Chapter II

REVIEW OF RELATED LITERATURE

A review of literature relating to effect of training on physical, motor and physiological variables as well as on performance in various sports and games, as the scholar could glean from the library of the Lakshmibai National College of Physical Education, Gwalior is presented in abstracts in this chapter to provide the variable background material for this study.

Effect of Training and Conditioning on Physical and Physiological Variables

The purpose of the Amusa and Sohi's\(^\dagger\) study was to examine the changes in muscular strength, muscular endurance, muscular power, speed, agility, cardio-respiratory endurance and body composition in college age soccer players following a twenty weeks training. The study concluded that all the muscular, speed, agility and cardio-respiratory endurance improved significantly, whereas a reduction in fat percentage was also seen.

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Myers\(^2\) examined and compared the effect of training highly conditioned varsity soccer players on running circuits of 1.86 degrees downhill and zero degree during a competitive season. The specific questions with which this study was concerned were the effects of downhill and level circuits on a varsity soccer players' maximum running speed, stride length, stride frequency and leg strength. After a five weeks of training the study concluded that:

1. The downhill methods of training significantly improved the stride length of the varsity soccer players.

2. The downhill method of training can be effectively used as a supplementary sprint training method.

3. The downhill methods of training did not significantly increase running speed and stride frequency.

Mazumder\(^3\) studied the changes in motor fitness component and playing ability resulting among soccer players at two stages of physical education and conditioning

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programme. He concluded that: (i) During the first stage of physical education and conditioning programme speed, maximum leg strength, agility and playing ability was improved. (ii) During second stage only maximum leg strength and agility improved significantly. (iii) The break in between the stages of training diminished the improvement of playing ability, maximum leg strength and agility. The speed was unaffected. (iv) The total year's of physical education and conditioning programme was proved to be of value in improving motor fitness component and playing ability.

Abraham investigated the effect of 6-weeks training programme on selected physiological variables (haemoglobin, pulse-rate, vital capacity, cardio-vascular endurance and peak expiratory flow rate) of professional college students. The data was collected before and after the experiment and analysed with the help of 't' test. The study concluded that cardio-vascular endurance and peak flow rate was improved due to training. There was a significant reduction in resting pulse-rate of the subjects and there were no significant changes in haemoglobin

content and vital capacity after 6-weeks of training.

Popli\(^5\) compared the effects of physical conditioning programme of the physiological variables of vegetarians and non-vegetarians. The subjects were 32 boys of the age group of 13-14 years. Before and after the 8-weeks of conditioning programme was administered the selected physiological variables (haemoglobin content, resting blood pressure and resting pulse rate) of the subjects were measured. After the collected data was analysed using 't' test, the study concluded that all the selected physiological variables of both the group improved significantly through a programme of physical conditioning but no group was found superior to each other as far as the physiological variables are concerned.

Pohlman\(^6\) determined the effects of a seven week isokinetic strength and endurance training programme on untrained females aged 20 to 34 years. Body composition, maximal oxygen consumption and power were assessed at

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\(^6\) Roberta Louise Pohlman, "Physiological Adaptations to Strength and Endurance Training," Dissertation Abstracts International 43 (February 1982): 2597-A.
pre and post-training for three exercising groups.

Maximal oxygen consumption significantly increased 21% to 15% in the strength - endurance group and endurance group, respectively. Power values for the strength endurance group decreased for the left leg extension, for both legs combined and when expressed relatively to total body weight. The strength group demonstrated numerous power increases. Other changes in physiological parameters were not significant for the various groups. No changes were recorded in body composition variables for any group.

The decline in power observed in the strength-endurance group and the lack of significant increase in power noted in the endurance group suggests that training designed to improve power and strength should not incorporate endurance exercise.

Salih\(^7\) identified the effects of a conditioning programme on selected physiological variables of college women gymnasts. Ten women gymnasts at Oklahoma State University were tested prior to and following a three-month conditioning programme. After the conditioning

\(^7\)Kamil Am Solih, "The Effects of Physical Conditioning Programme on Selected Physiological Variables of College Age Women Gymnasts," Dissertation Abstracts International 45 (June 1984): 3578-A.
programme the study concluded that significant improvement were found in anaerobic threshold heart rate, resting blood pressure in the standing position, percent body fat from both skinfold and under water weighing and all strength measures except for right leg strength. No significant differences were found in the means of VO₂ max (ml/kg/min), percentage of CO₂ max at anaerobic threshold, supine resting blood pressure, resting heart rate and right leg strength.

Parks determined the effects of a ten weeks physical fitness programme on selected physiological and psychological variables of individuals sixty five to eighty five years of age. After a ten weeks of medical physical fitness programme the study concluded that improvement in fitness for the elderly could be attain through participation in a physical training programme of moderate intensity. It was also concluded that under proper supervision could be safe and effective for the women between the ages of sixty and eighty two.

The purpose of Chaloupka's study was to initiate a conditioning regime, which would maintain the physiological benefits resulting from an 8-weeks interval training programme. After 8-weeks of training followed by physiological variables (Blood lactic acid concentration; resting, exercise and recovery heart rates; maximum oxygen consumption; submaximal oxygen consumption; physical working capacity; maximum ventilation; maximum muscular power and lean body mass) were retested. Based on collected data and analysis made by using ANOVA, the study concluded that all the selected variables improved in their functioning except the maximum muscular power.

Thompson studied the changes in body composition, especially body fat, by the use of skinfold measurements. The measurements at abdomen, chest and arm were made on varsity football players at the beginning and at the end of a season. Using this information, changes in body composition that occurred during conditioning and

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training were studied. Body weight did not change significantly, but significant losses occurred from the three skinfold sites. Body density as estimated from skinfold data increased with training and conditioning. Presumably this increase was due to loss of body fat and increase in muscle mass and other bodily components.

Daviss\textsuperscript{11} attempted to analyse the effects of training and condition for the 200 yard crawl stroke events upon the physical condition of non-varsity swimmers. Selected measures of Cardio-vascular conditions, general physical fitness, gross strength, motorfitness, strength of the muscle groups primarily utilized in swimming the crawl stroke, and the strength decrements of the muscles were taken before and after the experimental period in order to evaluate the effects of this period. In addition, the relationships between speed in swimming the 200 yard crawl stroke event and the various selected tests were studied. As a result of the training and conditioning programme, scores on test batteries used to measure

\textsuperscript{11}Jack F. Davis, "Effects of Training and Conditioning for Middle Distance Swimming upon Various Physical Measures," Research Quarterly 30 (December 1959): 399.
physical fitness, motor fitness and gross strength improved significantly. No significant difference was obtained for cardio-vascular condition. Further, no coefficient of correlation was obtained that was sufficiently high to be of value for prediction of swimming time.

Thompson, Buskirk and Goldman\textsuperscript{12} in their study investigated the changes in body fat, estimated from skinfold measurements of college basketball and hockey players during a season. Body weight and skinfold measurements were determined in ten varsity, four freshmen basketball players and ten hockey players before and after a season of play in their respective sports. The men maintained relatively constant body weight but a redistribution of weight was evident from the skinfold finding. The men lost subcutaneous fat in the three skinfold sites measured as a result of a season participation in basketball and hockey practices.

Testerman examined training and detraining effects on selected physiological measures of fitness in adult black women. Pre-, post- and detraining post measurements were made on body weight, heart rate, blood pressure, sum of skinfold and predicted VO$_2$ max. The study concluded that after 12 weeks of training the predicted max. VO$_2$ and sum of skinfold measurements were improved and reduced respectively. These betterment was reduced back to pretraining levels through detraining. Body weight, heart-rate, and systolic and diastolic blood pressure underwent almost no changes from training through detraining period.

36 male and 13 female volunteers were administered training for 14-weeks by Buccola. The training programme was consist of ten minutes of warm-up proceeded the cycling or walk-jog segment for 50 minutes. The study, after the training concluded that:

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1. Male cyclists decreased in total body weight, percent of body fat, systolic and diastolic blood pressure; they increased in estimated maximum oxygen uptake.

2. The male walk-joggers decreased in total body weight, systolic and diastolic blood pressure; they increased in estimated maximum oxygen uptake, and flexibility in hip and trunk.

The purpose of Chakrabarti's study was to compare effects of endurance running and vigorous free hand exercises on selected physiological variables. The data was collected on 32 male students of first year Bachelor of Physical Education class before and after an experimental period of eight weeks. The training was administered by dividing the subjects into two groups (N=16). One group took endurance running and other group received vigorous free hand exercises. The result of the study indicates that:

1. Both the training programme improved significantly Haemoglobin content, systolic blood pressure and

pulse rate in terms of their efficiency where as there was no improvement recorded in case of vital capacity and breath holding.

2. The result also indicated that neither of two training methods i.e. endurance running and vigorous free hand exercises were superior to each other.

Rajan determined the comparative effects of selected weight training and specific exercises on Volleyball playing ability. 60 students were trained for six weeks divided into three groups, group A received weight training and group B received specific exercises where as group C served as control group. After training was administered the study concluded that : Volleyball playing can be improved with the help of weight training or specific exercises. Study also concluded that both the treatments were found superior to only regular volleyball practice group.

The purpose of Lee's study was to compare the


effects of elementary courses in volleyball, soccer, tennis and conditioning on selected physical fitness tests. 77 subjects were divided into four groups and met twice a week for a period of twelve weeks. The findings of the study indicated the followings:

1. All of the four activity groups improved their scores to some degree on all of the nine selected test items (right and left hand grip, the vertical jump, the standing broad jump, the sit-ups, the push-ups, 50 yard dash, the 60 yard shuttle run and 880 yard run/walk).

2. The soccer group showed significant improvement on five of the test items (the vertical jump, the standing broad jump, the pull-ups, the 60 yard shuttle run and 50 yard dash) at .05 level.

3. The volleyball group showed improvement at .05 level on the test of 50 yard dash.

4. Except 60 yard shuttle run no significant differences were observed in the physical performance among the four groups.

5. Soccer group was found better than volleyball group in the improvement of the 60 yard shuttle run.
Shenoy's 18 experimental study concluded that:

1. High load of exercise increasing the heart beat to 150/min. is more effective than low load of exercise increasing the heart beat to 105/min.

2. High Physical Fitness group gains both with high load and low load of exercises, the gain with high load being greater.

3. It was not established whether low fitness group responds better to high load or low load of exercise.

Jaimitra 19 took fiftyfour randomly selected male subjects to determine the effects of selected exercises on the physical fitness of sedentary adults. The subjects were divided into two groups. One experimental and other control. Experimental group was subjected to a training programme in selected exercises for six weeks.

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The study concluded that these was significant gains in mean of the experimental group in abdominal strength and leg power and decreased the resting pulse rate.

McNamara's\(^{20}\) study was designed to compare the effects of three physical fitness training programmes on selected psychological and somatic (body composition, posture, flexibility, muscular strength, muscular endurance and cardio-vascular endurance) variables on both males and females. Three treatment (Army Readiness, Calisthenic and weight training) were administered for ten weeks. Statistical analysis of data indicated that physical fitness training enhances all the somatic variables irrespective of training programme.

The relative effectiveness of six intensive training programmes on the development of four selected skills was studied by Schultz\(^{21}\) with emphasis on limited time encouraged with in the semester organizational


plan (N=120). After a 16 weeks of training programme, the study concluded that:

1. Direct practice jumping, alone or combined with respective sprinting or weight training was superior to weight training alone or standing broad jump development.

2. Direct practice of zig-zag run was superior to both weight training and repetitive sprinting, and

3. When group acquisition of "adequate" skill is the objective, performance improved.

Thompson determined the effects of no warm-up, specific warm-up, general warm-up consisting stretching type of exercises and general warm-up in the form of warm showers upon the performance of speed, endurance, agility and power. The study concluded that:

1. There was no overall significance found between the different types of warm-ups on the combined performance tests.

2. Difference between the performance tests were not significant independently of the four types of warm-ups.

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

Effect of Endurance Training on Physical and Physiological Variables

Analysis of variance repeated measures design was used to examine the effect of endurance training on the following parameters: heart rate, systolic blood pressure and oxygen uptake during submaximal walking tests of McIntosh's\(^{23}\) study.

Significant reductions for the experimental group were found for total body weight, resting systolic and R.P.E. max. A 6.7% improvement in oxygen uptake (\(\text{VO}_2\) ml/kg. min) was found for the experimental group in

response to the sixteen month data collection period. Sub-maximal walking measures (heart rate, systolic blood pressure and oxygen uptake) were all found to decrease significantly, indicating an improvement in efficiency for these cardio-respiratory measures.

Priest designed a study to determine which measures significantly changes after seven weeks of aerobic training. A further purpose of this investigation was to determine the degree of relationship of these variables to 10,000 metres run times in university cross country runners.

The study concluded that training for 10,000 metres run produced improvement in 15 metres, 600 metres, 10,000 metres and 20 miles performance. Training for 10,000 metres also improved cardio-respiratory functions. The effect of training was comparatively less to body composition.

24 Jeo Weldon Priest, "The Effects of Aerobic Training upon Cardio-respiratory Function, Body Composition, and Training Indices and the Relationship of these variables to 10,000 metres Run Performance," Dissertation Abstracts International 44 (May 1984): 3320-A.
A study was designed by Priest\textsuperscript{25} to determine whether or not significant changes occur in flexibility, heart rate, body weight, selected anthropometric measurements, body fat and general physical condition as a result of participation in aerobic dancing or aerobicise. After a six week of training programme the study concluded that:

1. Participation in both the dance and exercise programmes resulted in an increase in general level of physical fitness.

2. Participation in the aerobic dancing programme significantly reduced body fat.

3. Participation in the aerobicise programme significantly increased flexibility.

4. Neither participation in the aerobicise nor aerobic dancing produced significant change in body weight.

5. Participation in aerobic dancing resulted in significant changes in various anthropometric measures.

\textsuperscript{25} Nita Nelson Priest, "Comparative Effects of Two Programmes of Aerobic Dance on the Flexibility, Body Composition and General Physical Condition of Selected College Women," Dissertation Abstracts International 44 (January 1984): 2086-A.
along with a significant decrease in body fat.

In Buccola and Stone's study thirty six men (age 60-79) were divided into two groups, jogging and cycling. The two groups were administered pre and post test on Astrand bike test and 16 P.F. (Cattell) test. The result of the study indicates that there was improvement in $V_{O_2}$ max and decreased in blood pressure and weight in both the groups where as flexibility in case of joggers and percent of body fat in case of cyclists showed significant difference.

Dulin's study attempted, through laboratory testing, to determine whether deconditioned adult males would, with regard to cardio-respiratory fitness, benefit more from working at duration running or from running in intervals. The study concluded that neither exercise programmes, interval running or continuous running, was superior to the other interms of promoting cardio-respiratory fitness of the participants.


Lathen\textsuperscript{28} investigated the effects of three types of treadmill running programmes on body weight, resting heart rate, heart weight, gastrocnemius muscle weight and other ratios in Sprague-Dawley rats. After a ten weeks of training, the study concluded that exercised animals had significantly less total body weight and fat free body weight than non-exercised animals. The long continuous running group had significantly less total body fat and percentage of body fat than any of the other groups. The non-exercised animals had significantly greater heart weight than those of the long continuous and interval groups, and they also had significantly greater gastrocnemius muscles weight than those of all the exercised animals. The data also indicated that long continuous groups had significantly greater changes in body composition. None of the running programmes produced a significant difference in resting heart rate as compared to the control group.

Thirty two male university students were pre-tested with Astrand's bicycle ergometer test of predicted

\textsuperscript{28} Calvin Wesley Lathen, "Running Programmes and Their Effects on Resting Heart Rate, Body Composition and Selected MuscleWeights in Rats," Dissertation Abstracts International 34 (November 1979): 2369-A.
maximum oxygen intake and selected strength tests. The subjects were randomly assigned to each of the eight treatment groups of 2x2x2 factorial design, to investigate the effect of speed, load and repetition of interval training bouts on endurance performance was the study of Tomik. He concluded that neither high levels nor low levels of experimental treatment favoured the development of greater endurance capability as increased by the performance test. There was some evidence that factors of repetition and load produced training effects which were more beneficial in certain combinations than in others.

The purpose of Thomas's study was to determine the effects of an interval training programme on aerobic, anaerobic and anthropometric parameters of women. Thirty one females between thirty and thirty nine years of age served as the subjects for this research. The training programme was submaximal in nature and continued for seven and one-third weeks, there was three session a week


for the equivalent of 60 minutes of activity for the most highly conditioned subjects. The activities included two flexibility exercises. Six weight training activities emphasizing muscle endurance, three calisthenics and runners.

There were statistically significant positive physical conditioning changes in all but three parameters: weight, body surface area and elbow flexion strength. 2. There was an 23.6% improvement in predicted maximal oxygen uptake using the Astrand Rhythming bicycle ergometer test. 3. An increase of 55.8% in the F-EMU Step test and a 13.3% increase on Cooper's 12 minute test, allowed the conclusion that all the parameters but three can be positively changed by providing a seven and one third week, submaximal interval training programme for women.

The study conducted by Gray was to see the effects of cycling, jogging and swimming on cardio-vascular endurance and to see if any of these three modes is more significant than the others in improving cardio-vascular endurance. The age of the subjects ranged from 17 to 29

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years. The subjects were allowed to select the aerobic training mode they desired (cycling, jogging and swimming). The subjects were trained 3 days per week for 7 weeks.

Based on the findings and within the limitation of this study, the following conclusions were drawn:

1. An aerobic exercise programme of cycling, jogging or swimming produced a significant gain in cardiovascular endurance.

2. There was no significant difference in cycling, jogging or swimming to produce a significant increase in cardiovascular endurance.

3. There was no significant difference in the specific exercise heart rate training method (experimental subgroups) and the non specific heart rate training (experimental sub-groups) and the non specific heart rate training method (control sub-groups) to produce a significant increase in cardiovascular endurance in the aerobic training modes of cycling, jogging and swimming.

Sixty three college aged females between seventeen and twenty-two years of age were randomly assigned to one of four running regimes described as (i) interval running group two times a week, (ii) long slow-distance running two times a week (iii) interval running group three times a week and (iv) Long Distance Endurance running
three times a week by Alteri.\textsuperscript{32} After the training, with the help "F" ratio the study revealed that:

1. Elevated cholesterol, Group 2;
2. Increased serum lactate dehydro-glucose in all four groups;
3. Elevated triglycerides values, group 2;
4. Increased calf girth for groups 1 and 3;
5. Decreased suprailiac skinfold for groups 1, 2, and 3 while groups 2 and 3 also decreased in sub-scapular skinfold;
6. Lowered resting heart rate for groups 1 and 2;
7. Increased post-exercise systolic blood pressure for groups 2 and 3.
8. Reduced diastolic blood pressure for groups 3 and 4;
9. Improved duration of effort on the modified Balke Treadmill Test for group 1, 3 and 4;
10. Improved distance covered on the Cooper Twelve minute run/walk test for women in all groups.
11. Improved sub-maximal aerobic power for groups 3 and 4.

Reddy\textsuperscript{33} examined the effects of massed and
distributed endurance running on selected physiological
variables. 60 male students of the age group 14 to 15 yrs.
were divided into three groups: Group A practiced
massed endurance running and Group B practiced distributed
enduranced running where as Group C served as control
group. The data on resting pulse rate, vital capacity and
12 minute run/walk tests before and after the experimental
period of ten weeks were recorded. With the help of ANOVA.
The study concludes that massed and distributed running
methods are effective in reducing resting pulse rate and
increasing vital capacity and performance of 12 minutes
run/walk test. It was also indicated that massed endurance
running is superior to distributed running programme
to reducing pulse rate, whereas in the case of vital
capacity and 12 minute run/walk test no difference was
found.

Gatch\textsuperscript{34} took thirty-two randomly selected subjects

\textsuperscript{33} P. Ranga Reddy, "Effects of Massed and Distri-
buted Endurance Running on Selected Physiological and
Physical Variables," (Unpublished Master's Thesis, Jiwaji
University, 1980).

\textsuperscript{34} Wendel Holmes Gatch, "A Comparison Between
Effect of Two Physical Training Programmes on Cardio-
vascular Function of 9 and 10 years old Boys," Dissertation
between the ages of 9 and 10 years from elementary physical education classes at the Florida State University Developmental Research School. The subjects were then divided into endurance and non-endurance group. The endurance training group participated in a bicycling activity specifically designed and controlled to require endurance training. The non-endurance training treatment group participated in their regular physical education classes. The physiological parameters investigated in this study were:

1. Hemodynamics (cardio-index, cardiac output, heart rate, stroke index and stroke volume).

2. Metabolic functions (arterio-venous oxygen difference, oxygen pulse and oxygen uptake), and

3. Physical work capacity.

The study concluded that an endurance training programme is superior to a non endurance (physical education) training programme in development of parameters which indicate cardio-vascular efficiency of 9 and 10 years old males. A physical education or non-endurance training programme by contrast, will not likely be of sufficient intensity to enlist an improvement in physical fitness without the
inclusion of endurance activities.

Marcal\textsuperscript{35} obtained data from 41 males and 31 females enrolled in the class exercise and health at university of Toledo, Ohio. The subjects were divided into 2 groups, 12 minutes continuous run group and the Cooper Group on the basis of VO\textsubscript{2} scores to produce groups that were approximately equivalent in fitness levels. After a pre-test and a past-test ten weeks later, the data were evaluated by a repeated measures ANOVA, using .05 level of significance.

The finding of this investigation demonstrated that participation in these exercise programmes produced a more positive attitude toward physical activity, reduced level of Neuroticism, decreased weight, decreased percent of body fat, decreased waist girth, decreased systolic and diastolic blood pressure and lowered resting, exercised or recovery heart rates. The programme also increased VO\textsubscript{2} scores, number of sit-ups and push-ups, flexibility and leg extension strength.

Effect of Strength Training on Physical and Physiological Variables

The effect of six weeks selected strength exercises programme on shooting accuracy in basketball was investigated by Nagarkote.\(^{36}\)

All three groups A, B, C were administered training: group A received no training, group B received weight training and group C practiced shooting respectively. After six weeks of training following conclusions were made:

1. Performance in free throw shooting can be improved by administered a programme of selected strength exercises alongwith practice in free throw shooting.

2. Practice in shooting accuracy for a period of six weeks can also bring about significant changes in shooting accuracy.

The purpose of Salariya's\(^{37}\) study was to assess


the effect of selected free hand exercises and weight training on performance in Johnson Basketball Ability Test. 30 subjects were divided into three groups: group A and B did weight training and free hand exercises and group C received no extra training respectively. They also participated in a 20 basketball practice matches. After training the study concluded that: All the treatment groups improved performance in Johnson basketball test but there was no evidence to indicate significant difference among the groups.

The purpose of the Seay's\textsuperscript{38} study was to determine if significant Cardio-vascular improvement would occur following an 8-week nautilus training programme.

The subjects were 36 male college students, divided into only Nautilus training, combined training group (soccer playing) and control group. The study concluded that an 8-week Nautilus programme was found to be beneficial in significantly increasing cardio-vascular fitness. In addition, submaximal heart rates were appreciably lowered through changes in resting heart rates did not significant at the .01 level. There was also found

to be no change in resting blood pressure as a result of the training programme.

Panny\textsuperscript{39} investigated the effects of resistance running on speed, strength, power, muscular endurance and agility. The training programme consisted of four fifty minute sessions per week for six weeks.

Results indicated that:

1. A training programme of resistance running alone or supplemented by weight training, iso-metric contractions, and repetitive sprinting would significantly increase speed, leg strength, leg power muscular endurance and agility;

2. Resistance running supplemented by isotonic leg exercises, isometric contractions, and repetitive sprinting will not improve standing broad jump ability as significantly as speed, leg strength, muscular endurance and agility.

3. Orthogonal comparison revealed upward trends in improvement of all variables during the six week training programme.

After administering a ten weeks of resistance exercises programme Sauders\textsuperscript{40} concluded that there was significant increases in strength within experimental groups on six of the eight strength tests, no significant increases in strength with in control group with the exception of the tests for knee flexion, and significant increases for the experimental group over the control group on the elbow flexion, knee extension and shoulder horizontal adduction strength tests. The results for muscle girth assessments revealed a significant upper arm girth increase with in the experimental group. No significant differences occurred on the remaining girths with in the experimental group or with in control group. Body compsoition as assessed with the help of skinfold thickness revealed no significant differences.

The purpose of Panye's\textsuperscript{41} study was two fold: to determine which exercise programme was most effective in producing a static strength gain and to determine


\textsuperscript{41} L. Anne Payne, "The Influence of Strength on Speed of Movement in Eight Grade Girls," Research Quarterly 39 (October 1968): 653.
the relationship between static strength and speed of movement (N=72). The subjects were divided into two experimental groups one using an isometric exercise programme, the other using isotonic programme. A control group played lead up games during experimental period. Strength and speed of movement of the arm and shoulder girdle were both measured by three tests, prior to training, correlations indicated a rather high relationship between strength and speed of movement. Following training there was little relationship between static strength, and speed of movement. The results of the training programme indicated an increase in mean performance in all three groups with the isotonic group being superior.

Boyd\textsuperscript{42} took one group of each sex trained at 8-12 repetitions and another group of each sex trained at 18-22 repetitions for eight weeks to record the effects on muscular strength, power endurance performance power (Margaria-Kalamen), body composition (under water weighing), girth measurements and cardio-vascular fitness.

All groups demonstrated significant increase in shoulder abduction (power and endurance) while female groups were the only groups to increase strength. The female endurance group demonstrated significant increase in shoulder abduction (strength, power endurance), while other three groups showed no significant differences. Performance power testing indicated no significant differences between or within groups during the study. Body composition resulted indicated significant increases for all groups in body density and lean body weight (except female strength group), the male groups decreased more significantly than the female in body fat and body weight. Girth measurement results showed significant increases in the thigh and biceps brachii measurements for all groups. All groups (except male strength) significantly increased in the forearm measurement. The male groups showed a significant increase in chest girth over female groups. Skinfold measurements showed a significant decrease in triceps (all groups), and biceps (all groups except male endurance) measurements. Results also show, oxygen consumption increases for male. Heart rate changes shows a significant increase for the strength group (resting) and a significant decrease for all groups except male
strength group (maximum).

Mosley, Hairabedian and Donaldsons\textsuperscript{43} study was to determine whether increased strength gain through weight training was accompanied by an increase in muscular co-ordination and speed of movement. 69 subjects were tested at the beginning of the experimental period. These subjects were distributed as follows 24 in the weight training group (X), 26 in the volleyball group (CV) and 19 in the sports lecture group (CL). During six weeks which comprised the actual experimental period, each group met for three 50 minutes seasons per week. The experimental group under gone weight training, the volleyball group (CV) was engaged in skill learning and lecture group was not engage either in skill learning or weight training. After the experimental period the subjects were retested. The analysis of data revealed that: A six week weight training increase strength and muscular co-ordination more than skill learning and inactivity groups. The study also revealed that speed of movement significantly increased due to weight training in experimental group

than that CV and CL groups.

Roby observed changes in the thickness of subcutaneous fat layer as a result of exercising an underlying unilateral muscle as a control. The observations were made on fifteen male subjects who participated in a ten-week weight training programme, which involved the triceps of the dominant arm. A Harpenden skinfold Calipers was used to estimate the thickness of the subcutaneous fat layers. The findings did not support the postulate that subcutaneous fat is reduced in localities where muscles are active and in proportion to their activities.

Dintiman made a study to determine whether a flexibility training, a weight training programme and the combination of both would affect running speed when used as supplementary training programmes to the conventional method of training sprinters. One hundred and fifty-five subjects randomly assigned to one of five training


groups were tested for flexibility, leg strength and running speed before and after an 8-week training period. Results showed that both weight training and flexibility training, as supplements to sprint training, increased running speed significantly more than an unsupplemented sprint training programme.

Arm strength, effective arm mass and speed in a lateral adductive arm movement were measured in 62 college men and remeasured ten weeks later. During this interval half of the subjects were given weight training exercise that did not involve the movement, while the other half remained in active in order to provide a control group. The average of the training group improved significantly in speed, strength and strength/mass ratios whereas the average of the control group declined. There was no correlation between individual differences in speed and strength/mass ratios; but individual changes in the ratio correlated significantly (r = .405) with individual changes in speed, whereas reaction time not improved by weight training were the findings of Charke and Henry's study.

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Alexander et. al.\textsuperscript{47} pointed out that due to heavy resistive isotonic exercises all the skinfold measurements were decreased and increase in all girth measurements except the waist girth was also recorded. The control group displayed marked differences in the triceps skinfold (decreases) and the waist girth (increase) measurements. The experimental group significantly improved on the physical fitness index while the control group did not improve. They also indicated that, for physically conditioned young males, exercising of this kind brings about changes in girth and skinfold measurements, improves muscular strength and endurance and has a small positive effect on improvement of the cardio-vascular fitness level.

Sixty adult women volunteers were randomly assigned to one of two groups: experimental (30) or control (30) group in Price's\textsuperscript{48} study. The experimental


group participated in a six week thirty session exercise programme using the Inch Master Exerciser, while the control group did not engage in any exercise programme. After a six week training session the study concluded that the differences in the mean changes between the experimental group and control group were tested for significance of difference at the .05 level of confidence using student's 't' test. The experimental group decreased significantly more in waist girth and right thigh girth; however, they significantly increased in spinal rotation flexibility and aerobic capacity. The control group scored significantly higher in right lateral flexion flexibility and vital capacity. No significant differences were found in right upper arm girth, breast girth, hip girth, right calf girth, subcutaneous fat, strength, trunk extension flexibility, resting cardio-vascular fitness and maximum breathing capacity.

Calvin's study was undertaken to investigate the effects of a programme of progressive resistive exercises in the form of weight training on the motor

co-ordination of high school boys. An experimental group participated in weight training exercises for four months. During this period, a control group participated in a general programme of physical education. All subjects were administered tests of motor coordination in the pre- and post experimental period. At the conclusion of the experimental period a statistical analysis of data indicated that the experimental group improved in motor coordination more significantly than did the control group. This increase in motor coordination was apparently associated with increased anthropometric and strength measurements caused by the progressive resistance exercise programme.

Wilkin\(^{50}\) investigated whether with heavy exercise of the resistance type causes an incipient muscle bound condition, defined impart as improve speed of movement. 58 subjects were tested in speed of movement and again retested after the experimental period. 30 subjects were received the treatment and remaining 28 students served as the control group. The analysis of data revealed that:

\(^{50}\)Bruce M. Wilkin, "The Effect of Weight Training on Speed of Movement," Research Quarterly 23 (October 1952): 361-369.
1. Weight training, over a period of semester has no slowing and muscle bound effect in speed of movement.

2. Speed of movement does not improved during one semester training.

Effects of continual heavy, resistive exercise on the range of movement in certain selected joints of young male adults was studied by Massey and Chaudet. They took an experimental group (N=13) trained with weight for approximately six months during which time a control group (N=13) participated in general physical education activities. Weight training did not have an appreciable effect upon range of joint movement throughout the body. A significant decrease did take place in the ability of the experimental group to move the extended arms from a position at the side of the body, back ward in the anterior-posterior plane.

Twenty eight springfield college students were exercised. Using the elbow flexor muscle group three times a week for a period of four weeks on the Hellebrandt

ergometer in Mathews et al.'s\textsuperscript{52} study.

The study concluded that there was a significant gain in strength in both the exercised and unexercised muscle groups. Significant increases in muscular endurance were found only in the exercised group.

Whitley and Smith\textsuperscript{53} experimented the effects of isometric - isotonic (A), dynamic over load (B) and free swing (C) exercise programmes on the speed and strength of a lateral arm movement. Twenty six college men in each group - three experimental and one control group performed its assigned exercises twice a week during the ten week training period. Following training there were significant speed increases in both the isometric-isotonic and dynamic over load groups (\(t = 10.06\) and 8.10), however, the difference in speed gain between conditions was not significant (\(F = .10\)). Strength increases in both these groups were also significant (\(t = 8.81\) and

\textsuperscript{52} Donald K. Mathews et al., "Cross Transfer Effects on Strength and Endurance," Research Quarterly 27 (December 1957): 418.

3.08), with that of the isometric isotonic group significantly greater than the dynamic over load group (F=5.11). No significant speed or strength games were registered by either the free swing or control group.

Takei\textsuperscript{54} investigated the relative effectiveness of force over load training (FOT) and Power over load training (LOT) for maximizing strength, power and performance of the straight-body bent-arm press to a hand stand on parallel bars. Eighteen gymnasts were randomly assigned to two groups. One engaging in FOT and the other in POT, Velocity was not imposed in FOT where as maximum velocity was required in POT. The FOT group trained with progressive over load of resistance only, where as the POT group employed progressive over load of both velocity and resistance.

After 10 weeks of training, the study concluded that both FOT and POT significantly improve maximum strength and gymnastic performance and that the two training methods do not differ significantly. However, only POT improves maximum power significantly.

Gillespie present investigation was to determine the effects of three weight training programmes on strength and muscular endurance. Specifically it was the aim of this study to determine the effects of 1. high resistance low repetition (H-R, L-R), 2. low resistance high repetition (L-R, H-R) and a combined weight training programme on strength and muscular endurance. No significant difference in improvement was recorded.

Three programmes of strength development were investigated with seventy five college male by Johnson. The three programmes included isotonic resistance on a weight machine, isokinetic resistance from a super minigym, and isometric with weights in a power rack. The muscles and exercises used for the study were biceps (the curl) and pectoralis major (brench press), respectively. A Cable Tensimeter was used for strength testing purposes. Resulting data indicated no significant difference among the three exercise programmes in terms of strength development. In terms of strength gain, five of the six variables investigated proved to be significant. The Pectoralis major gained significantly more strength than the biceps.

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No one programme proved to be significantly superior to the other two training programmes.

Girardi\(^{57}\) evaluated the effectiveness of isokinetic exercises in developing muscular strength, muscular endurance, muscular power and cardio-respiratory endurance; and compared the effectiveness of the isokinetic exercises in the development of strength and endurance with iso-metric and isotonic exercises.

The study made following conclusions:

1. Due to iso-kinetic treatment there were significant improvement in muscular endurance and muscular strength whereas no improvement recorded in the cases of muscular power and cardio-respiratory endurance.

2. The isokinetic group was superior to other two group in improving muscular endurance and muscular strength.

3. No treatment was significantly superior to any other treatments improving muscular power, grip strength, muscular endurance as measured by dips and circulo-respiratory endurance.

The effects of conventional, high repetition and modified high repetition weight training programmes on strength and cardio-vascular endurance was compared by Sorerson. The study also recorded the changes in specific body circumferences, percentage of body fat, vertical jumping ability, mile time and skinfold thickness.

Fifty five male students were randomly divided into three groups within each of three classes. The groups were leveled group A, group B and group C, group A followed a conventional weight training programme and served as control group, group B followed a modified high repetition weight training programme. Group C followed a high repetition weight training programme.

After the experimental programme, no significant differences among or within groups were found except for brench press where group A and B were superior to group C and in dead lift where group A was superior to group C. All groups produced significant desirable changes in all but three variables.

Nagle and Irwin⁵⁹ experimented with three groups: two experimental and one control group consisting of 20 college freshmen in each group to registered the effects on circulo-respiratory endurance and related physiological factors. The experimental groups participated in weight training programme and the control group in archery on bait casting. After training the study concluded that there was no difference among the groups in any of the variables chosen for the study but a significant improvement of all the variables was recorded after the training.

Forty-three male college students were randomly assigned to the training protocols.

The high resistance- low repetition group (N=15) performed three sets of 6-8 RM (Repetition Maximum) per session. The medium resistance- medium repetition subjects (N=16) trained by doing two sets of 30-40 RM per session, while the low resistance-high repetition group (N=12) used a single set of 100-150. All subjects trained with the brench press exercise three times per

week for nine weeks in Anderson and Kearney's study. Tests for strength (1 = RM) absolute and relative endurance were administered before and after training, statistical analysis revealed that the 20% improvement in maximum strength by the high resistance-low-repetition group was greater than the 8 and 5% gains reported for the medium resistance-medium repetition and low resistance high repetition respectively. Relative to absolute endurance, however, the 41 percent and 39 percent improvement registered by the low-resistance-high repetition and medium resistance - medium repetition groups respectively were not significantly greater than the 28% gain reported for the high resistance-low repetition group. Result for the relative endurance test revealed that the high resistance-low repetition group's performance actually decreased by 7% after training and was significantly poorer than the 22% and 28% improvements made by the other two groups.

Based on the statistical analysis the study

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concluded that significant gains in strength and muscular endurance were the results of HR-LR, LR-HR are the combined training.

Capen\textsuperscript{61} found out the effect of weight training on power, strength and endurance. Two groups of the students were used in his study. One group serves as a weight training group of Sophomores at the University of Tennessee. The other group was a conditioning class of Freshmen at the same university. Both groups met twice a week for eleven weeks. The data were collected on the selected variables before and after the experiment. Statistical analysis of data reveals that:

1. Muscular strength of weight training group improved significantly than that of conditioning group.

2. Muscular power and endurance of both the group improved significantly but there was no significant difference between them.

3. For both the groups no improvement was seen in cardio-respiratory endurance.

One hundred seventy-five male subjects (grade 9-12) were selected, at random, to take part in this study. Conducted by Hondras. They were assigned, each by change into one of the following five training programme sports and games. Functional Isometric contraction exercises weight training, isometric and controlled isotonic contraction exercise and running.

After a 6-week of training programme the study concludes that:

1. Participation in programmes of isometric, controlled isotonic training and sports and games training can result in improvement in muscular strength, muscular endurance and cardio-respiratory endurance.

2. Isometric and Isotonic training is more important methods of developing muscular strength and muscular endurance.

3. Running is a more effective methods of developing cardio-respiratory endurance than other four groups.

O'Shea's experiment was undertaken to determine the effect of a six-week progressive weight training programme on the development of strength and muscle hypertrophy, using one exercise, the deep-knee bend, with varying repetitions. Thirty students were chosen by random from beginning weight lifting classes at Michigan State University. Following a two-week conditioning period the subjects were divided into three groups of ten each for the controlled training period. The programmes were as follows: Group A - 3 sets of 9-10 repetitions, Group B - 3 sets 5-6 repetitions and Group C - 3 sets 2-3 repetition. Individual in each group handled maximum weight loads for the maximum of repetitions each was required to perform. The effectiveness of the programme was determined by three measurements (a) Thigh girth (b) dynamics strength as measured by one run on the deep-knee bend and (c) static strength as measured on the dynamo-meter. The results were graphically analyzed and percentages calculated. The data were also statistically treatment using analysis on covariance.

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significant difference were found between the three systems of training. All the training procedures resulted in the improvement of static and dynamic strength.