Chapter II

REVIEW OF RELATED LITERATURE

The research scholar had gone through all the relevant literatures which were available to him. In this respect, the library of Lakshmibai National College of Physical Education, Gwalior, INDIA had contributed the maximum share. The reviews of some of the relevant studies are presented in this chapter.

The effects of general warming up, massage, and stretching on ranges of motion (ROM) and strength of quadriceps and hamstring muscles were measured by Wiktorsson - Möller, et.al. in eight male volunteers. High muscle strength was not influenced by the experiment procedures. Stretching resulted in a significantly increased range of hip flexion/extension, hip abduction, knee flexion, and ankle dorsiflexions, the effect was significantly greater than that obtained by massage and warming-up separately or combined. Only ankle dorsiflexion was influenced by massage or warming-up, whereas stretching affected all muscle groups tested. Stretching was, therefore, superior to the other methods tested for increasing flexibility in the lower extremity.

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Blöhm\(^2\) compared mean of one-mile for no warm-up, warm-up followed by a 6-min. rest, warm-up followed by a 14-min. rest, and warm-up followed by a 22-min. rest. Eleven varsity cross-country runners were subjects. Results showed significant differences between no warm-up and both the 6-min. and 14-min. rest intervals. Performances following the 14-min. rest interval were significantly better than following the 22-min. rest interval.

McClellon\(^3\) conducted a study on the effects of a pre-exercise cold shower condition upon heart rates during exercise. Thirty SHS basketball players were exposed to 3 pre-exercise conditions: control (5-min. of rest), shower (5-min. of cold shower), and exercise shower (running in place until heart rate exceeded 140, then 5-min. of cold shower). Each of the 3 pre-exercise conditions was followed by a 10-min. ride on the bicycle ergometer with gradually increasing work load. Heart rate was monitored and recorded during the last 30 sec. of each minute. Conclusions were that heart rate prior to exercise was significantly decreased by either the cold shower or exercise-shower condition, with no significant difference found between shower and exercise-shower conditions.


Scogin\textsuperscript{4} used ten college varsity swimmers to compare mean time for swimming 100 yds, using the crawl stroke following 7 conditions of warm-up: no warm-up, moderate warm-up with a 2-min. rest interval, moderate warm-up with 15-min. rest, moderate warm-up with a 30-min. rest, heavy warm-up with a 2-min. rest, heavy warm-up with a 15-min. rest, and heavy warm-up with a 30-min. rest interval. No significant difference in swimming performance was noted when preceded by no warm-up or by any of the moderate or heavy warm-up conditions.

The purpose of Kracik's\textsuperscript{5} study was to ascertain the effects on bat speed of swinging a regular bat, swinging a weighted bat, stretching exercises and calisthenics, and no preliminary activity. The 27 subjects, SHS varsity baseball players were arbitrarily placed into 3 groups and were informed of the time of testing. A pilot study was conducted utilizing a test-retest method, to determine the bat speed test reliability. A single factor ANOVA with repeated measures design, used to determine any significant differences in bat speed due to the selected preliminary activities, yielded a nonsignificant F.


Wolfe\textsuperscript{6} took up a study on activation as a factor in warm-up decrement. Thirty eight subjects performed 70 trials on a discrete motor task involving speed of limb movement. Five-minute rest periods were interpolated between trials 30-31, 40-41, 50-51, and 60-61. Just prior to each post-rest performance S received 0,15,30, or 60 sec. (in a balanced order) of squeezing a hand dynamometer with the left hand at 1/4 maximum tension. Initial performance increased rapidly for about 20 trials, where the slope appeared to start levelling off. Warm-up was exhibited on Trial 61. Although the 60-sec. treatment means were generally lower than the other 3 treatment means, all the between treatment F's were non-significant, indicating that activation was not a factor in warm-up decrement.

Creek\textsuperscript{7} in his study randomly assigned seventy-four inexperienced softball players of two groups. One group used a regulation softball for warm-up prior to throwing; the other used a weighted softball for warm-up. Accuracy of throwing was measured in 10 throws at a rectangular target. Warm-up with a weighted softball had an adverse effect upon accuracy, although with repeated tests this effect appeared to diminish, leading to the possible conclusion that inexperience in throwing a softball might be related to the adverse effect of overload warm-up.


\textsuperscript{7}Donald Engene Creek, "The Effect of Overload Warm-up on the Accuracy of Throwing a Twelve - Inch Softball," Completed Research in Health, Physical Education and Recreation 7 (1965): 47.
Three varsity and three freshmen members of the State University of Iowa Track Squad served as subjects in Fremodt's study. Each subject ran a distance of 440 yds., after no warm-up, a 10 minute warm-up, and a 5-min. warm-up. After running, each subject walked and jogged for 20-minute and then ran another 440 yds. Each subject was tested three times for each procedure. No significant relationship was found between the time required for a 440 - yard run and the three procedures used before each run.

Two classes of grade 7 and 8 boys at St. Genevieve Missouri (N = 59), with about equal mean in the AAHPER Youth Fitness Test, were used by Webb as subjects. One class, determined by tossing a coin, had 5-min. of related warm-up and 35 min. instruction and practice in softball, touch football, and basketball. The other class had 15 min. of strenuous calisthenic exercise and 25 min. in the activities. Each activity lasted four weeks and 10 class periods were followed by skill and knowledge tests. The group using 15 min. of strenuous warm-up gained significantly in fitness at the .05 level, the group using 5 min. of selected warm-up did not gain significantly in fitness. The skill and knowledge test achievements were essentially equal. Students ranking high in fitness tended to rank

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8Hanson Cary Fremodt, "Relationship of Different Types of Warm-up to Performance in the 440- yard Run," Completed Research in Health, Physical Education and Recreation 2 (1960): 43.

high in intelligence and those ranking high in fitness and intelligence tended to do better in the skill and knowledge tests. The 15-min. strenuous calisthenic warm-up seemed preferable to the 5-min. related warm-up, since physical fitness improved significantly with no loss of skill or knowledge.

Two equated teams were selected from 20 boys in Grades VI through VIII at Horace Mann Elementary School in Beverly Hills by Williamson. The team alternated in having 15 swings/player in batting practice and no batting practice before the regulation 7-inning game. The individual batting averages ranged from .250 to .519 with batting warm-up and from .150 to .519 without. One team batting average was .413 with practice and .258 without, a reduction of .155. The other team had a reduction of .094, going from .381 with practice to .282 without. The differences were significant in favour of warm-up and suggested that warm-up procedure was justified.

Glidewell assessed junior high school boys (24) subjected to the following warm-up conditions to determine the effects on speed of reaction, speed of movement, strength, and power of the leg muscles: no warm-up, 10-min. rest period prior to testing, passive warm-up of 20 mins. period with legs between two electric blankets, cooling 10 mins. period.


with legs enclosed in two bags; overload warm-up exercise performed while wearing weight vest and leg weights. A treatment by subject analysis of variance revealed no pattern of differences except that performance on most tests was significantly lower after cooling the muscles than after other treatments. A tabular analysis suggested that warm-up was an individual matter since some subjects performed consistently better with a certain type of warm-up.

Smith's\textsuperscript{12} study was to determine the effect on speed in running of various techniques (body temperature showers, 110° F. Showers, and formal warm-up procedure) on twenty subjects. No statistically significant differences were found between the mean time required to run five yards at maximum speed (after running 30 yards) without warm-up and the mean time required to run the same distance after the use of the three warm-up procedures.

With 10 experienced graduate subjects, Pachec\textsuperscript{13} studied warm-up effects on vertical jump performance. The warm-up methods were isometric stretching of leg and hip muscles, stationary running, and deep knee bends, compared with control conditions (no warm-up), performances were improved by all three warm-ups; increases in


centimeters over the control were 3.35 for stationary running (7.80%),
2.14 for stretching (4.99%), and 1.24 for knee bends (2.88%). The results
of this experiment were verified by the investigator with 50 college men
as subjects.

Dykstra, Boilean and Misner\textsuperscript{14} examined the effectiveness of
inactivity and several levels of recovery exercises in removing blood lactate
following a strenuous but submaximal exercise stress. The rate of blood
lactic acid removal at five different recovery workloads and the maximal
oxygen consumption (VO\textsubscript{2} max.) were determined in three subjects on the
bicycle ergometer. During each of the five duplicated recovery tests
performed by each subject, an eight-minute stress at approximately 90%
VO\textsubscript{2} max. was followed by a twenty-minute period in which the subject
recovered at one of the following exercise levels: rest 25%, 40%, 55%
and 70% of the VO\textsubscript{2} max. Blood samples were taken from a pre-warmed
fingertip at five-minute intervals during the recovery period. Additionally,
oxygen intake and heart rate were determined periodically and the mecha-
nical work performed was monitored continuously in both the initial 90%
exercise stress and the selected recovery conditions. The slope of the line
relating the lag of the five lactic acid concentrations to time for each of
the five recovery workloads was compared to steady state heart rate,
steady rate VO\textsubscript{2} and mechanical work done during recovery. The results

\textsuperscript{14}Gregory L. Dykstra, Richard A. Boilean, and James E. Misner,
"Effect of Selected Warm-Down Work Levels on Blood Lactate Removal,"
obtained indicate that the disappearance of lactic acid was most rapid when the subject recovered within the following ranges: heart rates between 110 and 140, oxygen consumption at rates corresponding to between 25% and 47% of the VO₂ max., and recovery workloads between 410 and 725 KPM/min. This study suggested that active recovery at a moderate exercise level, rather than passive recovery most effectively reduced lactic acid in the blood, and therefore optioning the warm down effect.

Carter administered on fifteen subjects, ride to exhaustion at 15 mph, with 7.5 pounds’ resistance on a bicycle ergometer after no warm-up, one minute of warm-up, and five minutes of warm-up and two minutes' rest. The mean difference in duration of performance was not significant at the 5 percent level between one minute and five-minute warm-ups. No warm-up and a one-minute warm-up were significantly superior to five minutes of warm-up. Five minutes warm-up at 10 mph with no load appeared determined. Also, body weight appeared related to performance but was controlled experimentally.

Improved performance in selected athletic skills may result from the use of the proper warm-up procedure. It seems likely that this warm-up procedure must be of sufficient duration and intensity to bring about circulatory and temperature changes. No evidence was found by

de Vries, that the resistance offered by muscles antagonistic to the prime movers in motor performance can be reduced through preliminary stretching and for relaxing techniques to an extent which will result in measurable improvement of subsequent motor performance.

Thirty male volunteers who served at their own controls were subjected to body cooling followed by exercises ranging from moderate to strenuous in Hoogendoorn’s study. Reaction time of selected large and small muscle groups was measured after each condition. No significant differences in reaction time were found to result from any of the conditions employed, even exercise of an exhaustive nature.

After three months’ intensive training and conditioning, Twandowski studied the effect of warm-up upon 100-yd. swimming performance. 25 college, varsity and freshmen swimming team members swam 265 time-trials using the crawl stroke, after each of the following four warm-up procedures: formal calisthenics and swimming, hot shower

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at 105°F, for 4 minutes, and no warm-up (control). The mean time after formal warm-up was significantly faster than after the other three conditions. The mean time after no warm-up was significantly faster than after the hot shower and whirlpool bath.

In the study of Baumgarten\textsuperscript{19} forty college freshmen women took 3 trials on the Minnesota Manual Dexterity Test to measure speed of arm movements after each of 4 warm-up conditions. Performance following formal warm-up and general related warm-up were significantly faster than after no warm-up, and formal warm-up was significantly better than general calisthenic warm-up.

Eighty 16-year old girls were divided into four groups by Richards\textsuperscript{20} and given respectively one, two, four, and six minutes of stool stepping (25 steps per minute on a $15\frac{1}{2}$ inch stool) as a warm-up preceding a 6-trial vertical jump test. A test-retest balanced order design was employed to exclude the practice effect. The results showed that one or two minutes of stool stepping improved vertical jump height by approximately 20 per cent, while four minutes of stepping had no effect and six minute improved performance by 27 per cent.


Fanning studied the physiological effects of warm-up and varying rest intervals following warm-up on the running performance of trained endurance runners. The subjects used in this study were thirty three male trained endurance runners varying in age from seventeen to twenty-nine years. The results of the study were: (i) Warm-up followed by a six-minute and twelve-minute rest intervals produced a significantly superior endurance performance when compared with non warm-up, warm-up followed by either one or three minutes of rest. (ii) Six or twelve minutes of rest was location of optimum rest interval for this study. (iii) Most superior performances in time and physiological efficiency of cardiac output were run under warm-up following either six or twelve minutes of rest. (iv) Most detrimental performances in time and physiological efficiency of cardiac output were run under warm-up followed by one minute of rest. (v) There was no significant difference between no warm-up and warm-up followed by three minutes rest interval. (vi) Non warm-up condition produced superior performance levels when compared with warm-up followed by one minute of rest.

Bissell conducted a study to determine what effect, if any,

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22 Franklin Gene Bissell, "The Effects of No Warm-up, Skill Warm-up and Calisthenic Warm-up on Selected Football Skills, Agility and Speed," Dissertation Abstracts International 34 (December 1973): 3113-A.
selected warm-up regimens have on certain football skills and selected
motor fitness components that are associated with the game of football.
Specifically, the investigator wanted to discover the effect of no warm-up,
a skill warm-up, and a calisthenic warm-up on the football pass for
distance, the football punt for distance, football pass for accuracy, the
dodge run as a measure of agility, the 50-yd. dash as a measure of
speed, and football pass catching. The subjects were male under-graduate
students of Kansas Wesleyan, Salina, Kansas, who volunteered to be part
of the study. It was concluded that all groups improved in performance
on the criterion measure, except the control group in the football catches.
This suggests that learning was taking place, regardless of treatment.
In general the skill group performed better than the control or calisthenic
groups. There was no warm-up technique that was unique to all criterion
measures.

Murray’s study investigated the activity - set hypothesis in
reducing warm-up decrement (WUD). The hypothesis predicts that WUD,
which is a temporary loss of skill performance following rest, could be
reduced if an appropriate reinstating activity were engaged in just prior
to the resumption of practice. Seventy-five male volunteer under-graduates
from the University of Maryland were tested, in order to test the

 Joseph Francis Murray, "The Activity-Set Hypothesis for
Warm-up Decrement in a Movement Balance Task," Dissertation Abstracts
prediction of the activity - set hypothesis warm-up decrement was measured by computing the differences between the first post-rest trial and the last pre-rest trial (single trial method). Later it was concluded that the activity-set hypothesis that practising a task of the same class as the criterion task immediately prior to the resumption of the criterion task should reinstate the prior activity set causing a reduction in WUD was supported. Although significant differences occurred at the .05 level of confidence, the investigator had reason to suspect the result in that when plotting the mean scores of the three experimental groups, some indication surfaced supporting the possibility that the groups might have been different. Further, the investigator realized that other methods of computing and interpreting WUD might have resulted in drawing different conclusions.

Lichtman investigated the effect of pre-task speed training upon warm-up decrement and skill acquisition on the pursuit rotor tracking followed in equilateral triangular path in a clockwise direction. Fourteen right handed female volunteer subjects were randomly assigned to one of the following groups, 30-45, 45-45, 60-45, 60-60, 60-75, 75-75 or 90-75. Each number refers to the RPM at which subjects trained during the first and second days respectively. Multivariate analysis of

variance on trial scores for performance on the second day of training indicated that the 60-45 speed training group, however, skill levels for the 45-45 group and 30-45 treatment were comparable. However, subjects who tracked at 75 RPM on the second day performed at equivalent levels regardless of the speed worked during the first training day. Scores for blocks of trials performed at the criterion speed of 60 RPM during testing indicated the 75-75 and 90-75 treatments showed inferior performance when compared to the 60-60 per-task speed training groups, while the remaining groups performed at a level similar to that displayed by the 60-60 treatment.

Brown attempted to determine the effects of three intensity levels of warm-up on the reaction time and speed of movement in the baseball swing. Thirty male college students, members of Indiana University's varsity and junior varsity Baseball teams, served as subjects for their investigation. Their ages ranged from 18-22 years with a mean age of 20. There were three intensity levels of warm-up (No warm-up, Regular warm-up and overload warm-up) in which all 30 subjects participated; they were given in a random order. Each subject took one treatment per day following a day of orientation. Ten trials were given for each treatment and the mean of these trials was used as the criterion score. The conclusions drawn were:

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1. Warm-up significantly improves speed of movement in the baseball swing, however, it appears to have had no effect on the reaction time or response time of the baseball swing.

2. No difference exists between the use of regular and overload warm-up procedures as they are related to speed of movement in the baseball swing.

3. Warm-up is of benefit to a performer in increasing the speed movement of the baseball swing.

4. Reaction time and speed of movement are independent of each other in the baseball swing.

The study of Schwarzkopf\textsuperscript{26} was to: (i) gain knowledge of physiological responses to gymnastic performance, and (ii) explore relationship between the MVO\textsubscript{2} of gymnasts and selected parameters.

Three trained ring specialists and nine untrained college students acted as subjects. Oxygen consumption and heart rate were measured for a ten-minute exercise - recovery period from the start of a standardized ring routine (differing for each group) lasting slightly over thirty seconds.

\textsuperscript{26}Robert James Schwarzkopf, "Oxygen Consumption and Heart Rate Changes of Two Gymnastic Ring Routines due to Warm-up, Training and Fatigue," \textit{Dissertation Abstracts International} 33 (October 1972): 1494-A.
For the trained group, a related warm-up resulted in the lowest group mean oxygen consumption. Heart rates were lowest following the no warm-up treatment. Training did not produce a trend in either heart rate or oxygen consumption. Increases in oxygen consumption and heart rate from succeeding repetitions of the test routine within a test session suggested the presence of fatigue. No relationships were found between the MVO₂ of the trained subjects and the selected parameters.

For the untrained group warm-up was effective in decreasing oxygen consumptions. A downward trend in oxygen consumption over the training period was found but a consistent decrease in heart rate did not happen.

Efficiency of performance was computed from cinematographic analysis of vertical movement of the centre of gravity and oxygen consumption. Efficiencies were found to be low (3.76 per cent training, 3.36 per cent untrained) in comparison to locomotor activities.

The primary purpose of Simon's study was to determine the effects of mild and strenuous warm-up exercise on cardiac response to strenuous exercise. A secondary purpose was to investigate the effects of mild and strenuous warm-up on recovery from strenuous exercise.

Fifty physically fit male subjects participated in the study. The findings of the study were as follows:

1. Significant differences were found among the three pre-exercise conditions for times required to reach heart rate of 125, 150, and 175 beats per minute, as the strenuousness of the pre-exercise condition increased the times required to reach the designated heart rates decreased.

2. The pre-exercise condition that consumed less total performance time also required less time in recovery.

3. Regression of pre-exercise conditions and time in seconds required to reach the designated heart rates was significantly linear, in that the strenuousness of the warm-up and time required to reach the heart rates was inversely proportional.

Within the limits of this study the following conclusions were made:

1. Pre-exercise activity significantly affects the rate at which the heart rate increases during exercise in that the higher the heart rate is raised during warm-up the faster the heart rate will increase during the performance.

2. Since the time required for recovery related to the length of exercise the amount of warm-up should be considered in the total amount of energy expenditure for the event to be performed.

3. There appears to be slight overall relationship between starting resting heart rate and recovery rate following exercise. However, the
relationship is too low for prediction purpose.

The purposes of Thompson's²⁸ study were (i) to determine the effects of warm-up: specific warm-up, general warm-up consisting of stretching type exercises and general warm-up in the form of warm showers, upon the performance of speed, endurance, agility, and power and (ii) to ascertain if there was any significant differences between performance, scores of speed, endurance, agility and power under different warm-up conditions. Forty-four male college students ranging from 17 to 25 years of age were used as subjects for this study. These subjects were tested on the side-steps test for agility, the mile run for endurance, the 40-yard dash for speed, and standing broad jump for power based upon the findings and within the limitations of this study, the following may be concluded:

1. There was no overall significance found between the different types of warm-up on the combined performance test of speed, agility, power and endurance.

2. Differences between the performance tests were not significant independently of the four types of warm-up consisting of no warm-up, specific warm-up, general warm-up in the form of stretching type exercises, and general warm-up in the form of warm showers.

3. The combined effects of the performance tests and the different types of warm-ups were significant at the .01 level. This indicated that the combined effect of certain performance tests and warm-up types produced significant changes in performance.

Five trials per day on the Jump and Reach test were given by Pacheco to 166 girls of grades VIII and IX to determine if performance was improved by three minutes of vigorous running in place as a warm-up exercise. A balanced order test-retest experimental design was used, with the warm-up administered on Day 1 for half the subjects and on Day 2 for the others. A significant improvement of 4.83 percent was observed, caused by the warm-up. A practice effect caused the Day 2 scores to average 6.51 per cent higher than the Day 1 scores. There was also a significant improvement from practice, from trial to trial within each day. The average test-retest reliability coefficient was \( r = .868 \). There were indications that reliability could be improved by averaging the scores obtained on several days but could not be improved very much by giving more trials in a single day test. Ninth grade girls averaged 13.4 per cent higher in their jumps than eighth grade girls. The larger practice effect needs consideration in the interpretation of norms.

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The purpose of Mathews and Snyder's\textsuperscript{30} study was to determine if physical warm-up affects the running time of high school boys participating in the 440-yard dash. A secondary problem was to record injuries, if any, sustained during the experimental period. The study involved 50 pupils over a four-week period. Within the limitations of the study, the following results were apparent: (i) Warm-up prior to performing the 440-yard dash did not significantly improve the time over running the same distance without a preliminary warm-up, and (ii) no injuries were observed or reported during the testing period.

Other studies of Lotter's\textsuperscript{31} had shown a three component exponential fatigue curve can be used to compute speed on a function of elapsed time in running. The present investigation showed that this type of curve described accurately the initial build-up in rate of arm-shoulder movements and subsequent drop-off from fatigue in a four-minute test and retest of twenty college men. Warm-up preceding one of the tests was found to have no influence. One test period causes a practical effect of 2.7 percent, chiefly in the first third of the curve. Test-retest reliability was low (\( r = .51 \)) for the first five seconds of performance. For each third of the total test it was fairly high, ranging from .82 to .87.


\textsuperscript{31}Willand S. Lotter, "Effects of Fatigue and Warm-up on Speed of Arm Movements," \textit{Research Quarterly} 30 (March 1959): 57-65.
The purpose of De Vries's study was to determine the values that can be ascribed to the warm-up procedures customarily employed by competitive swimmers (hot showers, calisthenics, massage, and swimming). Thirteen subjects swam a total of 195 time-trials. Each swimmer swam three 100-yard time-trials with no warm-up and three time-trials after each of the four warm-up procedures. The group as a whole showed significant improvement only following the swimming warm-up, whereas the breast stroke and dolphin swimmers as a group had their best and significant decrease in speed in their trials after calisthenic warm-up.

The effect of preliminary heating by eight-minute hot showers was investigated by Carlile in a group of male swimmers who made more than 400 trial swims. There was an improvement of one percent in comparison with trials without preliminary heating. The difference in performance was statistically highly significant. Evidence has presented that the improvement could not be explained psychologically as the result of suggestion. Practical applications to the athlete of passive warming are considered.

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The purpose of Michael, Skubic and Rochelle's\textsuperscript{34} study was to investigate the effects of related and unrelated warm-ups on the distance a 12-inch softball could be thrown. The subjects, 77 college men, threw three softballs for distance with no preliminary warm-up, with a preliminary five-minute related throwing warm-up and with a preliminary five-minute non-related general warm-up. The results showed that both types of warm-up resulted in significantly longer throws. There was no significant difference between the various types of warm-up and no significant warm-up effect was demonstrated between trials 1 and 3 on a particular day of testing. The time spent and the strenuousness of the warm-up appeared to be the factors involved in improving the distance the balls were thrown.

Observations were made by Massey, Johnson, and Kramer\textsuperscript{35} on 15 male subjects riding a bicycle ergometer 100 revolutions against time after two conditions; warm-up by means of over-all bodily activity for a period of ten minutes and no warm-up. The subjects were tested four times, two times following each condition. The subjects were in a deep hypnotic state prior to all testing and when tested they had no conscious awareness of whether they had warmed up. Performances after the two

\textsuperscript{34}Ernest Michael, Vera Skubic and Rene Rochelle, "Effect of Warm-up on Softball Throw for Distance," Research Quarterly 28 (December 1957): 357-363.

conditions were about the same with the rate of pedaling slightly slower
following warm-up. The differences in mean performance were not
statistically significant. There was no evidence of muscle strain or injury
resulting from performance without warm-up.

Rochelle, Skubic and Michael\textsuperscript{36} conducted a study on performance
as affected by incentive and preliminary warm-up. Forty six male students
ages 18 to 22 years, were exposed to softball throw for distance, without
warm-up and with a 5-minute related warm-up preceding throwing. The
subjects were divided into two groups with the sequence of warm-up and no
warm-up alternated on different days in order to reduce the possibility of
practice effect, learning, or other unforeseen factors. Three throws for
maximum distance were allowed for each testing period. In an attempt
to rule out the possible psychological effects of not making maximum
throw without preliminary warm-up, the subject was given a monetary
reward for each throw greater than his established average. A significant
difference at the 1 percent level of probability was found between trials
when throwing was preceded by a warm-up. Despite the significant
increase in the distance between trials 1 and 3 when no warm-up preceded
throwing, subjects threw on the average $10.2 \pm 1.65$ feet farther when
throws were preceded by a 5-minute related warm-up. This difference
was significant at the 1 percent level of probability.

\textsuperscript{36}R.H. Rochelle, Vera Skubic, and E.D. Michael, "Performance
as Affected by Incentive and Preliminary Warm-up," \textit{Research Quarterly}
Pyke's\textsuperscript{37} study assessed the effect of five selected treatments of preliminary activity on performance in 60-yard dash, the cricket ball throw for distance, the jump reach, and the bicycle ergometer test of leg speed. The effect of such preliminary activity, at different levels of achievement in the same performance tests, was also investigated. An experimental sample of 15 to 17 years old school boys (\(N = 45\)) underwent a testing programme involving four consecutive days, with two sessions daily. On the basis of measures of pretreatment status, the subjects were matched into groups and subsequently exposed to the treatments. The treatments included identical maximal, identical submaximal, general strengthening, general flexibility and control routines. The statistical analysis of the results involved analysis of variance techniques. There was no evidence available indicating either that the treatments had an effect on the chosen motor performances or that there was a difference in this response at certain levels of achievement. As no measures of physiological function were taken, an assessment of the likely reasons for these findings could not be made.

Skubic and Hodgkins\textsuperscript{38} assessed three groups of women physical education, totaling 31 students, participated in a series of tests to


\textsuperscript{38} Vira Skubic and Jean Hodgkins, "Effect of Warm-up Activities on Speed, Strength, and Accuracy," \textit{Research Quarterly} 28 (May 1957): 147-152.
determine the effects of light warm-up activities on speed, strength, and accuracy. The tests used in the study were (i) Speed - a ride of one-tenth of a mile on a bicycle ergometer, (ii) Strength - the maximum distance a subject could throw a softball and (iii) Accuracy - the number of successful basketball free-throws a subject could score in ten trials. The data were analyzed in terms of the above tests, each of which were performed when preceded by no warming-up, by a general warm-up, and by a warm-up related to the test activity. A total of 360 usable tests were recorded. The results indicated that there were no significant differences in the scores made in relation to the three types of warm-up procedures. Also, no injuries or soreness were reported during the testing period.

The effect of passive heating on (a) muscular strength (elbow-flexion) and (b) collar endurance (grip) was investigated by Sedgwick and Whalen\(^\text{39}\), on 20 and 6 subjects respectively. Short-wave diathermy was the source of heat and the resulting temperature changes were recorded with thermoneedle. Heating was shown to decrease strength by .5 lb., and to have no effect on endurance.

Five groups of subjects were tested by Thompson\(^\text{40}\) to determine


if warm-up affected performance in speed and endurance in swimming, accuracy in basketball foul shooting, accuracy in bowling, speed and accuracy in typing, and strength of softball players. No evidence was found of improvement from informal warm-up immediately preceding testing in swimming, typing, or strength. Formal warm-up did improve group performance in speed and endurance in swimming, accuracy in basketball foul shooting, and accuracy in bowling, however, no significant difference was noted in the performance of the typists after participating in the formal warm-up prior to the testing.

In the study of Murray[^41^] 75 male volunteers were divided into 1 of 3 groups and given 20, 20 sec. pre-practice training bouts on a stabilometer immediately prior to testing, followed by a period of rest. Immediately following rest, subjects in each group were given 10, 20 sec. tests on the stabilometer, and then either rested, rested and then performed an interpolated task for the activity-set hypothesis, or rested and performed an interpolated task for the activation hypothesis. Subjects were then rested on the stabilometer for an additional 6 trials. It was concluded that the activity-set hypothesis was effective in reducing warm-up decrement (WUD) and that activation was not a factor. In addition, the prediction was supported that the activity-set hypothesis that practising a task of

the same class as the criterion task immediately prior to the resumption of the criterion task should reinstate the proper activity-set, causing a reduction in WUD.

Wrisberg\textsuperscript{42} conducted a study on interference and warm-up factors in motor short-term memory. One hundred eighty four subjects were used in two experiments to investigate the influence of interference and warm-up factors in motor short-term memory. It was predicted that an appropriate opposite-hand warm-up should reduce short-term retention loss in the recall of a criterion position if (a) the warm-up activity was of the same response class (e.g., one class of response may emphasize speed while another requires precision and training) as the criterion, and (b) the warm-up was performed immediately prior to presentation of the criterion position.

Phillips\textsuperscript{43} studied the influence of Fatiguing Warm-up Exercises on speed of movement and reaction latency. Related warm-up exercises of moderate intensity failed to improve arm speed in a large muscle criterion movement, while heavy but non-related warm-up exercises did improve the speed by 16 per cent. Three groups, each consisting of 25 male

\textsuperscript{42}Geig Alan Wrisberg, "Interference and Warm-up Factors in Motor Short-Term Memory," \textit{Dissertation Abstracts International} 35 (May 1975): 7110-A.

college students, were measured under both test and control conditions. Neither of the warm-up exercises influenced reaction latency. The correlation between RT and MT scores was non-significant ($r = .17$). For the heavy exercise (stool stepping), highly reliable individual differences were observed in stepping rate drop-off before fatigue ($r = .93$) and after 37 per cent fatigue ($r = .98$), but the two types of drop-off scores were not significantly correlated ($r = -.24$). In the arm action warm-up exercises, the correlation between initial rate of movement and rate of 24 per cent fatigue was non-significant ($r = .08$).

The purpose of Hardoge's\textsuperscript{44} study was to investigate the effect of warm-up upon performance in running, jumping and throwing activities using lack of experience and age to control the psychological variable. This study utilized ninety seven third grade boys and girls to examine the physiological effect of a selected warm-up treatment on performance of the fifty yard dash, the standing long jump, and the softball throw. A rational group design was used in this study, allowing each subject to be exposed to each experimental condition on equal number of times. The warm-up treatment selected for this study was 220-yard dash at maximum speed.

\textsuperscript{44} Billy Dean Hardoge, "Effects of Warm-up on Running, Jumping and Throwing activities using Age and Lack of Experience to Control the Physiological Variable," Dissertation Abstracts International \textit{34} (March 1974): 5688-A.
The results of this study showed that performance in standing long jump, softball throw and fifty yard dash improved significantly after experiencing the prescribed warm-up treatment. It was concluded that the performance on the long jump, on the softball throw for distance and on fifty yard dash, students on third grade, was significantly better following the prescribed warm-up procedure than when no warm-up was experienced prior to performance.

Morehouse and Miller\textsuperscript{45} claim "Performance is improved if the muscles have been slightly warmed up just before the activity." The contraction of isolated muscles provides a clue to the nature of the warming up process.

Karpovich\textsuperscript{46} stated that after administering hundreds of tests in his laboratory over the past 10 years, some with, but most without warming-up "No difference in endurance in treadmill running was observed," and that after administering over a thousand tests requiring maximum exertion in cold condition. Except for temporary soreness not much injuries have occured.


\textsuperscript{46} P. Karpovich, \textit{Physiology of Muscular Activity} (Philadelphia: W.B. Saunders Co. 1966), p. 76.