute, two-minute, four-minute, and six-minute periods. The subjects were tested in the vertical jump immediately following the warm-up exercises and performed six jumps with a fifteen-second rest between jumps. The results following the one-minute and two-minute warm-ups were statistically significant at the .05 level. The warm-up of four minutes yielded a net effect of approximately zero, while the six-minute warm-ups had a loss of vertical jumping power that was significant at the .05 level.

In a recent study, Pike[13] tested forty-five schoolboys with ages ranging from fifteen to seventeen years. The tests were the sixty-yard dash, the jump and reach test, the cricket ball throw for distance, and the bicycle ergometer test of leg speed. Preliminary activity or warm-up included sprint running, cycling, swimming, vertical jumping, and distance throwing. The warm-up was of short duration so fatigue could not become a factor in the study. The

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[12]D. K. Richards, "A Two-Factor Theory of the Warm-up Effect in Jumping Performance," Research Quarterly, XXXIX (October, 1968), 668-673.

[13]Frank S. Pike, "The Effect of Preliminary Activity on Maximal Motor Performance," Research Quarterly, XXXIX (December, 1968), 1069-1076.

investigator concluded from the study that observed effects of selected types and intensities of preliminary activity on certain tests of maximal motor performance can only be attributed to chance variation.

Passive Warm-Up Contrasted with Active Warm-Up

Asmussen and Boje,[14] in their study of body temperature and work capacity, used passive and active methods of warming the bodies of the subjects being tested on the bicycle ergometer. The methods included radiodiathermy, massage, hot showers, and preliminary work. Four subjects were used in the study. It was reported that preliminary work had a favorable effect upon performance, but the amount of preliminary exercise was so great that only an experienced athlete in excellent training status could be expected to perform such exercise without fatigue. They also reported that heating by diathermy increased performance 3.9 to 7.6 percent, while hot showers resulted in an improvement in performance of 5.0 to 7.2 percent. Massage did not cause a significant improvement in performance. The investigator concluded that improvement in performance was attributed to the rise in muscle temperature.

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[14] Asmussen and Boje, "Body Temperature and Capacity for Work," Acta Physiological Scandinavica, X (1945), 1-22.

Muido[15] concluded from his study that hot showers of forty to forty-three degrees centigrade for a time of fifteen to eighteen minutes had similar results which Asmussen and Boje had reported. Muido also used heating by diathermy and preliminary work in the study and reported significant improvement. Muido did disagree with Asmussen and Boje over the physiological basis for the improved performance. He felt that the improvement was due to increased blood temperature rather than the increase in muscle temperature.

In a study using warm-up procedures of hot showers, massage, calisthenics, and swimming, de Vries[16] found that the total group of thirteen subjects had significant improvement following the swimming warm-up but was not affected by the procedures of hot showers, calisthenics, or massage. The swimming warm-up consisted of swimming 500 yards at a pace which each subject desired. The warm-up by use of hot showers was of six minutes duration with water as hot as the subjects could stand it. The calisthenic exercises were selected for flexing the hips, stretching the back and chest muscles, and strengthening the muscles of the back, hips, and abdomen. The massage was administered for ten minutes upon

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[15] L. Muido, "The Influence of Body Temperature on Performances in Swimming," Acta Physiological Scandinavica, XII (1946), 102-109.

[16] Herbert A. de Vries, "Effects of Various Warm-up Procedures on 100-Yard Times of Competitive Swimmers," Research Quarterly, XXX (March, 1959), 11-20.

each subject with the back, legs, arms, shoulders, and chest being massaged. Using Fisher's t for significance of difference between the means, de Vries reported a significant improvement at better than the .01 level for the swimming warm-up.

A speed and endurance study was conducted by Sills and O'Riley.[17] Comparisons were made on the effects of rest, exercise, and cold spray on the performance of spot-running. The subjects performed best after receiving an application of cold spray on the lower half of the abdomen. It was also found that performance was improved more by rest than by the exercise of walking and jogging for ten minutes.

Astand and Rodahl[18] reported a study by Hogbert and Ljunggren on the effects of warm-up in running 100, 400, or 800 meters. The warm-up consisted of moderate speed running and calisthenics. They compared this effect with the effect of heating the body passively in a sauna bath for a period of twenty minutes prior to the running of the 100, 400, or 800 meters. The beneficial effect obtained by heating the body in the sauna bath was less than the effect obtained through physical exercise. The improvement in the 100-meter

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[17]Frank D. Sills and Vernon E. O'Riley, "Comparative Effects of Rest, Exercise, and Cold Spray upon Performance in Spot-Running," Research Quarterly, XXVII (May, 1957), 217-219.

[18]Per-Olof Astand and Kaare Rodahl, Textbook of Work Physiology (New York, 1970), pp. 491-530.

dash after the exercise warm-up was .5 to .6 second, or 3 to 4 percent improvement over the sauna warm-up. The improvement in the 400-meter run after the exercise warm-up was one and one-half to three seconds or 3 to 6 percent over the sauna warm-up. The improvement in the 800-meter run was four to six seconds or 2-1/2 percent greater after exercise warm-up when compared with sauna warm-up. The percentage of improvement was nearly the same at all distances examined. The investigators also observed better results after fifteen minutes of exercise warm-up as compared to five minutes of exercise warm-up, but no further significant improvement occurred when the warm-up was extended to thirty minutes. No deterioration in performance attributable to fatigue resulted from the vigorous warm-up. It was recommended that warm-up of fifteen to thirty minutes would provide the best results in running events. The rest period between warm-up and the start of the race should be no longer than fifteen minutes. The duration and intensity of the warm-up would be dependent also upon the environmental temperature and amount of clothing worn.

McGavin[19] did a study using five warm-up methods to determine the effect each warm-up method had on speed of leg movement. The related warm-ups of moderate and high

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[19]Robert James McGavin, "Effect of Different Warm-up Exercises of Varying Intensities on Speed of Leg Movement," Research Quarterly, XXXIX (March, 1968), 125-130.

intensities imitated the speed of leg movement test exactly with only two twenty-second series used for the moderate warm-up and four twenty-five-second series used for the high intensity warm-up. The unrelated warm-up consisted of body exercises such as jogging, push-ups, sit-ups, side-straddle hops, and running in place. The high intensity unrelated warm-ups consisted of exercises causing intense physical work, while the moderate intensity warm-ups required only a slight amount of physical work. The passive warm-up consisted of a hot shower lasting seven minutes. The tests used in the study embodied the basic movements of the leg and consisted of one-foot tapping for twenty seconds, two-foot tapping for fifteen seconds, and leg circling for fifteen seconds. The t test for the difference between means was used and the following conclusions were made: (1) warm-ups were significantly beneficial to speed of leg movement, (2) the unrelated, high-intensity warm-up was the most beneficial to the speed of leg movement, (3) high intensity warm-ups were significantly better than moderate intensity warm-ups in preparing for speed of leg movement activities, and (4) a passive warm-up consisting of a hot shower aided performance utilizing speed of leg movement.

Related and Unrelated Warm-Up

Michael, Rochelle, and Skubic[20] did a study in which college male subjects were tested in the softball throw for distance. The conditions used were (1) no preliminary warm-up, (2) warm-ups related to the activity, and (3) warm-ups unrelated to the activity (calisthenics and jogging). The warm-up related to the activity consisted of throwing and catching a softball for one minute each at distances of twenty-five feet, fifty feet, seventy-five feet, one hundred feet, and over one hundred feet. The unrelated warm-up activities consisted of one minute of jumping jacks, one minute of toe touching, one minute of alternate toe touching, and two minutes of sprint running. The test results indicated significant improvement on both types of warm-up.

Thompson[21] tested performance in (1) swimming thirty yards, (2) swimming maximum distance for five minutes, (3) basketball shooting, (4) bowling, (5) typing, and (6) back and leg dynamometer. Two types of warm-up were utilized and described as being formal (related to the activity) and informal (unrelated to the activity). Formal warm-up caused significant improvement beyond the .01 level in the thirty

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[20]E. D. Michael, Vera Skubic, and R. H. Rochelle, "Effects of Warm-up on Softball Throw for Distance," Research Quarterly, XXVIII (December, 1957), 357-363.

[21]Hugh Thompson, "Effect of Warm-up upon Physical Performance in Selected Activities," Research Quarterly, XXIX (May, 1958), 231-246.

yard swim, basketball shooting, and bowling. Distance swimming was improved following formal warm-up, and the improvement was significant at the 5 percent level. Formal warm-up produced no significant difference in strength scores as measured by the leg dynamometer, and typing speed or accuracy did not improve after formal warm-up. The formal warm-up did not cause any significant improvement on any of the test performances.

Skubic and Hodgkins[22] used thirty-one woman subjects in a series of tests to determine the effects of light warm-up activities on speed, strength, and accuracy. The test for speed consisted of a ride on the bicycle ergometer for one-tenth of a mile. The strength test administered was the softball throw for distance. The test of accuracy was the number of successful basketball free throws a subject could score in ten attempts. The warm-up activities were of two types. One type consisted of warm-up related to the activity; basketball free throws were taken before the strength test and eight revolutions were permitted on the bicycle ergometer prior to the test for speed. The second type of warm-up consisted of twelve jumping jacks prior to the tests for speed, strength, and accuracy. Related warm-up, unrelated warm-up, and no warm-up results were obtained and

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[22]Vera Skubic and Jean Hodgkins, "Effect of Warm-up Activities on Speed, Strength, and Accuracy," Research Quarterly, XXVIII (May, 1957), 147-152.

compared. It was concluded that (1) neither the presence nor absence of light warm-ups of short duration appeared to affect significantly the performance of subjects of average skill, and (2) while there was no significant difference between scores in three different activities using three methods of warm-up, a slight tendency toward better scores was noted in tests which were preceded by related warm-ups.

A study by Rochelle, Skubic, and Michael,[23] in which forty-six male subjects were involved in the softball throw for distance, used monetary rewards to induce the subjects to throw as far as possible. The five-minute related warm-up consisted of throwing at various distances. Three throws were allowed in the test and the average of the throws following warm-up was 10.2 ± 1.65 feet farther than the throws allowed without warm-up. The difference in distance had a *t* ratio of 6.182, which was significant at the .01 level. It was also stated that despite the significant increase in distance between trials one and three when no warm-up preceded throwing, subjects threw farther when throws were preceded by a related warm-up. This difference was significant at the .01 level.

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[23] R. H. Rochelle, Vera Skubic, and E. D. Michael, "Performance as Effected by Incentive and Preliminary Warm-ups," Research Quarterly, XXXI (October, 1960), 499.

Hipple[24] was one of the first physical educators who questioned the value of warm-up exercises prior to sprint running. To secure some practical information on pre-race warm-up, and at the same time learn something about how rapidly eighth-grade boys become fatigued in running short sprints, a series of test runs were made. Each subject ran five fifty-yard sprints with only a five-minute rest between the sprints. The best times were found to occur in the first, second, and third trials. Each of those trials had 30 percent of the fastest times. Trial four had only 3 percent of the fastest times, and trial five had 7 percent of the fastest times. It was concluded that the first race had no beneficial warm-up effect on the second race, and cumulative warm-up of the first and second races had no beneficial effect on the third race. The fourth and fifth races were slower because of fatigue.

It has been traditional for athletes of certain sports to use the overload principle for warm-up. Baseball players have for years used weighted bats or several bats in their practice swings before stepping into the batter's box. Huss, Albrecht, Nelson, and Hagerman[25] explored this practice of

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[24]Joseph E. Hipple, "Warm-up and Fatigue in Junior High School Sprints," Research Quarterly, XVI (May, 1955), 246-247.

[25]W. D. Van Huss, L. Albrecht, R. Nelson, and R. Hagerman, "Effect of Overload Warm-up on the Velocity and Accuracy of Throwing," Research Quarterly, XXXIII (October, 1962), 472-474.

overload warm-up on the velocity and accuracy of throwing. They used fifty members of a university baseball team as subjects. The subjects warmed up in the usual manner and then threw ten times with maximal velocity with a regulation baseball of five ounces. The speed and accuracy of each throw was measured with a chronoscope and target. Following a rest period of ten minutes, the subjects took the overload warm-up, which consisted of twenty-five throws with an eleven-ounce ball. The subjects threw ten times with the regulation ball of five ounces after the overload warm-ups. The speed and accuracy was measured as before and the following conclusions were made: (1) overload warm-up significantly improved the velocity of throwing, and (2) the accuracy response following overload warm-up was altered, yielding a significantly different pattern of successive throws.

Singer and Beaver[26] studied the effect of warm-up on bowling scores. The subjects bowled without benefit of the related warm-up of throwing one or two balls on each alley. Each subject participated in three games a week for a five-week period. After an analysis of each frame of bowling, it was concluded that frames five and ten yielded significantly better scores than frame one. Since frame one was the only frame to result in a poorer performance, it was recommended

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[26]Robert N. Singer and Robert Beaver, "Bowling and the Warm-up Effect," Research Quarterly, XXX (May, 1969), 372-375.

that a bowler might benefit from two practice balls prior to bowling for a score. When an analysis of game scores was made, it was revealed that game three scores were much better than game one scores. The investigators stated that a practice game prior to bowling for a score might be beneficial.

One of the most recent studies concerning warm-up on running performance was conducted by Grodjinovsky and Magel.[27] The purpose of the study was to determine the effect of two warm-up procedures, regular warm-up and vigorous warm-up, on the 60-yard, 440-yard, and one-mile runs, and on oxygen consumption measured during a five-minute maximal treadmill run. The regular warm-up consisted of five minutes of jogging and a set of eight calisthenic exercises which included jumping jacks, side bends, push-ups, sit-ups, toe touches, body rotations, body lunges, and sitting toe touches. The vigorous warm-up consisted of the regular warm-up and a run of 176 yards at near-maximal speed. The control group had no warm-up prior to a running or treadmill performance. The results of this study which used 13 male subjects were as follows: (1) regular and vigorous warm-up improved performance significantly at the .05 level in the 60-yard and 440-yard events as compared to no warm-up, (2) vigorous warm-up improved performance in the one-mile run significantly more

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[27]Amos Grodjinovsky and John R. Magel, "Effect of Warm-up on Running Performance," Research Quarterly, XXXXI (March, 1970), 116-119.

than the regular warm-up or no warm-up, and (3) no significant difference between oxygen consumption was obtained during maximal treadmill running following the warm-up conditions.

The benefit of warm-up discussed by Astrand and Rodahl[28] lies in the fact that the metabolic processes in the cell can proceed at a higher rate, since these processes are temperature-dependent. The exchange of oxygen from the blood to the tissues is more rapid and nerve messages travel faster at a high temperature in a frog, and nerve impulses travel eight times as fast in humans. Therefore, it should be beneficial for athletes to keep body temperature up, even at the considerable expense of fatigue, in order that they may move more quickly. Proper warming up may make a difference of three seconds in a 440-yard dash. "The higher the muscle temperature, the better is the performance."[29]

In the summary of his chapter on warming up, deVries makes the following statements:

1. Whole-body warm-up that raises muscle and blood (rectal) temperatures can significantly improve athletic performance.
2. Wherever possible, a "related" warm-up (which raises muscle and blood temperatures) is preferable so that a practice effect may be simultaneously achieved.
3. Warming up is important for preventing muscle soreness and/or injury.
4. Warming-up procedures must be suited to the individual.

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[28]Per-Olof Astrand and Kaare Rodahl, Textbook of Work Physiology (New York, 1970), pp. 491-530.

[29]Ibid., pp. 524-525.

5. Warming-up procedures must be suited to the athletic event.
6. A combination of intensity and duration of warm-up must be achieved that results in temperature increases in the deep tissues without undue fatigue. Sweating is an indication of increased internal temperature. For high-level competitive performances, the additional effort of taking the rectal temperature appears worthwhile; an increase of 1 or 2° F. is desirable.
7. If active, related warm-up is impossible, passive heating can be used effectively.
8. Warming-up appears to be most important (makes the greatest contribution) in activities that directly involve strength, and indirectly in events that have a large element of power of acceleration of body weight.
9. Overload warm-up may be valuable for events in which neuromuscular coordination patterns are of major importance.
10. Tissue temperature changes brought about by warming-up probably persist for forty-five to eighty minutes.[30]

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[30]Herbert A. deVries, Physiology of Exercise for Physical Education and Athletes (Dubuque, 1966), pp. 372-381.

CHAPTER III

PROCEDURES

Description of Subjects

The subjects initially consisted of forty-eight men enrolled in one of two weight training and conditioning exercise sections offered at Midwestern University during the spring semester of 1970. All of the subjects had previous experience in physical education activity classes, but none had taken the weight training and conditioning exercise class. The subjects volunteered to participate in the study, with no favors or rewards offered for participation. The subjects had not used the sauna bath previous to their experience during this investigation. Scores for subjects who did not participate in all of the testing sessions were not included in the data. A total of forty-two subjects completed all of the tests, and their performances were included in the analysis of the data.

Description of Tests

The tests selected for the study tested leg power, agility, cardiovascular endurance, and mental alertness. The areas tested are considered by most authorities as important areas in athletic prowess.

Vertical Jump Test

The vertical jump test devised by Sargent[1] was used as a test of leg power in several test batteries. The JCR test battery[2] used the vertical jump with chinning and the 100-yard shuttle run to test motor fitness. The reliability coefficient of the vertical jump in the JCR test battery was reported as .89. The Indiana Motor Fitness Test constructed by Bookwalter[3] used the vertical jump with chins and push-ups and reported a predictive validity coefficient of .859.

The subject executing the vertical jump test takes a crouched position with the knees bent approximately at a right angle. The subject jumps upward as high as possible, swinging the arms forcefully forward and upward. The subject places a magnet, held between the two middle fingers, on the metallic jump and reach board at the height of the jump. The metallic board contains a sliding metal scale which is measured off at intervals of one-quarter inch. Each subject executes three jumps on each of the two testing periods, with the best jump of each period being recorded.[4]

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[1]Dudley A. Sargent, "Physical Test of a Man," American Physical Education Review, XXVI (April, 1921), 188.

[2]B. E. Phillips, "The JCR Test," Research Quarterly, XVIII (March, 1947), 12-29.

[3]Karl W. Bookwalter and Carolyn W. Bookwalter, "A Measure of Motor Fitness for College," Bulletin of the School of Education, Indiana University, XIX (March, 1953).

[4]H. Harison Clarke, Application of Measurement to Health and Physical Education (Englewood Cliffs, New Jersey, 1959), p. 303.

Zigzag Run Test

The zigzag run test for agility, constructed by Barrow, is part of the Barrow Motor Ability Test for College Men.[5] Barrow used expert opinion to select eight factors of motor ability and twenty-nine items as potential measures of these factors. The Barrow Motor Ability Test for College Men was administered on a test-retest basis to 222 male students, and statistical analysis covered item reliability, objectivity, correlations with the criterion, and intercorrelations. The reliability coefficient for the zigzag run test was reported as .795.

The zigzag run test is run on a course sixteen feet long and ten feet wide. The subject starts at point X in a semi-crouched position. The subject traverses the course three times and does not touch the standards being used as obstacles. The standards are wooden two-inch by two-inch posts with a base twelve inches square and a total height of five feet, one inch. The standards are pointed white so that the subject is able to see them easily. The time is recorded to the nearest tenth of a second, with a stopwatch being used to measure the time necessary for the completion of the zigzag run test. A diagram of the course is given in Figure 1.

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[5]Harold M. Barrow, "Test of Motor Ability for College Men," Research Quarterly, XXV (October, 1954), 253-260.

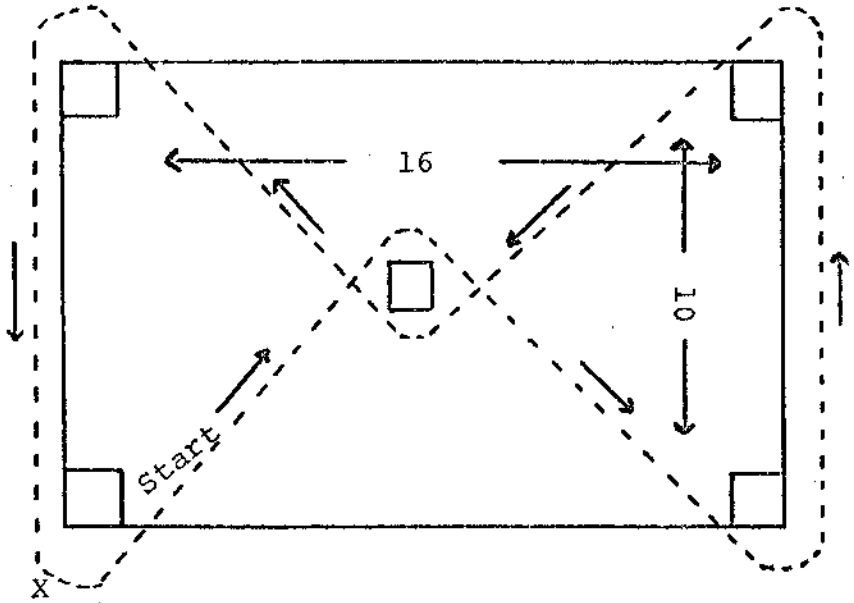

Fig. 1--Course for zigzag run

440-Yard Run Test

The 440-yard run test is run on an oval course. Each complete lap of the course represents 152 yards; therefore 2-17/19 laps are necessary to complete the 440 yards. The subject starts from a half-crouched position, running with the left side of his body nearest the inside railing of the track. A stopwatch is used to measure the time required for the completion of the 440-yard run test. The time is recorded to the nearest tenth of a second.

Thurstone Test of Mental Alertness

The Thurstone Test of Mental Alertness[6] was designed to measure an individual's capacity for acquiring new knowledge

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[6]L. L. Thurstone and Thelma G. Thurstone, "Thurstone Test of Mental Alertness," Examiner Manual, pp. 1-13.

and learning new skills. The test is a paper and pencil test with a time factor of 20 minutes and consists of 126 items. The test has two forms, A and B, with a correlation coefficient between them of .95. The test is designed for people from the ninth-grade level to the adult level. The test questions consist of arithmetic reasoning, number series, same-opposite word meanings, and definitions. The arithmetic reasoning and number series yield a score for problem solving or quantitative ability called the Q Score. The L Score is derived from the same-opposite and definition items and indicates linguistic or verbal ability. The sum of the Q Score and the L Score is the Total Score. A high Total Score reflects an ability to respond quickly and correctly to two types of questions. Since the verbal items are alternated with quantitative items, the test score reflects how rapidly the subject is able to adapt to different situations.

Procedures for Collecting the Data

During the second week of the spring semester, the investigator met with two classes enrolled in weight training and asked for volunteers to participate in the study. A total of forty-eight men volunteered to participate and their names were recorded by the investigator. Information concerning the testing procedures and the order in which the tests were to be conducted was given verbally to the subjects in the class meeting.

The vertical jump test was the first test given and was conducted on the fifth, sixth, and seventh class days. On the fifth class day one-half of the subjects received the sauna bath warm-up of 180° F. for ten minutes prior to taking the vertical jump test. The rest of the subjects took the vertical jump test without participating in any warm-up. On the sixth class day the procedure was reversed, with the subjects who had received the warm-up on the previous testing day participating without the warm-up, and the subjects who had not received the warm-up on the fifth day took the vertical jump test after undergoing the sauna bath warm-up. The seventh class day was used to conduct the vertical jump test for any subjects who had missed either of the previous two days allotted to the test.

On the eighth class day, subjects took the zigzag run test. One-half of the subjects received the sauna bath warm-up prior to taking the test. The rest of the subjects took the test without warm-up. The ninth class day, the procedure was reversed, with the subjects who had taken the zigzag run test without warm-up on the eighth day participating after warm-up, and those subjects who had performed the test following warm-up on the eighth day were tested in the zigzag run without warm-up. The tenth class day was used to test subjects who had missed the test given on the eighth or ninth days.

The 440-yard run test was conducted on the eleventh day. The subjects ran in groups of 3, with 15 seconds being allowed between the starting of each individual subject. The twelfth day was used to conduct the second 440-yard run test. Those subjects who had run following the warm-up on the preceding day took the test without any warm-up and the subjects who participated without warm-up on the eleventh day took the test on the twelfth day following warm-up. On the thirteenth day, subjects who had missed the 440-yard run test on either of the two previous days were tested.

The final test conducted was the Thurstone Test of Mental Alertness. Due to the late arrival of the test and the Easter holidays, this test was first conducted on the twenty-second class day. Subjects were divided into two groups, A and B, with twenty-one in each group. Ten subjects in Group A took the Thurstone Test of Mental Alertness, Form A, after receiving the warm-up. The other eleven subjects in Group A took the Form A of the test without the warm-up. Eleven subjects in Group B took Form B of the test following warm-up, while the other ten subjects took Form B of the test without warm-up. The twenty-third day was used to conduct the second part of the Thurstone Test of Mental Alertness. The two Groups A and B remained the same. The ten subjects in Group A who had taken Form A of the test after warm-up on the previous test day took Form B of the test without warm-up. The other eleven subjects of Group A took Form B after

receiving the warm-up treatment. The eleven subjects in Group B who had taken Form B following a warm-up were administered Form A of the test without a warm-up. The remaining ten subjects in Group B took Form A of the test after receiving a warm-up treatment.

The Thurstone Test of Mental Alertness was conducted in a classroom following instructions concerning the test. Since all subjects took the test on the twenty-second and twenty-third class days, a make-up period on the twenty-fourth day was not necessary. Scores were obtained for each in the four areas of testing which included performances following warm-up and performances without warm-up. The scores were recorded on a chart containing the subject's name, test name, and with or without warm-up score space. An analysis of the collected data was done by the investigator with the aid of an adding machine.

Procedures for Treating the Data

Fisher's t test for significance of difference between the means of related samples was used to test the tenability of the four hypotheses for which comparisons were made between heat treatment exposure and no heat treatment on tests of leg power, agility, endurance, and mental alertness.

CHAPTER IV

RESULTS OF THE STUDY

It was the purpose of this study to examine the effect of a warm-up treatment of dry heat from a sauna bath upon a test of leg power, agility, endurance, and mental alertness. Data were collected from university male students enrolled in the required physical education weight training courses at Midwestern University. The subjects were tested twice each on the vertical jump test, zigzag run, 440-yard run, and the Thurstone Test of Mental Alertness. Each subject took the test following a warm-up treatment in the sauna bath and also without warm-up treatment. An analysis was performed on data obtained from the tests.

Statistical Technique of the Analysis

The Fisher's *t* test for significance of difference between the means of related samples was the statistical technique utilized. This statistical technique is used often in physical education research which involves before and after experiments. The data were collected from one population of paired differences. The formula for the *t* test for related samples was taken from the text by Weber and Lamb.[1]

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[1]Jerome C. Weber and David R. Lamb, Statistics and Research in Physical Education (St. Louis, 1970), pp. 99-100.

$$t \propto n-1 = \frac{\bar{d} - \mu d}{\frac{Sd}{\sqrt{n}}} = \frac{\sqrt{n}\ (\bar{d} - \mu d)}{Sd}$$

A t ratio of 2.018 was required for rejection of the null hypothesis at the .05 level of significance.

Findings Related to the Hypotheses

The t ratio for the significance of difference between the means in the vertical jump test without the heat treatment and the vertical jump test following the heat treatment is presented in Table I.

TABLE I

SUMS AND t RATIO FOR PERFORMANCE SCORES ON THE VERTICAL JUMP TEST (N = 42)

Treatment	Sums	t
Warm-up	4600.25"	1.24
No Warm-up	4585.75"	

Hypothesis I stated that exposure to heat treatment would significantly increase the performance of leg power, as measured by the "Sargent's Vertical Jump Test."

Calculation of the t ratio for the data collected from the vertical jump test yielded a ratio of 1.24, which was not statistically significant; therefore Hypothesis I was rejected.

The t ratio for the significance of difference between the means of the zigzag run without the heat treatment and the zigzag run following the heat treatment is presented in Table II.

TABLE II

SUMS AND t RATIO FOR PERFORMANCE SCORES ON THE ZIGZAG RUN (N = 42)

Treatment	Sums	t
Warm-up	1016.0 seconds	.351
No Warm-up	1018.7 seconds	

Hypothesis II stated that exposure to heat treatment would significantly increase the performance of agility as measured by the zigzag run.

Calculation of the t ratio for the data collected from the zigzag run yielded a ratio of .351 which was not statistically significant. Hypothesis II was not supported by the data and was therefore rejected.

Presented in Table III is the t ratio for the significance of difference between the means of the 440-yard run test following heat treatment and the 440-yard run test without heat treatment.

Hypothesis III stated that exposure to heat treatment would significantly increase the performance of endurance, as measured by the 440-yard run.

TABLE III

SUMS AND *t* RATIO FOR PERFORMANCE SCORES ON THE 440-YARD RUN TEST (N = 42)

Treatment	Sums	*t*
Warm-up	3080.7 seconds	2.163
No Warm-up	3027.4 seconds	

Calculation of the *t* ratio for the data collected from the 440-yard run yielded a ratio of 2.163, which was statistically significant at the .05 level of significance; however, improvement was in favor of the no-heat treatment and Hypothesis III was rejected.

The *t* ratio for the significance of difference between the means for the Thurstone Test of Mental Alertness, Forms A and B, is presented in Table IV for performance following the heat treatment and performance without the heat treatment.

TABLE IV

SUMS AND *t* RATIO FOR PERFORMANCE SCORES ON THE THURSTONE TEST OF MENTAL ALERTNESS (N = 42)

Treatment	Sums	*t*
Warm-up	2736 points	2.699
No Warm-up	2518 points	

A *t* ratio of 2.018 or more is required to denote a significant difference at the .05 level of significance.

Hypothesis IV stated that exposure to heat treatment would significantly increase the performance of mental alertness, as measured by the Thurstone Test of Mental Alertness.

Calculation of the t ratio for the data collected from the mental alertness test yielded a ratio of 2.699, which was statistically significant at the .05 level of significance; therefore Hypothesis IV was accepted.

An analysis of the data collected for the four tests revealed that the Thurstone Test of Mental Alertness was the only test in which heat treatment in the sauna bath significantly improved performance. The results in the vertical jump test and the zigzag run test indicated slight improvement in performance after the heat treatment, but this improvement was not statistically significant. The 440-yard run test results were significantly different, but in favor of the no-heat treatment.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The problem under consideration was a study of the effect of dry heat of 180° F. for ten minutes duration in a sauna bath upon test performance of leg power, agility, endurance, and mental alertness. Past research regarding various types of warm-up programs provided little agreement concerning the effect of warm-up upon performance. Only a limited number of studies have utilized heat from a sauna bath, and those studies did not use the performance tests included in this study. The purpose of this study was to examine the effect that heat from a sauna bath would have on the selected tests of leg power, agility, endurance, and mental alertness.

The following hypotheses were tested in this study:

I. Exposure to heat treatment will significantly increase the performance of leg power, as measured by the "Sargent's Vertical Jump Test."

II. Exposure to heat treatment will significantly increase the performance of agility, as measured by the zigzag run.

III. Exposure to heat treatment will significantly increase the performance of endurance, as measured by the 440-yard run.

IV. Exposure to heat treatment will significantly increase the performance of mental alertness, as measured by the Thurstone Mental Alertness Test.

The subjects involved in the study were enrolled in one of the two weight training and conditioning classes offered during the 1970 spring semester at Midwestern University. A total of forty-eight subjects volunteered to participate in the study, with forty-two of the subjects completing all of the tests. The study was designed to allow each subject to be tested twice for the test of leg power, agility, endurance, and mental alertness. One test experience followed heat treatment in the sauna bath and the other test experience was conducted without any type of warm-up prior to testing. A total of eight test performances were recorded for each subject.

The analysis of the data for the tests revealed that the vertical jump and the zigzag run had slight improvement, but was not statistically significant. The 440-yard run test for endurance had a significant difference in favor of the no-heat treatment, while the test of mental alertness did have a significantly improved performance in favor of the heat treatment. All of the test results were analyzed

by using Fisher's t test for the significance of difference between the means of related samples.

Findings

1. The sauna bath heat treatment did not significantly improve the performance in the vertical jump test when compared with the performance completed without any heat treatment.

2. The sauna bath heat treatment did not significantly improve the performance in the zigzag run when compared with the performance completed without any heat treatment.

3. The sauna bath heat treatment did not significantly improve the performance in the 440-yard run; in fact, a significant difference was obtained in favor of the no-heat treatment.

4. A significant improvement following the sauna bath heat treatment was obtained on mental alertness, as compared with the mental alertness performance completed without any heat treatment.

Conclusions

1. Heat treatment does not cause great improvement in leg power.

2. Heat treatment does not cause great improvement in agility.

3. Heat treatment causes slower performance times in encurance runs as compared with endurance runs completed without heat treatment.

4. Heat treatment causes an improvement in mental alertness test performance when compared with mental alertness performances completed without heat treatment.

Recommendations

1. When mental alertness is the primary factor in performance tasks, it is recommended that the sauna bath be used for heat treatment prior to the performance.

2. Further studies should be conducted using various time limits and temperatures for tests of power, agility, endurance, and mental alertness for skilled and non-skilled performers.

3. Psychological factors which might influence studies of this type need to be determined and a method of control established.

4. The relationship between mental alertness and physical performances should be investigated in greater depth.

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