# CHAPTER – IV

# ANALYSIS AND INTERPRETATION OF DATA

# CHAPTER - IV

# ANALYSIS OF DATA AND RESULTS OF THE STUDY

In general, data may be valid, reliable and adequate. But they do not serve any useful purpose unless they are carefully processed, systematically shifted, classified, tabulated, scientifically analyzed, intelligently interpreted and rationally concluded. After the data have been collected, they should be processed and critically analyzed to draw exact conclusions. The results and discussion on findings of treatment effects individually and comparatively on variables used in the present study are presented in this chapter.

## 4.1 LEVEL OF SIGNIFICANCE

For testing the hypothesis of homogeneity of group mean gains, as well as significance of differences of pairs of group means, the level of significance was set at 0.05 level of confidence, which was considered adequate for the purpose of this study.

## 4.2 RESULTS OF TREATMENT EFFECT

The statistical analysis on significance of the mean gains or losses made between pre and post-tests of Combination of Resistance Training followed by Plyometric Training in the same session (CRTPT, Group - I), Complex Training of Resistance Training followed by Matched Plyometric Training in the same session (CTRTMPT, Group - II), Resistance Training for first six weeks followed by Complex Training of Resistance Training with Matched Plyometric Training for another six weeks (RTCTRTMPT, Group - III) and Control Group (CG, Group – IV) on muscle fitness parameters, physiological parameters and skill performance variables and overall playing ability are presented in the tables 4.1 to 4.4.

## TABLE- 4.1

**SIGNIFICANCE OF MEAN GAINS /LOSSES BETWEEN PRE AND POST TEST OF COMBINATION OF RESISTANCE TRAINING FOLLOWED BY PLYOMETRIC TRAINING IN THE SAME SESSION ON MUSCLE FITNESS PARAMETERS, PHYSIOLOGICAL AND SKILL PERFORMANCE VARIABLES AND OVERALL PLAYING ABILITY**

| Variables | Pre test mean ±SD | Post test mean ± SD | M. D | SEM | 't'-ratio |
|---|---|---|---|---|---|
| ***Muscle fitness Parameters*** | | | | | |
| Upper body Muscular Strength (in Kilograms) | 51.85 ±5.66 | 54.20 ±5.59 | 2.35 | 0.17 | 14.10* |
| Lower body Muscular Strength (in Kilograms) | 53.05 ±2.70 | 56.45 ±2.50 | 3.40 | 0.26 | 13.31* |
| Abdominal Muscular Strength and Endurance (in Numbers) | 33.45 ±5.45 | 35.20 ±5.55 | 1.75 | 0.12 | 14.23* |
| Upper body Muscular Power (in Meters) | 6.45 ±0.28 | 6.74 ±0.28 | 0.29 | 0.03 | 8.96* |
| Lower body Muscular Power (in Centimeters) | 46.15 ±8.43 | 52.40 ±7.44 | 6.25 | 0.35 | 18.01* |
| ***Physiological Parameters*** | | | | | |
| Aerobic Capacity (in ml/kg/min) | 55.64 ±3.75 | 61.35 ±2.43 | 5.71 | 0.39 | 14.53* |
| Anaerobic Capacity (in Kg/mts/sec) | 1196.5 ±98.78 | 1244.3 ±103.51 | 47.75 | 7.27 | 6.57* |
| ***Skill performance variables*** | | | | | |
| Serving Ability (in points) | 27.85 ±3.56 | 30.15 ±3.33 | 2.30 | 0.22 | 10.51* |
| Passing Ability (in points) | 20.30 ±3.44 | 22.50 ±3.24 | 2.20 | 0.17 | 12.82* |
| Overall Playing Ability (in points) | 5.00 ±0.26 | 5.40 ±0.26 | 0.41 | 0.06 | 7.09* |

*Significant at 0.05 level

Table – 4.1indicates the obtained ‘t’ ratios for all the muscle fitness parameters, physiological and skill performance variables and overall playing ability. The obtained t- ratios were 14.10 (upper body muscular strength), 13.31 (lower body muscular strength), 14.23 (abdominal muscular strength and endurance), 8.96 (upper body muscular power), 18.01(lower body muscular power), 14.53 (aerobic capacity), 6.57 (anaerobic capacity), 10.51 (serving ability), 12.82 (passing ability) and 7. 09 (overall playing ability). The obtained‘t’ ratios on muscle fitness parameters, physiological and skill performance variables were greater than the critical value of 2.09 for degrees of freedom 19. It was observed that the mean gains and losses made from pre-test and post-test were statistically significant resulting that twelve weeks practice of combination of resistance training followed by Plyometric training in the same session produced significant improvement in upper body muscular strength (2.35$p<0.05$), lower body muscular strength (3.40$p<0.05$), abdominal muscular strength and endurance (1.75$p<0.05$), upper body muscular power (0.29$p<0.05$), lower body muscular power (6.25$p<0.05$), aerobic capacity(5.71$p<0.05$), anaerobic capacity (47.75$p<0.05$), serving ability (2.30$p<0.05$), passing ability (2.20$p<0.05$) and overall playing ability (0.41$p<0.05$) from the performance of baseline. Thus the formulated hypothesis No.1 is accepted.

## TABLE - 4.2

**SIGNIFICANCE OF MEAN GAINS /LOSSES BETWEEN PRE AND POST TEST OF COMPLEX TRAINING OF RESISTANCE TRAINING FOLLOWED BY MATCHED PLYOMETRIC TRAINING IN THE SAME SESSION ON MUSCLE FITNESS PARAMETERS, PHYSIOLOGICAL AND SKILL PERFORMANCE VARIABLES AND OVERALL PLAYING ABILITY**

| Variables | Pre test mean ±SD | Post test mean ± SD | M. D | SEM | 't'-ratio |
|---|---|---|---|---|---|
| ***Muscle fitness Parameters*** | | | | | |
| Upper body Muscular Strength (in Kilograms) | 51.75 ±4.30 | 55.25 ±4.30 | 3.50 | 0.24 | 14.89* |
| Lower body Muscular Strength (in Kilograms) | 53.15 ±3.57 | 57.50 ±3.14 | 4.35 | 0.18 | 23.94* |
| Abdominal Muscular Strength and Endurance (in Numbers) | 33.50 ±3.49 | 35.95 ±3.33 | 2.45 | 0.15 | 15.96* |
| Upper body Muscular Power (in Meters) | 6.48 ±0.25 | 6.88 ±0.22 | 0.41 | 0.03 | 13.26* |
| Lower body Muscular Power (in Centimeters) | 46.70 ±5.81 | 54.65 ±6.40 | 7.95 | 0.38 | 20.91* |
| ***Physiological Parameters*** | | | | | |
| Aerobic Capacity (in ml/kg/min) | 55.89 ±3.85 | 60.34 ±3.46 | 4.45 | 0.35 | 12.70* |
| Anaerobic Capacity (in Kg/mts/sec) | 1225.4 ±86.73 | 1315.8 ±45.11 | 90.35 | 13.85 | 6.52* |
| ***Skill performance variables*** | | | | | |
| Serving Ability (in points) | 27.90 ±4.46 | 31.45 ±3.99 | 3.55 | 0.21 | 16.81* |
| Passing Ability (in points) | 20.90 ±2.45 | 24.00 ±2.55 | 3.10 | 0.25 | 12.39* |
| Overall Playing Ability (in points) | 5.03 ±0.39 | 5.62 ±0.37 | 0.59 | 0.054 | 11.17* |

*Significant at 0.05 level

Table – 4.2 1indicates the obtained 't' ratios for all the muscle fitness parameters, physiological and skill performance variables and overall playing ability. The obtained t- ratios were 14.89 (upper body muscular strength), 23.94 (lower body muscular strength), 15.96 (abdominal muscular strength and endurance), 13.26 (upper body muscular power), 20.91 (lower body muscular power), 12.70 (aerobic capacity), 6.52 (anaerobic capacity), 16.81 (serving ability), 12.39 (passing ability) and 11.17 (overall playing ability). The obtained't' ratios on muscle fitness parameters, physiological and skill performance variables were greater than the critical value of 2.09 for degrees of freedom 19. It was observed that the mean gains and losses made from pre-test and post-test were statistically significant resulting that twelve weeks practice of complex training of resistance training followed by matched plyometric training in the same session produced significant improvement in upper body muscular strength ($3.50p<0.05$), lower body muscular strength ($4.35p<0.05$), abdominal muscular strength and endurance ($2.45p<0.05$), upper body muscular power ($0.41p<0.05$), lower body muscular power ($7.95p<0.05$), aerobic capacity ($90.35p<0.05$), anaerobic capacity ($43.49p<0.05$), serving ability ($3.55p<0.05$), passing ability ($-3.10p<0.05$) and overall playing ability ($0.59p<0.05$) from the performance of baseline. Thus the formulated hypothesis No.1 is accepted.

**TABLE-4.3**

**SIGNIFICANCE OF MEAN GAINS /LOSSES BETWEEN PRE AND POST TEST OF RESISTANCE TRAINING FOR FIRST SIX WEEKS FOLLOWED BY COMPLEX TRAINING OF RESISTANCE TRAINING WITH MATCHED PLYOMETRIC TRAINING FOR ANOTHER SIX WEEKS ON MUSCLE FITNESS PARAMETERS, PHYSIOLOGICAL AND SKILL PERFORMANCE VARIABLES AND OVERALL PLAYING ABILITY**

| Variables | Pre test mean ±SD | Post test mean ± SD | M. D | SEM | 't'-ratio |
|---|---|---|---|---|---|
| ***Muscle fitness Parameters*** | | | | | |
| Upper body Muscular Strength (in Kilograms) | 51.50 ±6.48 | 56.95 ±6.35 | 5.45 | 0.34 | 16.21* |
| Lower body Muscular Strength (in Kilograms) | 53.90 ±4.54 | 59.20 ±4.44 | 5.30 | 0.22 | 24.22* |
| Abdominal Muscular Strength and Endurance (in Numbers) | 33.95 ±3.71 | 37.80 ±3.74 | 3.85 | 0.18 | 21.19* |
| Upper body Muscular Power (in Meters) | 6.61 ±0.21 | 7.14 ±0.241 | 0.54 | 0.04 | 11.93* |
| Lower body Muscular Power (in Centimeters) | 46.60 ±6.23 | 56.60 ±5.40 | 10.00 | 0.84 | 11.86* |
| ***Physiological Parameters*** | | | | | |
| Aerobic Capacity (in ml/kg/min) | 55.64 ±3.75 | 60.59 ±2.91 | 4.96 | 0.38 | 13.21* |
| Anaerobic Capacity (in Kg/mts/sec) | 1221.10 ±109.85 | 1350.7 ±74.91 | 129.60 | 12.61 | 10.28* |
| ***Skill performance variables*** | | | | | |
| Serving Ability (in points) | 26.75 ±3.55 | 31.70 ±3.45 | 4.95 | 0.20 | 24.96* |
| Passing Ability (in points) | 21.30 ±2.18 | 25.60 ±2.50 | 4.30 | 0.24 | 17.79* |
| Overall Playing Ability (in points) | 5.15 ±0.35 | 6.10 ±0.39 | 0.95 | 0.05 | 17.44* |

*Significant at 0.05 level

Table – 4.3 indicates the obtained 't' ratio for all the muscle fitness parameters, physiological and skill performance variables. The obtained t-ratios were 16.21(upper body muscular strength), 24.22 (lower body muscular strength), 21.19 (abdominal muscular strength and endurance), 11.93 (upper body muscular power), 11.86 (lower body muscular power), 13.21 (aerobic capacity), 10.28 (anaerobic capacity), 24.96 (serving ability), 17.79 (passing ability) and 17.44 (overall playing ability). The obtained 't' ratios on muscle fitness parameters, physiological and skill performance variables were greater than the critical value of 2.09 for degrees of freedom 19. It was observed that the mean gains and losses made from pre-test and post-test were statistically significant resulting that twelve weeks practice of resistance training for first six weeks followed by complex training of resistance training with matched plyometric training for another six weeks on muscle fitness parameters, physiological and skill performance variables produced significant improvement in upper body muscular strength ($5.30p<0.05$), lower body muscular strength ($5.10p<0.05$), abdominal muscular strength and endurance ($3.85p<0.05$), upper body muscular power ($0.54p<0.05$), lower body muscular power ($10.0p<0.05$), aerobic capacity($4.96<0.05$),anaerobic capacity ($129.60p<0.05$), serving ability ($4.95p<0.05$), passing ability ($4.30p<0.05$) and overall playing ability ($0.95p<0.05$) from the performance of baseline. Thus the formulated hypothesis No.1 is accepted.

**TABLE- 4.4**

**SIGNIFICANCE OF MEAN GAINS /LOSSES BETWEEN PRE AND POST TEST OF TRADITIONAL TRAINING GROUPS ON MUSCLE FITNESS PARAMETERS, PHYSIOLOGICAL AND SKILL PERFORMANCE VARIABLES AND OVERALL PLAYING ABILITY**

| Variables | Pre test mean ±SD | Post test mean ± SD | M. D | SEM | 't'-ratio |
|---|---|---|---|---|---|
| ***Muscle fitness Parameters*** | | | | | |
| Upper body Muscular Strength (in Kilograms) | 51.05 ±3.43 | 51.45 ±3.52 | 0.40 | 0.33 | 1.22 |
| Lower body Muscular Strength (in Kilograms) | 53.05 ±2.70 | 53.55 ±3.02 | 0.50 | 0.26 | 1.95 |
| Abdominal Muscular Strength and Endurance (in Numbers) | 33.05 ±5.66 | 33.40 ±5.58 | 0.350 | 0.21 | 1.68 |
| Upper body Muscular Power (in Meters) | 6.42 ±0.27 | 6.44 ±0.24 | 0.12 | 0.015 | 1.13 |
| Lower body Muscular Power (in Centimeters) | 45.90 ±7.87 | 46.40 ±8.53 | 0.50 | 0.25 | 2.03 |
| ***Physiological Parameters*** | | | | | |
| Aerobic Capacity (in ml/kg/min) | 54.46 ±5.67 | 54.71 ±5.23 | 0.25 | 0.33 | 0.77 |
| Anaerobic Capacity (in Kg/mts/sec) | 1232.40 ± 106.78 | 1233.60 ±103.16 | 1.18 | 7.17 | 0.16 |
| ***Skill performance variables*** | | | | | |
| Serving Ability (in points) | 27.40 ±4.49 | 27.90 ±4.15 | 0.50 | 0.53 | 0.95 |
| Passing Ability (in points) | 19.75 ±2.45 | 20.20 ±2.55 | 0.45 | 0.22 | 2.02 |
| Overall Playing Ability (in points) | 5.05 ±0.34 | 5.08 ±0.38 | 0.03 | 0.03 | 1.17 |

*significant

Table – 4.4 indicates the obtained t-ratio for all the muscle fitness parameters, physiological and skill performance variables. The obtained t-ratios were: 1.22(upper body muscular strength), 1.95 (lower body muscular strength), 1.68 (abdominal muscular strength and endurance), 1.13 (upper body muscular power), 2.03 (lower body muscular power), 0.77 (aerobic capacity), 0.16 (anaerobic capacity), 0.95 (serving ability), 2.02 (passing ability) and 1.17 (overall playing ability). The obtained't' ratios on muscle fitness parameters, physiological and skill performance variables were lesser than the critical value of 2.09 for degrees of freedom 19. It is observed that the mean gains and losses made from pre and post-test statistically insignificant, resulting that they did not make any significant change from the baseline performance.

The pre-test and post-test mean differences of Combination of Resistance Training followed by Plyometric Training in the same session (CTRTPT), Complex Training of Resistance Training followed by Matched Plyometric Training in the same session (CTRTMPT), Resistance Training for first six weeks followed by Complex Training of Resistance Training with Matched Plyometric Training for another six weeks (RTCTRTMPT) and Control Group (CG) on upper body muscular strength, lower body muscular strength, abdominal muscular strength and endurance, upper body muscular power, lower body muscular power, aerobic capacity, anaerobic capacity, serving ability, passing ability, and overall playing ability are graphically represented in Figure 4.1 to 4.10.

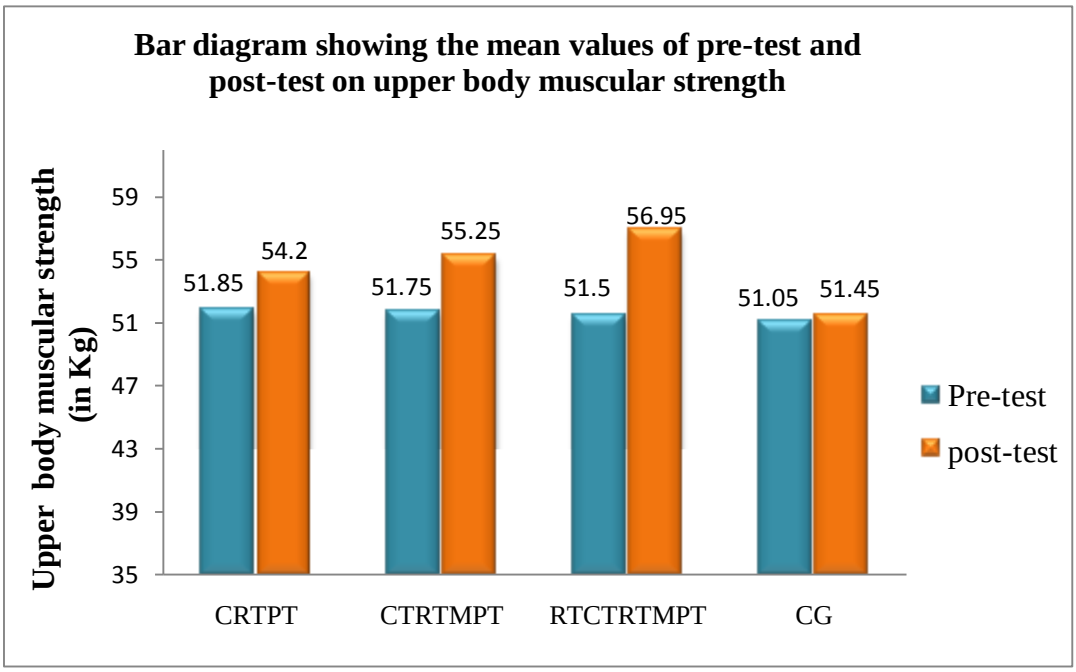
Bar diagram showing the mean values of pre-test and post-test on upper body muscular strength
Upper body muscular strength (in Kg)
59
55
51
47
43
39
35
51.85
54.2
51.75
55.25
51.5
56.95
51.05
51.45
CRTPT
CTRTMPT
RTCTRTMPT
CG
Pre-test
post-test

**Fig. 4.1**

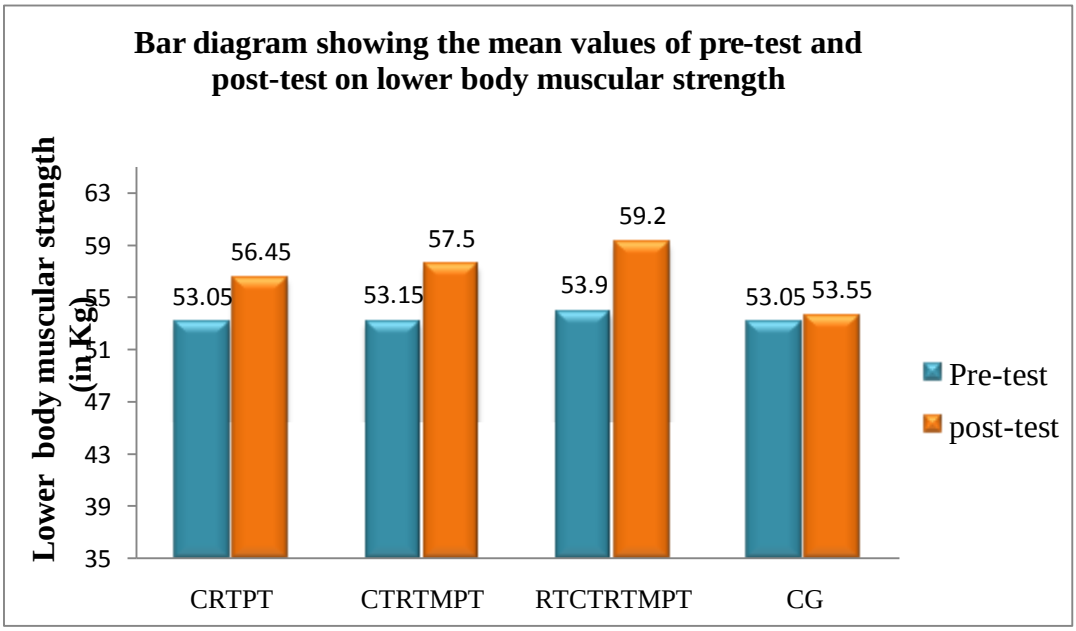
Bar diagram showing the mean values of pre-test and post-test on lower body muscular strength
Lower body muscular strength (in Kg)
63
59
55
51
47
43
39
35
53.05
56.45
53.15
57.5
53.9
59.2
53.05
53.55
CRTPT
CTRTMPT
RTCTRTMPT
CG
Pre-test
post-test

**Fig. 4.2**

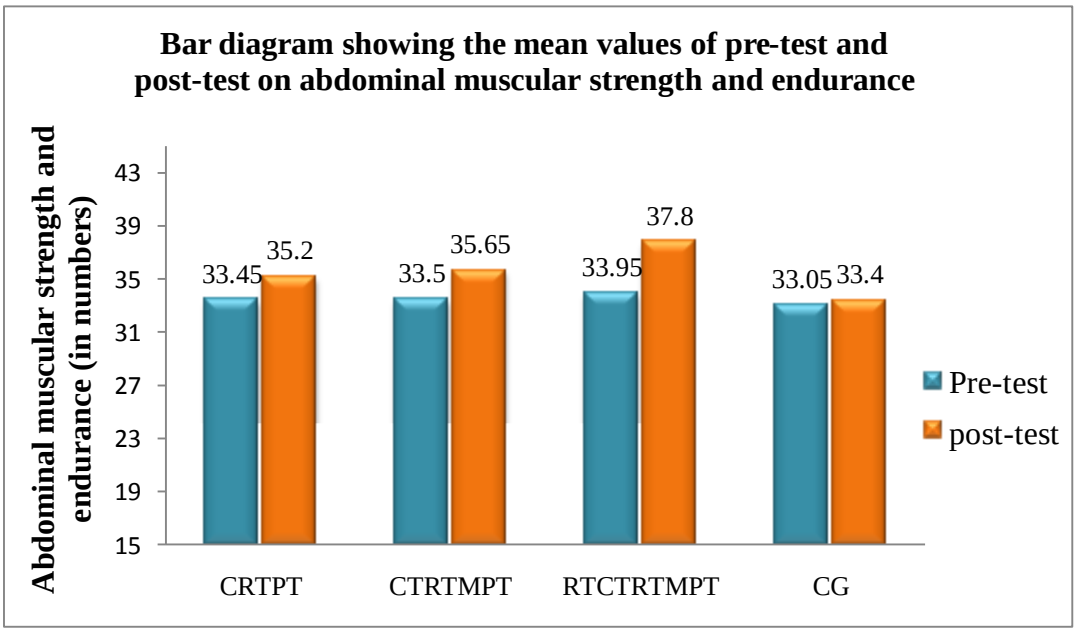
Bar diagram showing the mean values of pre-test and post-test on abdominal muscular strength and endurance
Abdominal muscular strength and endurance (in numbers)
43
39
35
31
27
23
19
15
33.45
35.2
33.5
35.65
33.95
37.8
33.05
33.4
CRTPT
CTRTMPT
RTCTRTMPT
CG
Pre-test
post-test

**Fig. 4.3**

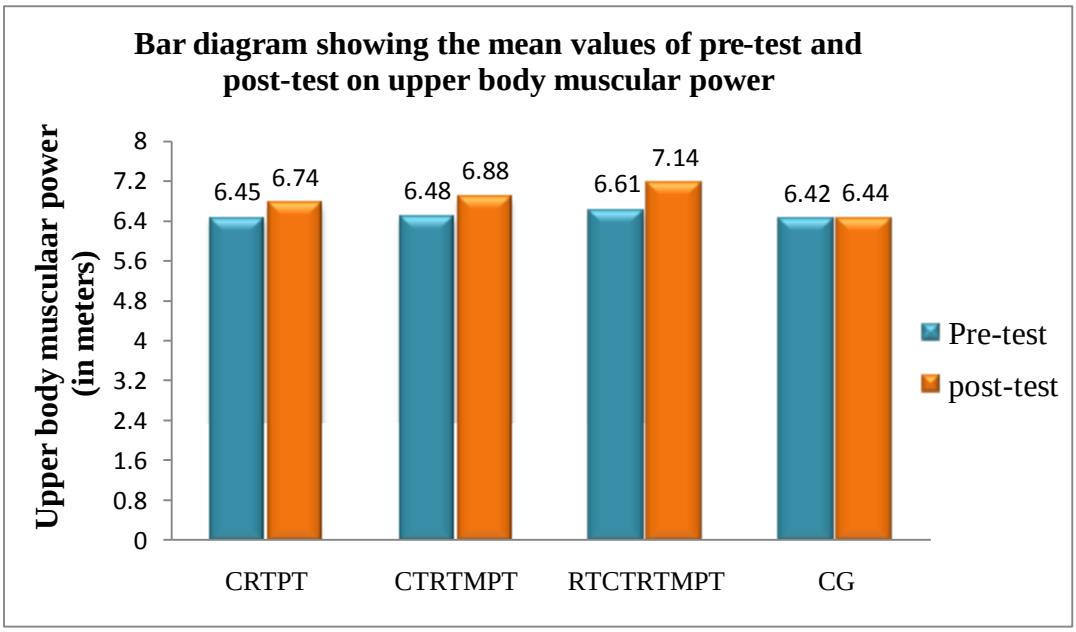
Bar diagram showing the mean values of pre-test and post-test on upper body muscular power
Upper body musculaar power (in meters)
8
7.2
6.4
5.6
4.8
4
3.2
2.4
1.6
0.8
0
6.45
6.74
6.48
6.88
6.61
7.14
6.42
6.44
CRTPT
CTRTMPT
RTCTRTMPT
CG
Pre-test
post-test

**Fig. 4.4**

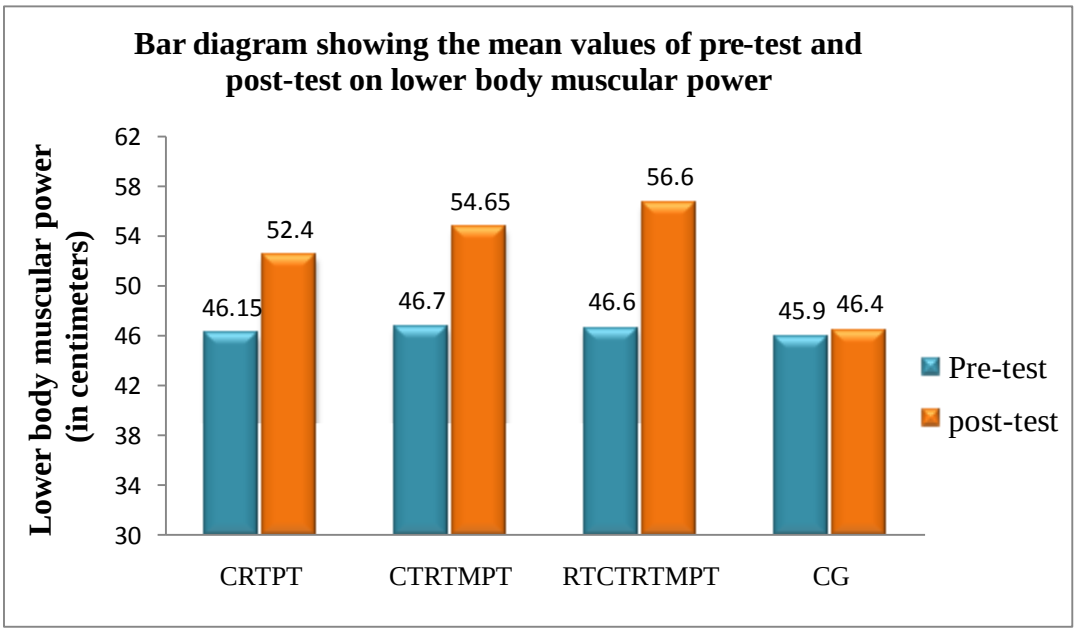
Bar diagram showing the mean values of pre-test and post-test on lower body muscular power
Lower body muscular power (in centimeters)
62
58
54
50
46
42
38
34
30
46.15
52.4
46.7
54.65
46.6
56.6
45.9
46.4
CRTPT
CTRTMPT
RTCTRTMPT
CG
Pre-test
post-test

**Fig. 4.5**

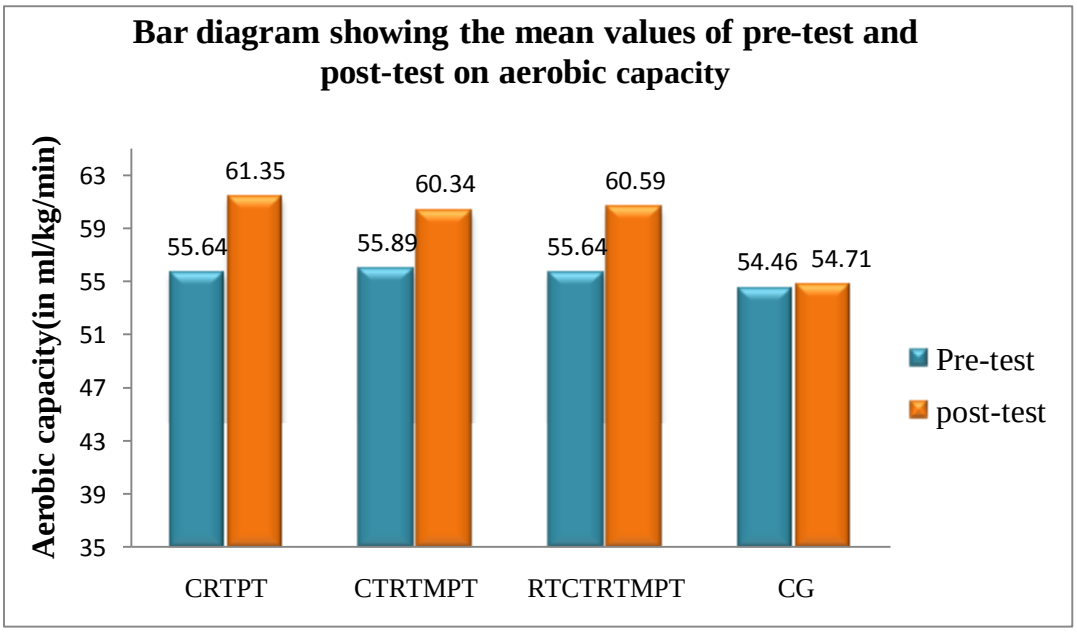
Bar diagram showing the mean values of pre-test and post-test on aerobic capacity
Aerobic capacity(in ml/kg/min)
63
59
55
51
47
43
39
35
55.64
61.35
55.89
60.34
55.64
60.59
54.46
54.71
CRTPT
CTRTMPT
RTCTRTMPT
CG
Pre-test
post-test

**Fig. 4.6**

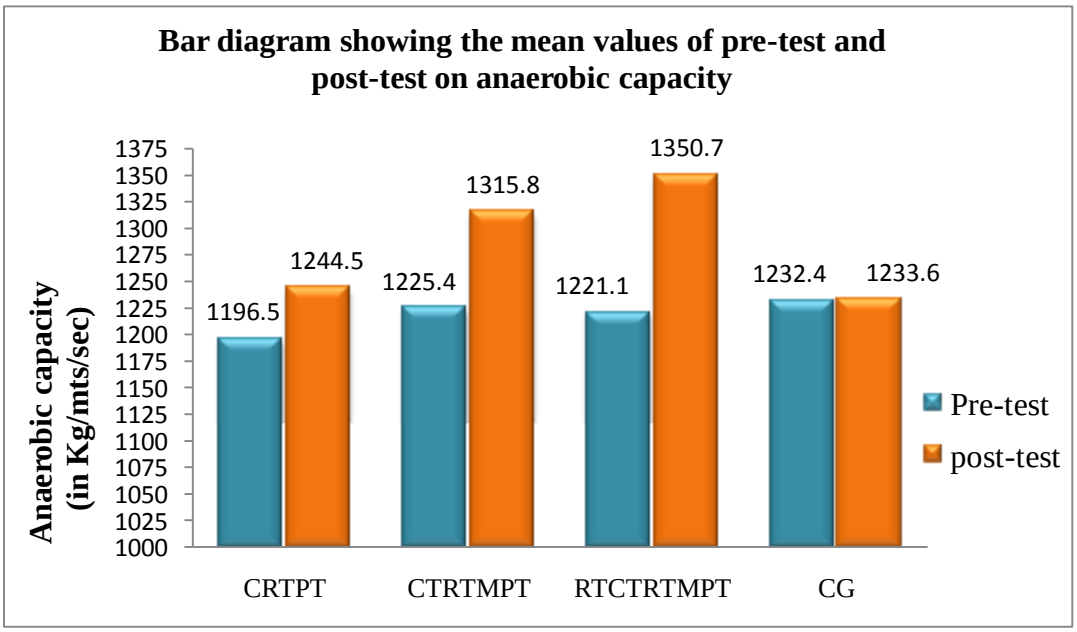
Bar diagram showing the mean values of pre-test and post-test on anaerobic capacity
Anaerobic capacity (in Kg/mts/sec)
1375
1350
1325
1300
1275
1250
1225
1200
1175
1150
1125
1100
1075
1050
1025
1000
1196.5
1244.5
1225.4
1315.8
1221.1
1350.7
1232.4
1233.6
CRTPT
CTRTMPT
RTCTRTMPT
CG
Pre-test
post-test

**Fig. 4.7**

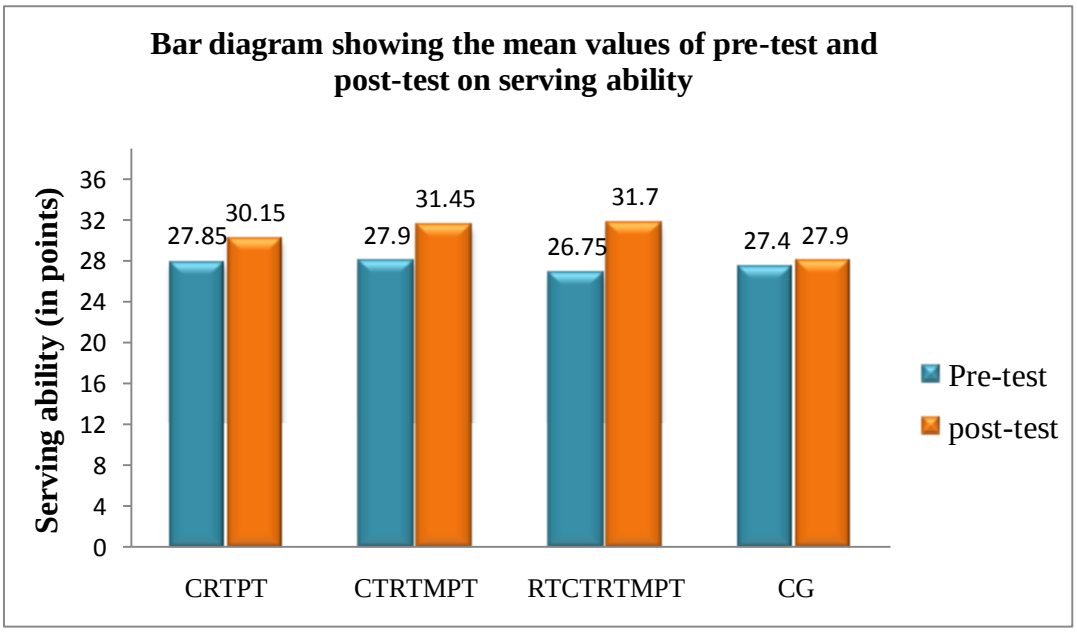
Bar diagram showing the mean values of pre-test and post-test on serving ability
Serving ability (in points)
36
32
28
24
20
16
12
8
4
0
27.85
30.15
27.9
31.45
26.75
31.7
27.4
27.9
CRTPT
CTRTMPT
RTCTRTMPT
CG
Pre-test
post-test

**Fig. 4.8**

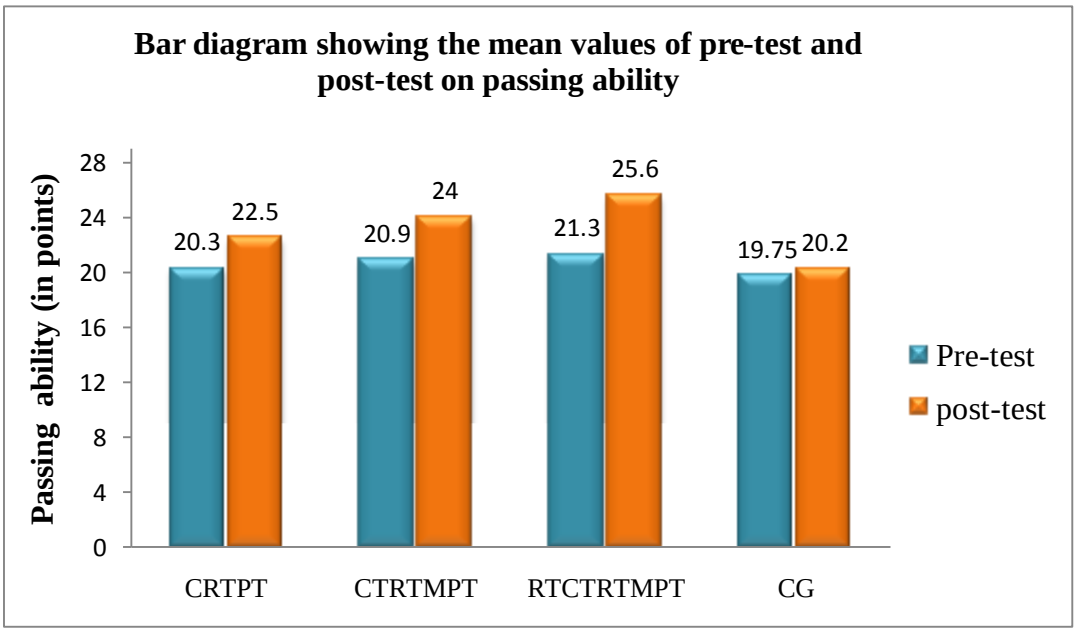


**Fig. 4.9**

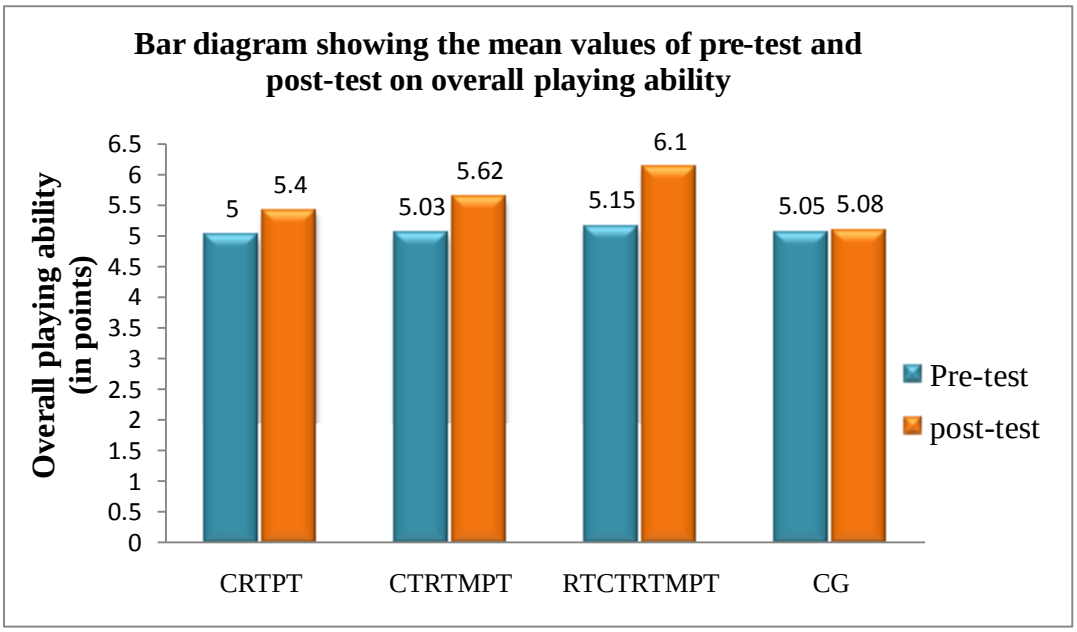


**Fig. 4.10**

## 4.3 RESULTS OF ANALYSIS OF VARIANCE ON PRE-TEST MEANS

In the initial data analysis, of variance('F' test) was applied to find out the significance of mean difference in the pre-test among the four groups namely Combination of Resistance Training followed by Plyometric Training in the same session (CRTPT), Complex Training of Resistance Training followed by Matched Plyometric Training in the same session (CTRTMPT), Resistance Training for first six weeks followed by Complex Training of Resistance Training with Matched Plyometric Training for another six weeks (RTCTRTMPT) and Control Group (CG) on muscle fitness parameters, physiological and skill performance variables. The analysis is presented in table 4.5

**TABLE – 4.5**

**ANALYSIS OF VARIANCE ON PRE-TEST MEANS AMONG THE CRTPT, CTRTMPT, RTCTRTMPT AND TG ON MUSCLE FITNESS PARAMETERS, PHYSIOLOGICAL AND SKILL PERFORMANCE VARIABLES AND OVERALL PLAYING ABILITY**

| S.No | Variables | Source of variance | Sum of Square | df | Means Square | 'F' ratio |
|---|---|---|---|---|---|---|
| | ***Muscle fitness parameters*** | | | | | |
| 1 | Upper body Muscular Strength (in kg ) | Between Sets | 7.64 | 3.00 | 2.55 | 0.10 |
| | | Within Sets | 1982.25 | 76.00 | 26.08 | |
| 2 | Lower body Muscular Strength (in kg ) | Between Sets | 10.14 | 3.00 | 3.38 | 0.28 |
| | | Within Sets | 912.25 | 76.00 | 12.00 | |
| 3 | Abdominal Muscular strength and endurance ( in numbers) | Between Sets | 8.14 | 3.00 | 2.71 | 0.12 |
| | | Within Sets | 1665.85 | 76.00 | 21.92 | |
| 4 | Upper body Muscular Power (in meters) | Between Sets | 0.40 | 3.00 | 0.13 | 2.05 |
| | | Within Sets | 4.92 | 76.00 | 0.06 | |
| 5 | Lower body Muscular Power (in centimeters) | Between Sets | 8.54 | 3.00 | 2.85 | 0.06 |
| | | Within Sets | 3907.35 | 76.00 | 51.41 | |
| ***Physiological Parameteres*** | | | | | | |
| 6 | Aerobic Capacity ((in ml/kg/min)) | Between Sets | 26.64 | 3.00 | 8.88 | 0.45 |
| | | Within Sets | 1490.37 | 76.00 | 19.61 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 7 | Anaerobic Capacity (in Kg/mts/sec) | Between Sets | 14645.24 | 3.00 | 4881.75 | 0.48 |
| | | Within Sets | 773062.4 | 76.00 | 10171.88 | |
| ***Skill performance variables*** | | | | | | |
| 8 | Serving (in points) | Between Sets | 17.05 | 3.00 | 5.68 | 0.35 |
| | | Within Sets | 1240.90 | 76.00 | 16.33 | |
| 9 | Passing (in points) | Between Sets | 27.74 | 3.00 | 9.25 | 1.30 |
| | | Within Sets | 541.95 | 76.00 | 7.13 | |
| 10 | Overall playing ability (in rating scale) | Between Sets | 0.27 | 3.00 | 0.09 | 0.80 |
| | | Within Sets | 8.71 | 76.00 | 0.11 | |

Table – 4.5 reveals the obtained 'F' values on pre-test means among the four groups. The obtained 'F'ratios were: 0.10(upper body muscular strength), 0.28 (lower body muscular strength), 0.12 (abdominal muscular strength and endurance), 2.05 (upper body muscular power), 0.06 (lower body muscular power), 0.45 (aerobic capacity), 0.48 (anaerobic capacity), 0.35 (serving ability), 1.30 (passing ability) and 0.80 (overall playing ability). The 'F' values observed on these variables are not significant since it fails to reach the critical ratio of 2.73 for degree of freedom 3, 76 at 0.05 levels. Based on the results it is inferred that the mean differences among the four groups of Combination of Resistance Training followed by Plyometric Training in the same session (CRTPT, Group - I), Complex Training of Resistance Training followed by Matched Plyometric Training in the same session (CTRTMPT, Group - II), Resistance Training for first six weeks followed by Complex Training of Resistance Training with Matched Plyometric Training for another six weeks (RTCTRTMPT, Group - III) and Control Group (CG, Group – IV) on muscle fitness parameters, physiological and skill performance variables (Fig 4.1 to 4.10) used in this study before the start of the respective treatments are found to be insignificant. Thus this analysis confirms the random assignment of subjects into four groups are successful.

## 4.4 RESULTS OF ANALYSIS OF VARIANCE ON POST-TEST MEANS

In the analysis of variance on post-test means, F' test was applied to find out the significance of mean differences in the post-test among the four groups namely Combination of Resistance Training followed by Plyometric Training in the same session (CRTPT, Group - I), Complex Training of Resistance Training followed by Matched Plyometric Training in the same session (CTRTMPT, Group - II), Resistance Training for first six weeks followed by Complex Training of Resistance Training with Matched Plyometric Training for another six weeks (RTCTRTMPT, Group - III) and Control Group (CG, Group – IV) on muscle fitness parameters, physiological and skill performance variables. The analysis is presented in table 4.6

**TABLE – 4.6**

**ANALYSIS OF VARIANCE ON POST-TEST MEANS AMONG THE CRTPT, CRTMPT, RTCRTMPT AND TG ON MUSCLE FITNESS PARAMETERS, PHYSIOLOGICAL PARAMETERS AND SKILL PERFORMANCE VARIABLES AND OVERALL PLAYING ABILITY**

| S.No | Variables | Source of variance | Sum of Square | df | Means Square | 'F' ratio |
|---|---|---|---|---|---|---|
| | ***Muscle fitness parameters*** | | | | | |
| 1 | Upper body Muscular Strength (in kg ) | Between Sets | 319.04 | 3.00 | 106. 35 | 4.16* |
| | | Within Sets | 1944.85 | 76.00 | 25.59 | |
| 2 | Lower body Muscular Strength (in kg ) | Between Sets | 370.45 | 3.00 | 112.48 | 10.01* |
| | | Within Sets | 854.10 | 76.00 | 11.24 | |
| 3 | Abdominal Muscular strength and endurance ( in numbers) | Between Sets | 199.24 | 3.00 | 66.41 | 3.06* |
| | | Within Sets | 1652.15 | 76.00 | 21.74 | |
| 4 | Upper body Muscular Power (in meters) | Between Sets | 5.17 | 3.00 | 1.72 | 28.88* |
| | | Within Sets | 4.54 | 76.00 | 0.06 | |
| 5 | Lower body Muscular Power (in centimeters) | Between Sets | 1173.04 | 3.00 | 391.01 | 7.86* |
| | | Within Sets | 3778.95 | 76.00 | 49.72 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| ***Physiological Parameteres*** | | | | | | |
| 6 | Aerobic Capacity ((in ml/kg/min)) | Between Sets | 512.09 | 3.00 | 170.70 | 11.18* |
| | | Within Sets | 1160.15 | 76.00 | 15.27 | |
| 7 | Anaerobic Capacity (in Kg/mts/sec) | Between Sets | 1191138.49 | 3.00 | 63712.83 | 8.79* |
| | | Within Sets | 551059.16 | 76.00 | 7250.78 | |
| ***Skill performance variables*** | | | | | | |
| 8 | Serving (in points) | Between Sets | 181.30 | 3.00 | 60.43 | 4.30* |
| | | Within Sets | 1067.50 | 76.00 | 14.05 | |
| 9 | Passing (in points) | Between Sets | 316.55 | 3.00 | 105.52 | 14.19* |
| | | Within Sets | 565.00 | 76.00 | 7.43 | |
| 10 | Overall playing ability (in rating scale) | Between Sets | 11.03 | 3.00 | 3.68 | 28.99* |
| | | Within Sets | 9.64 | 76.00 | 0.13 | |

*Significant at 0.05 level.

Table – 4.6 reveals the obtained 'F' values on post-test means among the four groups. The obtained 'F' ratios were: 4.16(upper body muscular strength), 10.01 (lower body muscular strength), 3.06 (abdominal muscular strength and endurance), 28.88 (upper body muscular power), 7.86 (lower body muscular power), 11.18 (aerobic capacity), 8.79 (anaerobic capacity), 4.30 (serving ability), 14.19 (passing ability) and 28.99 (overall playing ability). Since the observed F- values on post-test means among the groups namely Combination of Resistance Training followed by Plyometric Training in the same session (CRTPT, Group - I), Complex Training of Resistance Training followed by Matched Plyometric Training in the same session (CTRTMPT, Group - II), Resistance Training for first six weeks followed by Complex Training of Resistance Training with Matched Plyometric Training for another six weeks (RTCTRTMPT, Group - III) and Control Group (CG, Group – IV) on muscle fitness parameters, physiological and skill performance variables are highly significant as the values are higher than the required critical value 2.73. Thus the results obtained proved that the

interventions namely Combination of Resistance Training followed by Plyometric Training in the same session (CRTPT, Group - I), Complex Training of Resistance Training followed by Matched Plyometric Training in the same session (CTRTMPT, Group - II), Resistance Training for first six weeks followed by Complex Training of Resistance Training with Matched Plyometric Training for another six weeks (RTCTRTMPT, Group - III) and Control Group (CG, Group – IV) produced significantly different improvements among themselves.

## 4.5 RESULTS OF ANALYSIS OF CO-VARIANCE ON ADJUSTED POST-TEST MEANS

Since individuals and group differ in their initial scores, analysis of covariance was applied to determine whether the training programmes produced significantly different improvements in each variable. The analysis is presented in Table 4.7

**TABLE – 4.7**

**ANALYSIS OF CO-VARIANCE ON ADJUSTED POST-TEST MEANS AMONG THE CRTPT, CTRTMPT, RTCTRTMPT AND TG ON MUSCLE FITNESS PARAMETERS, PHYSIOLOGICAL PARAMETERS AND SKILL PERFORMANCE VARIABLES AND OVERALL PLAYING ABILITY**

| S.No | Variables | Source of variance | Sum of Square | df | Means Square | 'F' ratio |
|---|---|---|---|---|---|---|
| | ***Muscle fitness parameters*** | | | | | |
| 1 | Upper body Muscular Strength (in kg ) | Between Sets | 269.68 | 3.00 | 89.89 | 60.00* |
| | | Within Sets | 112.36 | 75.00 | 1.50 | |
| 2 | Lower body Muscular Strength (in kg ) | Between Sets | 262.39 | 3.00 | 87.46 | 87.14* |
| | | Within Sets | 75.28 | 75.00 | 1.00 | |
| 3 | Abdominal Muscular strength and endurance ( in numbers) | Between Sets | 127.89 | 3.00 | 42.63 | 73.83* |
| | | Within Sets | 43.30 | 75.00 | 0.58 | |
| 4 | Upper body Muscular Power | Between Sets | 3.16 | 3.00 | 1.05 | 56.92* |

| | | | | | | |
|---|---|---|---|---|---|---|
| | (in meters) | Within Sets | 1.39 | 75.00 | 0.02 | |
| 5 | Lower body Muscular Power (in centimeters) | Between Sets | 1009.13 | 3.00 | 336.38 | 67.05* |
| | | Within Sets | 376.26 | 75.00 | 5.02 | |
| ***Physiological Parameteres*** | | | | | | |
| 6 | Aerobic Capacity (in ml/kg/min) | Between Sets | 350.62 | 3.00 | 116.87 | 69.14* |
| | | Within Sets | 126.78 | 75.00 | 2.69 | |
| 7 | Anaerobic Capacity (in Kg/mts/sec) | Between Sets | 182583.38 | 3.00 | 60861.13 | 37.26* |
| | | Within Sets | 122498.66 | 75.00 | 1633.32 | |
| ***Skill performance variables*** | | | | | | |
| 8 | Serving (in points) | Between Sets | 207.69 | 3.00 | 69.23 | 38.93* |
| | | Within Sets | 133.36 | 75.00 | 1.78 | |
| 9 | Passing (in points) | Between Sets | 156.48 | 3.00 | 52.16 | 52.26* |
| | | Within Sets | 74.85 | 75.00 | 1.00 | |
| 10 | Overall playing ability (in rating scale) | Between Sets | 9.01 | 3.00 | 3.00 | 63.83* |
| | | Within Sets | 3.53 | 75.00 | 0.05 | |

*Significant at 0.05 level.

The F-ratio obtained from testing the adjusted post-test means among the four groups on muscle fitness parameters, physiological parameters and skill performance variables are shown in table 4.7. The obtained‘F’ values were: 60.00 (upper body muscular strength), 87.14 (lower body muscular strength), 73.83 (abdominal muscular strength and endurance), 56.92 (upper body muscular power), 67.05 (lower body muscular power), 69.14 (aerobic capacity), 37.26 (anaerobic capacity) 38.93 (serving ability), 52.26 (passing ability) and 63.83 (overall playing ability). The observed F-values on adjusted post-test means among the groups of Combination of Resistance Training followed by Plyometric Training in the same session (CRTPT, Group - I), Complex Training of Resistance Training followed by Matched Plyometric Training

in the same session (CTRTMPT, Group - II), Resistance Training for first six weeks followed by Complex Training of Resistance Training with Matched Plyometric Training for another six weeks (RTCTRTMPT, Group - III) and Control Group (CG, Group – IV) on muscle fitness parameters, physiological and skill performance variables are found to be higher than the required critical value 2.73 at 0.05 level of confidence for df 2,75. This means that the null hypothesis is rejected and it is concluded that there is a significant mean differences among the four treatment groups in developing the selected muscle fitness parameters, physiological and skill performance variables. In order to find out which intervention programme used in the present study is the source for the significance of adjusted means was tested by Schefee's post hoc test. The results of the same are presented in the table 4.8.

**TABLE – 4.8**

**SCHEFFE'S TEST FOR THE DIFFERENCE BETWEEN PAIRED ADJUSTED POST TEST MEANS**

| S.No | Adjusted post-test Means | | | | | M.D | F-Value | Critical value |
|---|---|---|---|---|---|---|---|---|
| | Variables | CRTPT | CTRTMPT | RTCTRTMPT | TTG | | | |
| 1 | Upper body Muscular Strength (in kg) | 53.90 | 55.05 | ---- | ---- | 1.15 | 8.77* | 8.19 |
| | | 53.90 | ---- | 56.99 | ---- | 3.09 | 63.59* | 8.19 |
| | | 53.90 | ---- | ---- | 51.92 | 1.98 | 26.19* | 8.19 |
| | | ---- | 55.05 | 56.99 | ---- | 1.94 | 25.13* | 8.19 |
| | | ---- | 55.05 | ---- | 51.92 | 3.13 | 65.27* | 8.19 |
| | | ---- | ---- | 56.99 | 51.92 | 5.07 | 171.40* | 8.19 |
| 2 | Lower body Muscular Strength (in kg) | 56.67 | 57.63 | ---- | ---- | 0.96 | 9.14* | 8.19 |
| | | 56.67 | ---- | 58.63 | ---- | 1.96 | 38.45* | 8.19 |
| | | 56.67 | ---- | ---- | 53.77 | 2.90 | 83.79* | 8.19 |
| | | ---- | 57.63 | 58.63 | ---- | 1.00 | 10.10* | 8.19 |
| | | ---- | 57.63 | ---- | 53.77 | 3.86 | 148.26* | 8.19 |
| | | ---- | ---- | 58.63 | 53.77 | 4.86 | 235.77* | 8.19 |
| 3 | Abdominal Muscular Strength and Endurance ( in numbers) | 35.24 | 35.94 | ---- | ---- | 0.70 | 8.51* | 8.19 |
| | | 35.24 | ---- | 37.35 | ---- | 2.11 | 77.01* | 8.19 |
| | | 35.24 | ---- | ---- | 33.83 | 1.41 | 33.28* | 8.19 |
| | | ---- | 35.94 | 37.35 | ---- | 1.41 | 34.32* | 8.19 |
| | | ---- | 35.94 | ---- | 33.83 | 2.11 | 76.94* | 8.19 |
| | | ---- | ---- | 37.35 | 33.83 | 3.52 | 214.05* | 8.19 |
| 4 | Upper body Muscular Power (in meters) | 6.77 | 6.89 | ---- | ---- | 0.12 | 7.51* | 8.19 |
| | | 6.77 | ---- | 7.05 | ---- | 0.28 | 40.31* | 8.19 |
| | | 6.77 | ---- | ---- | 6.49 | 0.28 | 44.01* | 8.19 |
| | | ---- | 6.89 | 7.05 | ---- | 0.16 | 13.03* | 8.19 |
| | | ---- | 6.89 | ---- | 6.49 | 0.40 | 87.88* | 8.19 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | ---- | ---- | 7.05 | 6.49 | 0.56 | 168.57* | 8.19 |
| **5** | **Lower body Muscular Power (in centimeters)** | 52.57 | 54.31 | ---- | ---- | 1.74 | 6.01* | 8.19 |
| | | 52.57 | ---- | 56.36 | ---- | 3.79 | 28.48* | 8.19 |
| | | 52.57 | ---- | ---- | 46.81 | 5.76 | 66.29* | 8.19 |
| | | ---- | 54.31 | 56.36 | ---- | 2.05 | 8.32* | 8.19 |
| | | ---- | 54.31 | ---- | 46.81 | 7.5 | 112.23* | 8.19 |
| | | ---- | ---- | 56.36 | 46.81 | 9.55 | 181.67* | 8.19 |
| **6** | **Aerobic capacity (in ml/kg/min)** | 58.70 | 59.97 | ---- | ---- | 1.27 | 9.60* | 8.19 |
| | | 58.70 | ---- | 61.19 | ---- | 2.49 | 36.74* | 8.19 |
| | | 58.70 | ---- | ---- | 55.54 | 3.16 | 59.26* | 8.19 |
| | | ---- | 59.97 | 61.19 | ---- | 1.22 | 8.77* | 8.19 |
| | | ---- | 59.97 | ---- | 55.54 | 4.43 | 116.57* | 8.19 |
| | | ---- | ---- | 61.19 | 55.54 | 5.65 | 189.30* | 8.19 |
| **7** | **Anaerobic capacity (in Kg/mts/sec)** | 1260.91 | 1310.90 | ---- | ---- | 49.99 | 15.30* | 8.19 |
| | | 1260.91 | ---- | 1349.05 | ---- | 88.14 | 47.56* | 8.19 |
| | | 1260.91 | ---- | ---- | 1223.51 | 37.4 | 8.57* | 8.19 |
| | | ---- | 1310.90 | 1349.05 | ---- | 38.15 | 8.91* | 8.19 |
| | | ---- | 1310.90 | ---- | 1223.51 | 87.39 | 46.76* | 8.19 |
| | | ---- | ---- | 1349.05 | 1223.51 | 125.54 | 96.49* | 8.19 |
| **8** | **Serving Ability (in Points)** | 29.82 | 31.08 | ---- | ---- | 1.26 | 8.88* | 8.19 |
| | | 29.82 | ---- | 32.33 | ---- | 2.51 | 35.27* | 8.19 |
| | | 29.82 | ---- | ---- | 27.97 | 1.85 | 19.45* | 8.19 |
| | | ---- | 31.08 | 32.33 | ---- | 1.25 | 8.76* | 8.19 |
| | | ---- | 31.08 | ---- | 27.97 | 3.11 | 54.61* | 8.19 |
| | | ---- | ---- | 32.33 | 27.97 | 4.36 | 107.10* | 8.19 |
| **9** | **Passing Ability (in Points)** | 22.75 | 23.68 | ---- | ---- | 0.93 | 8.66 | 8.19 |
| | | 22.75 | ---- | 24.90 | ---- | 2.15 | 46.27* | 8.19 |
| | | 22.75 | ---- | ---- | 20.97 | 1.78 | 31.64* | 8.19 |
| | | ---- | 23.68 | 24.90 | ---- | 1.22 | 14.90* | 8.19 |
| | | ---- | 23.68 | ---- | 20.97 | 2.71 | 73.39* | 8.19 |
| | | ---- | ---- | 24.90 | 20.97 | 3.93 | 154.49* | 8.19 |
| **10** | **Overall playing ability (in Points)** | 5.45 | 5.65 | ---- | ---- | 0.20 | 8.33* | 8.19 |
| | | 5.45 | ---- | 6.02 | ---- | 0.52 | 68.96* | 8.19 |
| | | 5.45 | ---- | ---- | 5.09 | 0.36 | 28.30* | 8.19 |
| | | ---- | 5.65 | 6.02 | ---- | 0.37 | 29.36* | 8.19 |
| | | ---- | 5.65 | ---- | 5.09 | 0.56 | 67.34* | 8.19 |
| | | ---- | ---- | 6.02 | 5.09 | 0.12 | 185.62* | 8.19 |

***Significance at 0.05 level.**

Table 4.8 shows the F-ratio on paired adjusted post-test means on variables among the treatment groups namely Combination of Resistance Training followed by Plyometric Training in the same session (CRTPT), Complex Training of Resistance Training followed by Matched Plyometric Training in the same session (CTRTMPT), Resistance Training for first six weeks followed by Complex Training of Resistance Training with Matched Plyometric Training for another six weeks (RTCTRTMPT) and Control Group (CG). The obtained F value to be significant at 0.05 levels, the required critical value is 8.19. When the adjusted post test means of treatment groups were compared with the adjusted post-test mean of the Control group on muscle fitness parameters, physiological and skill performance variables it is observed that the obtained F ratios were higher than the required critical value of 8.19. Thus it is concluded that the treatment groups namely Combination of Resistance Training followed by Plyometric Training in the same session (CRTPT), Complex Training of Resistance Training followed by Matched Plyometric Training in the same session (CTRTMPT), Resistance Training for first six weeks followed by Complex Training of Resistance Training with Matched Plyometric Training for another six weeks (RTCTRTMPT) improved the selected variables better than the Control Group (CG).

### 4.8.1 Comparing the Effect of Combination of Resistance Training followed by Plyometric Training in the same session (CRTPT) with Complex Training of Resistance Training followed by Matched Plyometric Training in the same session (CTRTMPT)

In comparing the effect of combination of resistance training followed by plyometric training in the same session and complex training of resistance training followed by matched plyometric training in the same session on muscle fitness parameters, physiological and skill performance variables, from the obtained F-ratios, it is observed that CTRTMPT showed better performance on upper body muscular strength (8.77 P<.05), lower body muscular strength (9.14 P<.05), abdominal muscular strength and endurance (8.51 P<.05), upper body muscular power (7.51

P<.05), lower body muscular power (6.01P<.05), aerobic capacity (9.60 P<.05), anaerobic capacity (15.30 P<.05),serving ability (8.88 P<.05), passing ability (8.66 P<.05) and overall playing ability (8.33P<.05).

### 4.8.2. Comparing the Effect of Combination of Resistance Training followed by Plyometric Training in the same session (CRTPT) with Resistance Training for first six weeks followed by Complex Training of Resistance Training with Matched Plyometric Training for another six weeks (RTCTRTMPT)

In comparing the effect of combination of resistance training followed by plyometric training in the same session and resistance training for first six weeks followed by complex training of resistance training with matched plyometric training for another six weeks on muscle fitness parameters, physiological and skill performance variables, from the obtained F-ratios, it is observed that RTCTRTMPT showed superior performance on upper body muscular strength (63.59 P<.05), lower body muscular strength (38.45 P<.05), abdominal muscular strength and endurance (77.01 P<.05), upper body muscular power (40.31 P<.05), lower body muscular power (28.48 P<.05), aerobic capacity (36.74 P<.05), anaerobic capacity (47.56 P<.05),serving ability (35.27 P<.05), passing ability(46.27 P<.05) and overall playing ability (68.96 P<.05).

### 4.8.3. Comparing the Effect of Complex Training of Resistance Training followed by Matched Plyometric Training in the same session (CTRTMPT) with Resistance Training for first six weeks followed by Complex Training of Resistance Training with Matched Plyometric Training for another six weeks (RTCTRTMPT)

In comparing the effect of complex Training of resistance training followed by matched plyometric training in the same session with resistance training for first six weeks followed by complex Training of resistance training with matched plyometric training for another six weeks on muscle fitness parameters, physiological and skill performance variables, from the obtained F-ratios, it is observed that RTCTRTMPT showed superior performance on upper body muscular strength (25.13 P<.05), lower

body muscular strength (10.10 P<.05), abdominal muscular strength and endurance (34.32 P<.05), upper body muscular power (13.03 P<.05), lower body muscular power (8.32 P<.05), aerobic capacity (8.77 P<.05), anaerobic capacity (8.91P<.05),serving ability (8.76 P<.05), passing ability(14.90 P<.05) and overall playing ability (29.36 P<.05).

### 4.8.4. Comparing the Effect of Combination of Resistance Training followed by Plyometric Training in the same session (CRTPT), Complex Training of Resistance Training followed by Matched Plyometric Training in the same session (CTRTMPT), and Resistance Training for first six weeks followed by Complex Training of Resistance Training with Matched Plyometric Training for another six weeks (RTCTRTMPT) with Traditional Training Group (TTG)

In comparing the effect of combination of resistance training followed by plyometric training in the same session with the traditional training group on muscle fitness parameters, physiological and skill performance variables, from the obtained 'F'-ratios, it is observed that CRTPT showed better performance on upper body muscular strength (26.19 P<.05), lower body muscular strength (83.79 P<.05), abdominal muscular strength and endurance (33.28 P<.05), upper body muscular power(44.01 P<.05), lower body muscular power(66.29 P<.05), aerobic capacity (59.26 P<.05), anaerobic capacity (8.57 P<.05), serving ability (19.45 P<.05) passing ability (31.64 P<.05) and overall playing ability (28.30 P<.05).

In comparing the effect of complex training of resistance training followed by plyometric training in the same session with the traditional training group on muscle fitness parameters, physiological and skill performance variables, from the obtained 'F'-ratios, it is observed that CTRTMPT showed better performance on upper body muscular strength (65.27 P<.05), lower body muscular strength (148.26 P<.05), abdominal muscular strength and endurance (76.94 P<.05), upper body muscular power(87.88 P<.05), lower body muscular power(112.23 P<.05), aerobic capacity (116.57 P<.05), anaerobic capacity (46.76 P<.05), serving ability (54.61 P<.05) passing ability (73.39 P<.05) and overall playing ability (67.34 P<.05).

In comparing the effect of resistance training for first six weeks followed by complex training of resistance training with matched plyometric training for another six weeks with the traditional training group on muscle fitness parameters, physiological and skill performance variables, from the obtained 'F'-ratios, it is observed that RTCTRTMPT showed better performance on upper body muscular strength (171.40 P<.05), lower body muscular strength (235.77 P<.05), abdominal muscular strength and endurance (214.05 P<.05), upper body muscular power(168.57 P<.05), lower body muscular power(181.67 P<.05), aerobic capacity (189.30 P<.05), anaerobic capacity (96.49 P<.05), serving ability (107.10 P<.05) passing ability (154.49 P<.05) and overall playing ability (185.62 P<.05).

The adjusted post-test means of Combination of Resistance Training followed by Plyometric Training in the same session (CRTPT), Complex Training of Resistance Training followed by Matched Plyometric Training in the same session (CTRTMPT), Resistance Training for first six weeks followed by Complex Training of Resistance Training with Matched Plyometric Training for another six weeks (RTCTRTMPT) and Control Group (CG) on upper body muscular strength, lower body muscular strength, abdominal muscular strength and endurance, upper body muscular power, lower body muscular power, aerobic capacity, anaerobic capacity, serving ability, passing ability, and overall playing ability are graphically represented in Figure 4.11 to 4.20.

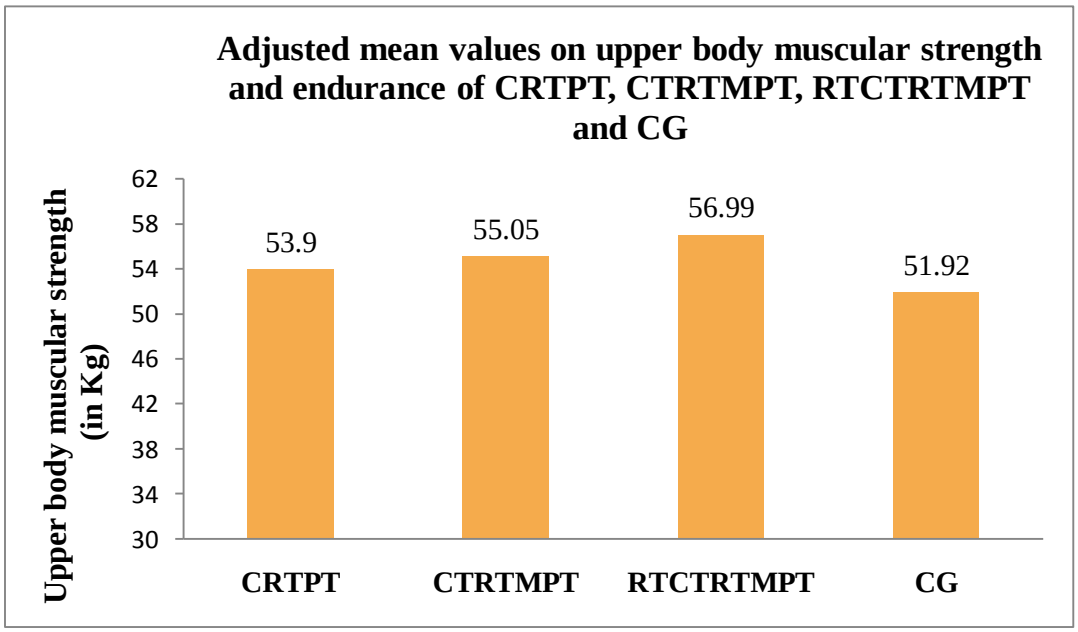


**Fig. 4.11**

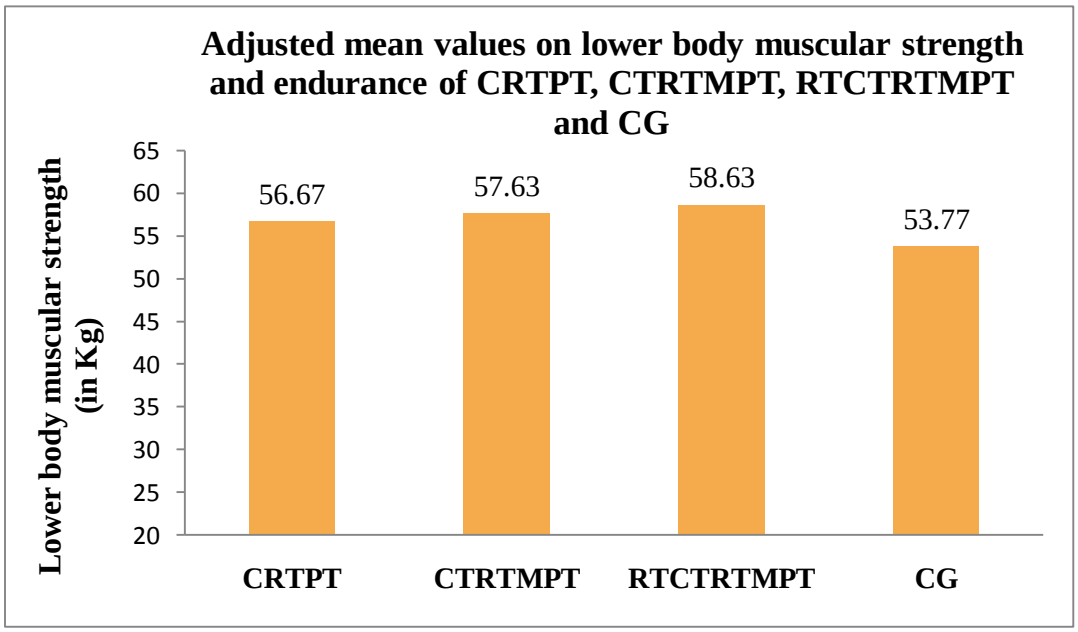


**Fig. 4.12**

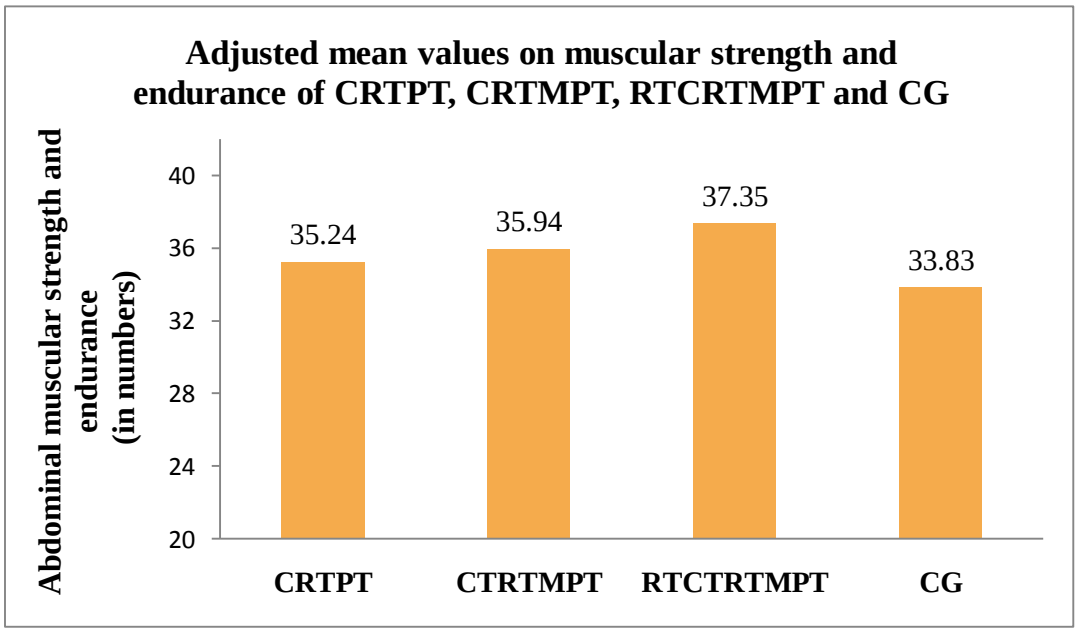


**Fig. 4.13**

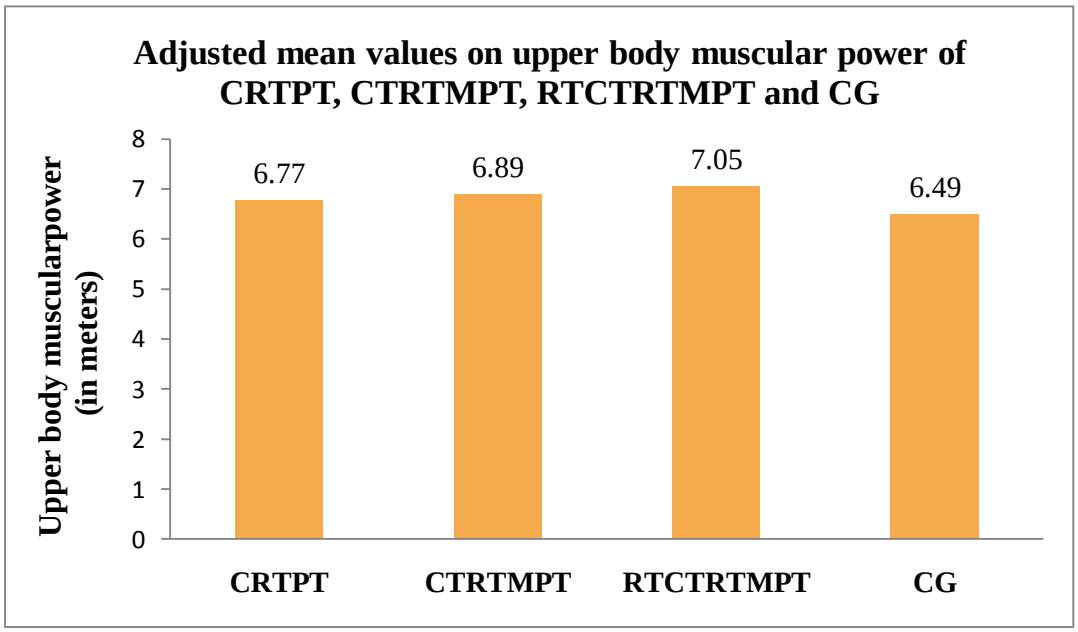


**Fig. 4.14**

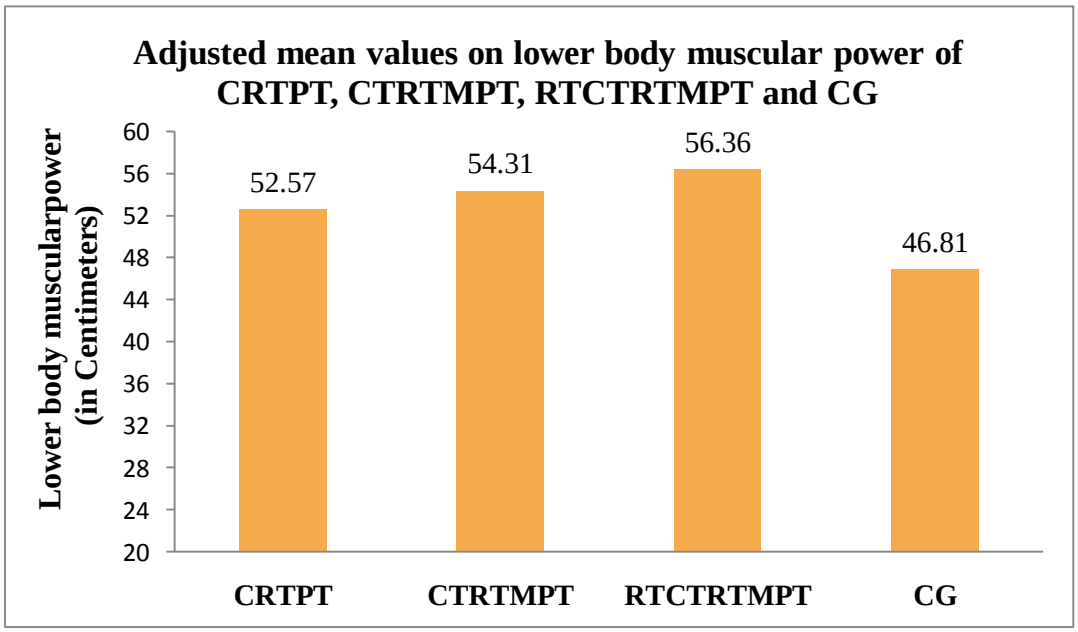


**Fig. 4.15**

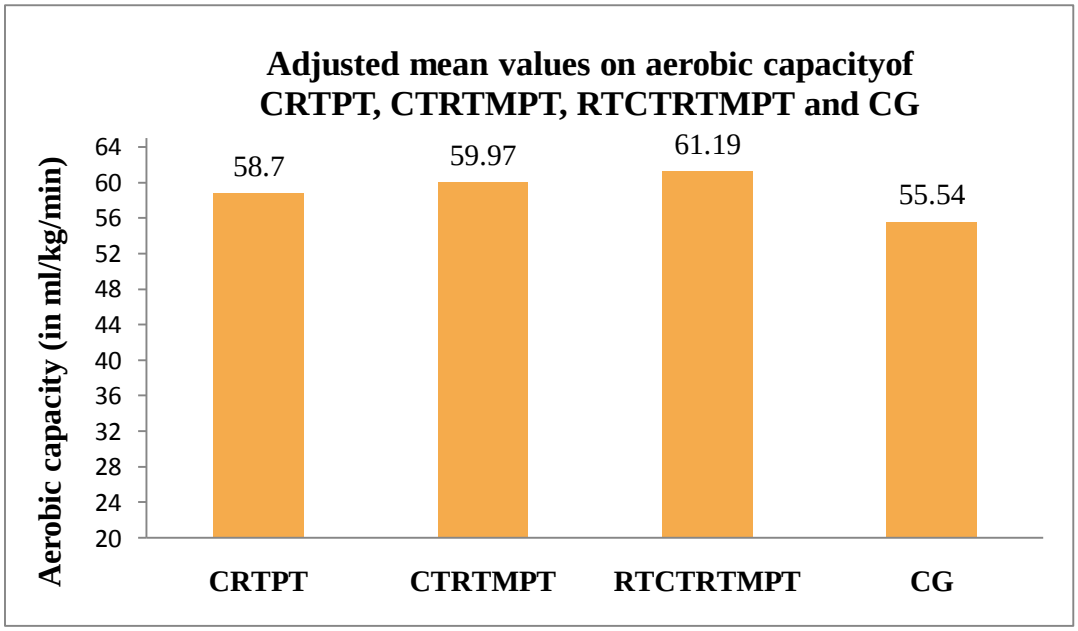


**Fig. 4.16**

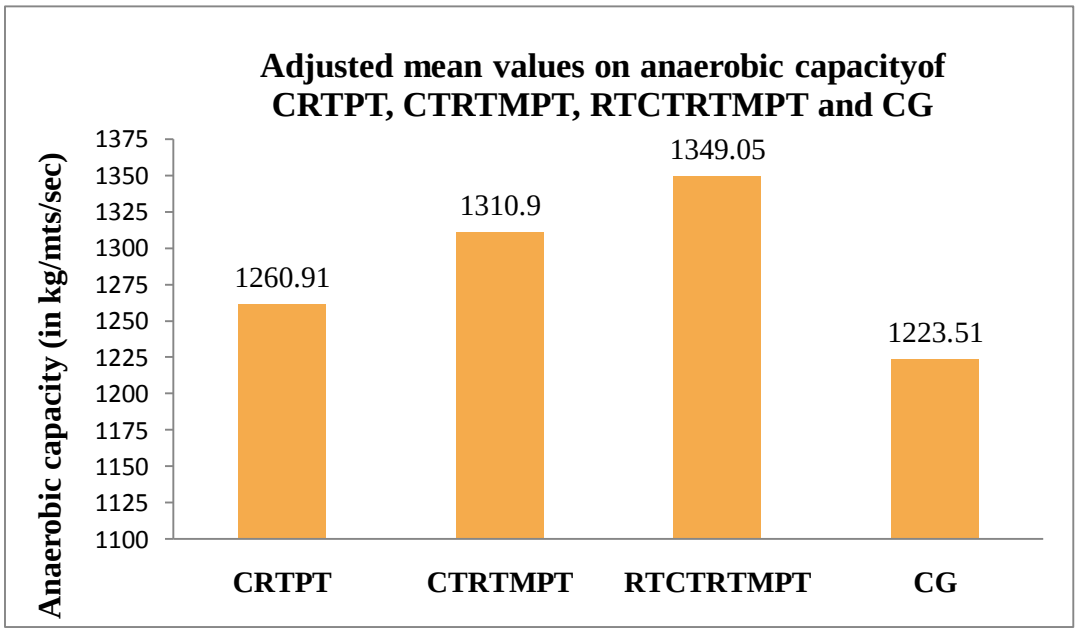


**Fig. 4.17**

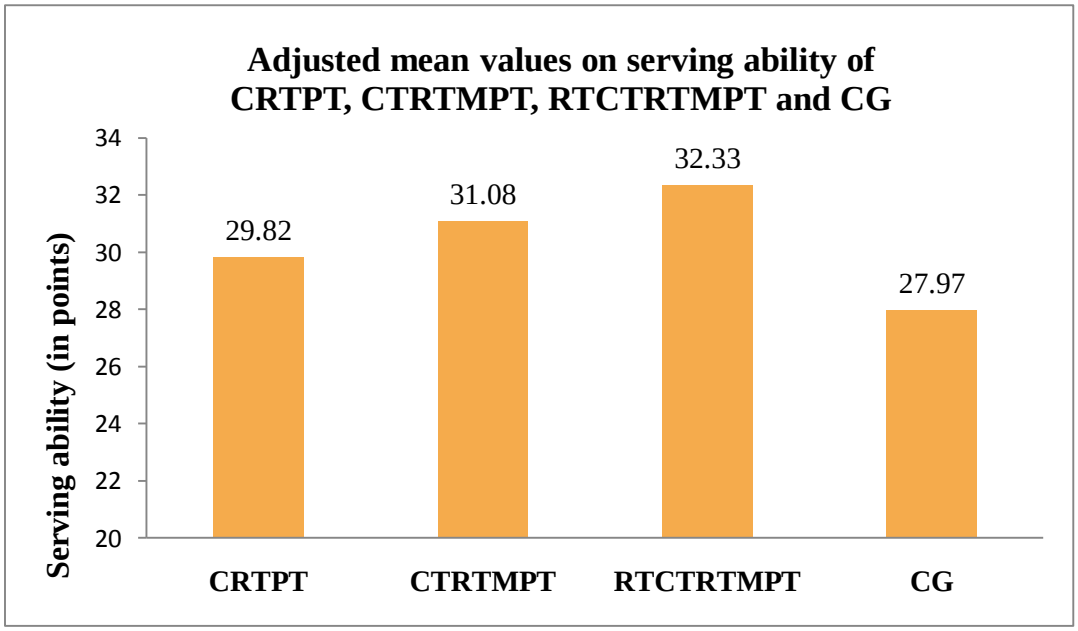


**Fig. 4.18**

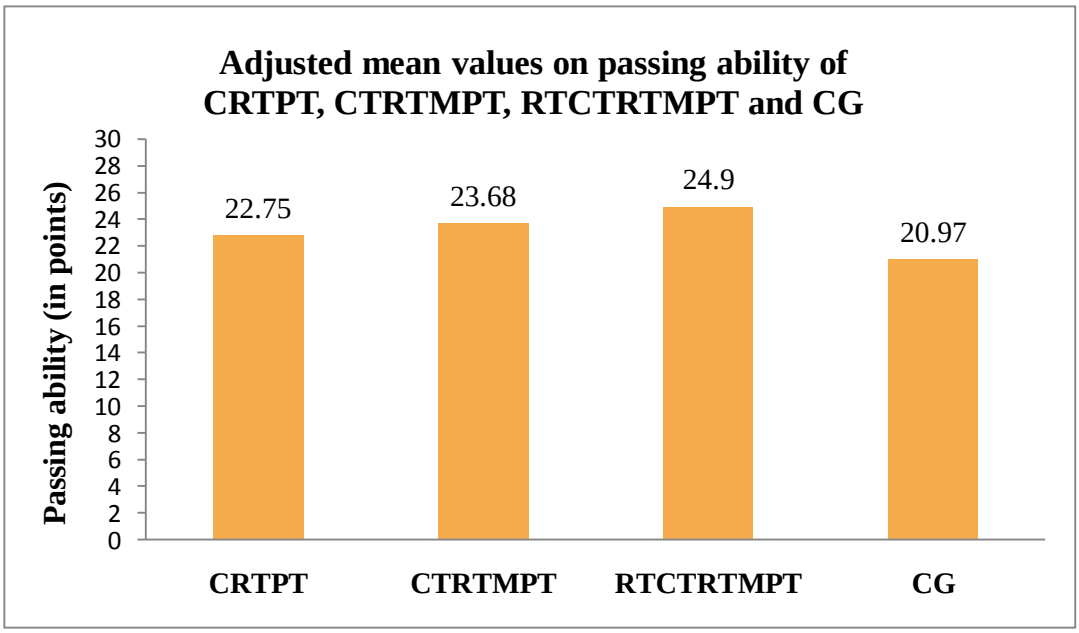


**Fig. 4.19**

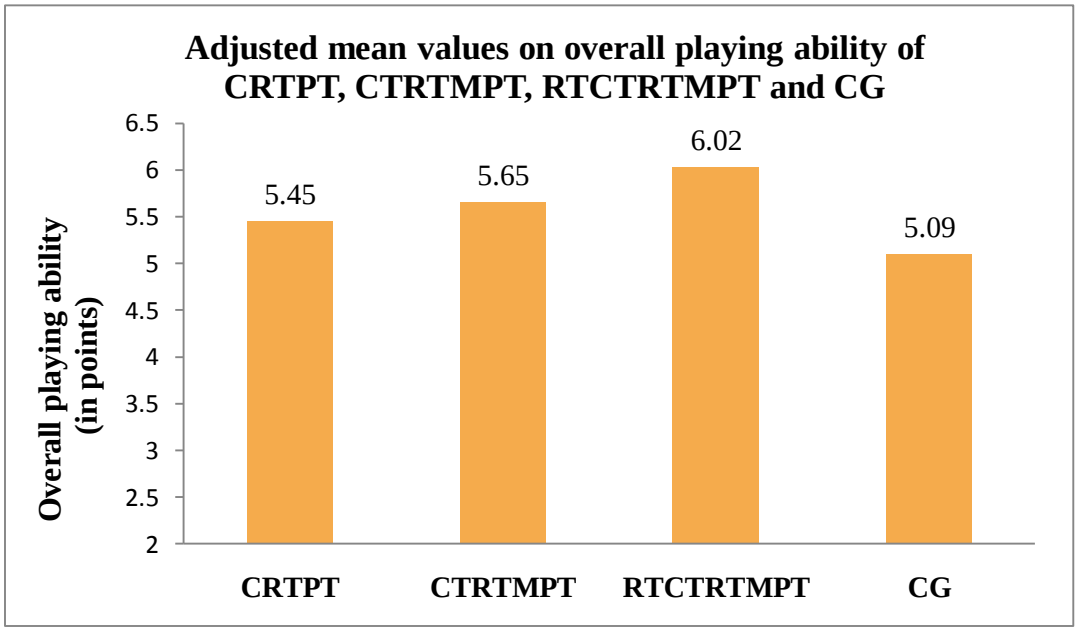


**Fig. 4.20**

## 4.6 DISCUSSION ON FINDING

The purpose of the present investigation was to determine the effect of combination of resistance training and plyometric training, complex training of resistance training and matched plyometric training and complex training of resistance training and matched plyometric training preceded with resistance training in developing the muscle fitness variables of strength, endurance and power and physiological parameters of anaerobic and aerobic power and skill performance variables of serving ability, passing ability and overall playing ability of volleyball male collegiate players.

We tested the hypothesis that combinatory effect of complex training of resistance training and matched plyometric training preceded with resistance training would result in significantly greater improvements in muscle fitness parameters of strength, endurance and power, physiological parameters of aerobic and anaerobic power and skill performance of serving ability, passing ability and overall playing ability as compared to combination of resistance and plyometric training and complex training of resistance training and matched plyometric training.

In testing the comparative effects of these three different training modules, the results confirmed that there are significant differences among them . Thus the formulated hypothesis No.2 related to this is accepted. When studying the results of Scheffe's post-hoc the obtained results are significantly in favour of the volleyball players who practiced complex training preceded with resistance training and it seemed to be predominant among the three different forms of training. The results derived from the comparative effect of varied training modules on their influences on muscular fitness parameters, physiological and skill performance variables of male volleyball players are discussed using the theoretical and empirical constructs.

When complex training of resistance training and matched plyometric training preceded with resistance training was compared with complex training of resistance training and matched plyometric training the present study demonstrated an increase in upper body muscular strength of 10.58% and 6.76% for complex training proceeded

with resistance training and complex training respectively. In the lower body muscular strength both programmes increased by 9.83% and 8.18% respectively. In the case of explosive power the upper body explosive power increased by 8.17% and 6.35% and lower body explosive power increased by 21.46% and 17.02% for complex training preceded with resistance training and complex training respectively. The complex training preceded with resistance training had nearly twice the increase in sit-ups (muscular strength and endurance) performance compared to the complex training group (6.31% vs 11.34%). In the physiological variables the complex training preceded with resistance training increased by 8.91% in aerobic capacity and 10.61% in anaerobic capacity. The complex training programme increased by 7.96% in aerobic capacity and 7.37% in anaerobic capacity. And in the skill performance variables the complex training preceded with resistance training group increased by 18.50% in serving ability, 20.19% in passing ability and 18.45% in overall playing ability. Whereas the complex training programme increased by 12.72% in serving ability and 14.83% in passing ability and 11.73% in overall playing ability.

Further when complex training of resistance training and matched plyometric training preceded with resistance training was compared with combination of resistance training and plyometric training the present study demonstrated an increase in upper body muscular strength of 10.58% and 4.55 for complex training preceded with resistance training and complex training respectively. In both the programmes the lower body muscular strength increased by 9.83% and 6.41% respectively. In the case of explosive power the upper body explosive power increased by 8.17% and 4.50% and lower body explosive power increased by 21.46% and 13.54% for complex training preceded with resistance training and complex training respectively. The complex training preceded with resistance training had nearly twice the increase in sit-ups (muscular strength and endurance) performance compared to the complex training group (6.31% vs 10.54%). In the physiological variables the complex training preceded with resistance training increased by 8.91% in aerobic capacity and 10.61% in anaerobic capacity. Whereas the complex training programme increased by 7.96% in aerobic capacity and 7.37% in anaerobic capacity. In the skill performance

variables the complex training preceded with resistance training group increased by 18.50% in serving ability, 20.19% in passing ability and 18.45% in overall playing ability. Whereas the complex training programme increased by 8.26% in serving ability and 10.84% in passing ability and 8.26% in overall playing ability.

Thus the complex training of resistance training and matched plyometric training preceded with resistance training is superior to the other two training methods of combination of resistance training and plyometric training, and complex training of resistance training and matched plyometric training for developing the muscular fitness parameters (upper body muscular strength, lower body muscular strength, abdominal muscular strength and endurance, upper body muscular power, lower body muscular power, aerobic capacity, anaerobic capacity) and skill performance variables (serving ability, passing ability and overall playing ability).

In analyzing comparative results of above said training programmes, the sources behind the dominance of complex training preceded with resistance training is the prerequisite development of strength before implementing the complex training i.e. resistance training followed by plyometric training. This idea is supported by recent complex training studies that examined the effect of complex training for children and female athletes suggests that complex training is equally effective, but not superior to other strength training programmes (Faigenbaum et al., 1999; Zepeda and Gonzalez, 2000). This finding may be consistent with the idea that prerequisite strength is necessary for complex training to be most effective and that this type of training may be best suited for those who are highly trained (Ebben and Watts, 1998).

Generally, complex training is a training programme that involves resistance training followed by plyometric training with high intensity [>80%] (Beachle and Earle). Besides, Ebban states that complex training is a training programme alternates bio-mechanically similar high load weight training exercises with plyometric exercises set for set in the same workout as a set of sequence followed by a set of jump squads. Further from the literature review published by Ebben (2000), it was observed that research in the effect of complex training on both the acute and long

term effects of cited exercises that an appropriate high load weight training exercises performed minute before a power exercise increases the power specially for stronger individuals. As far as the effect of complex training is concerned the role of resistance exercise is remarkably higher in its outcome. It is confirmed by the research conducted by Fastorme (1986) using weight training exercises only, plyometric training only and combination of resistance exercises followed by plyometric training as he found that although all training methods improved vertical jump and squad performance, athletes combining plyometric with weights experienced the greatest performance enhancement.

In deriving the complex training effect, the exercises used for resistance training should be in excess of 70% 1 repetition maximum (1RM) since higher loads are considered adequate for activating type IIb fibers and setting off the potentiation effect. Ebben and Watts (1998) also strongly emphasized the role of high load resistance exercise as it increases motor neuron excitability and reflex potentiation which may create optimum training conditions for subsequent plyometric exercise. Also the fatigue associated with high load weight training may force motor units to be recruited during the plyometric phase, possibly enhancing the training state. In the present study high load 70% resistance was used by all the three treatment groups in performing the resistance training exercises. This may be the reason for the significant improvement of the selected parameters.

The key physiological vindication for these workouts is the potentiation effect, i.e. the enhancing effect of one training mode over the other. Initially research focused on the potentiation of plyometric exercises with the resistance exercises. The involved exercises are paired and work the same muscle groups as in the case of complex training of resistance training and matched plyometric training preceded with resistance training.

In high load resistance training only the muscle fibers of fast twitch type IIb pronounced for deriving the complex training effects since fast twitch muscle fibers are the key to increase dynamic sports performance and contract 2 to 3 times faster

than the slow twitch fibers. Such a type IIb fast twitch fibers could have been developed appreciably by resistance training. In such way the exclusively added programme of resistance training along with the complex training of resistance exercise followed by plyometric exercise might have been the healthy foundation for showing better performance of complex training of resistance training and matched plyometric training preceded with resistance training on muscle fitness parameters and skill performance variables since the potentiation of effect of plyometric exercise is significantly influenced by the effect of resistance training. The order of exercises used for the complex training may also be a significant source for its dominance over the other form of exercises. Several authors postulated complex training as alternating biomechanically comparable high load weight training exercise with matched plyometric exercises. Such an alternate order exercises (resistance exercises matched by plyometric exercise) are important potential variables in the success of complex training of resistance training and matched plyometric training preceded with resistance training. It substantiates the basic theory conveyed by sports scientist Yuri Verkhoshansky (1986).

Further, when complex training of resistance training followed by matched plyometric was compared with combination of resistance and plyometric training, the subjects demonstrated an increase in upper body muscular strength of 6.76% and 4.55% for complex and combined training respectively. In both programmes the lower body muscular strength increased by 8.18% and 6.41% respectively. The upper body explosive power increased by 7.31% and 5.23% respectively. The lower body explosive power increased by 17.02%% and 13.54% respectively. Aerobic capacity increased by 7.96% and 10.26% respectively. The complex training group had nearly twice the increase in aerobic capacity performance compared to the combined group (5.96% vs 10.26%). In the anaerobic capacity both groups increased by 7.37% and 0.43% respectively and in the skill performance variables the complex training group increased by 12.72% in serving ability, 14.83% in passing ability and 11.73% in overall playing ability. Whereas in the combination training group increased by 8.26% in serving ability, 10.84% in passing ability and 8.20% in over all playing ability.

Initially, the increases made by the volley ball players in the current study, may seem to be low when compare to other studies. But one must remember that the volley ball players in the present study were already very well trained.

The volley ball players have been close to their genetic potential for performance, or may require more time to attain similar results due to the high level of performance already achieved following several years of intense training. These conclusions supported by the previous statement may have merit due to two bio-physical principles that lend support to complex training. First, in complex training there may be a neuromuscular state that is optimal for plyometric training brought about by the high-load resistance training which increases motor neuron excite ability and reflex potentiation (Verkhoshansky, 1966, and Verkhoshansky, 1986). Chu (1996 and 1986) as well as Donald Chu in "Explosive Power and Strength" proposed that fatigue may be associated with an enhanced training state by forcing more motor units to be recruited during plyometric training. Another study (by Rooney, Hergert, and Blanove, 1994) also supports the idea that fatigue plays a role in stimulating strength. These results are further supported by work from Berger and Hardage (1967).

One of the proposed benefits of complex training is that the individual is required to perform powerful plyometric movements in a fatigued state, which is expected to increase power (Hedrick, 1994; Hedrick, 1996). Requiring power productive in a fatigued state is also more representative of sports especially in games like volleyball in which the movements are mostly explosive in nature and similar to plyometric exercises, while using heavy and light weights in the same workout allows one to experience the feel of speed which some researchers believe is critical for enhanced sport performance (Yessis, 1995). Another benefit of complex training is that it may allow those individuals with vast experience in training programme to continue to make gains in strength and power development

Rooney et. al., (1994) ties both the theory of an optimal neuromuscular state and fatigue's role in strength development, by mentioning that the high-intensity

fatiguing protocols cause a greater motor unit recruitment than non-fatiguing high intensity training. Rooney also points to the fact that the magnitude of strength gain from a training programme is related to the amount of motor unit activation caused by the training protocol. In support of this statement two studies (Bigland-Ritchie, Furbush, and Woods, 1986, Maton, 1981) studied fatigues as a result of sub maximal isometric contractions which found that as muscles fatigue they progressively receive an increased activation.

The previous information directly supports the use of complex training. High intensity loading performed prior to plyometrics for optimal motor unit recruitment, and maximal fatigue stimulation are principles utilized in complex training. Complex training is more fatigue causing than traditional, or combined training, following one set of exercise the individual has the opportunity to rest, but in complex training the participant must perform an additional set of exercise (the plyometric exercise) after being previously fatigued by the heavy load lift. This should result in greater fatigue and optimal development of strength and power as previously addressed.

It is possible that the true benefit of the complex training programme may not be something that is easily identified by strength and power testing. The concept behind complex training (performing powerful muscle contractions in a fatigued state) is that it may produce a stimulus more specific to what would be experienced on the playing field (Yessis, 1995). For example, the benefit may be that a player maintains strength and power to explode off jumping and spiking through out a prolonged volleyball game. These attributes are more difficult to quantify than bench press strength, or an increase in vertical jump height.

The results of this study support the use of resistance training programmes which combine plyometric with weight training as previously determined or stated (Adams, 1992; Baker, 1996; Canavan, 1996; Garhammer & Gregor; 1992, Hedrick, 1996; Hedrick & Anderson, 1996; Newton, 1993; Yessis, 1994; Yessis, 1995). However, these results statistically indicate that the complex training programme used in the study is superior to the combined training programme for increasing strength,

power, muscular endurance, aerobic capacity, anaerobic capacity and skill performance and playing ability in college volleyball players.

It is difficult to compare the results of this study to previous work because of the lack of studies performed on division I-A athletes involved in an organized strength and conditioning programme. The majority of previous research utilized subjects who were not involved in collegiate athletics. Therefore, any comparisons to other data should be cautiously evaluated. One study (Polhemus, Using, Burkhardt and Patterson, 1980) evaluating a six week combined training programme using track athletes revealed an increase in vertical jump of 3 inches and an increase in broad jump of 7.25 inches. In a six week study comparing a plyometric versus a weight training program, in college students from PE classes reported a 2.4 and a 1.4 inch increase in vertical jump respectively (Holcomb, Lander, Rutland, and Wilson, 1996). In an eight week study on a combined weight training and plyometric program using untrained athletes, results revealed a 1.3 foot increase in the medicine ball throw, a 26.7 lb increase in bench press, 2.2 inches in vertical jump, and a 33 lb increase in squat performance (Lyttle, Wilson, and Ostrowski, 1996). A final study (Adams, et al., 1992) recorded an increase in vertical jump of 4.3 inches in a six week study when traditional resistance training (using squats) was combined with plyometrics.

Although neither the complex nor the combined programme demonstrated a true advantage at increasing athletic performance, the data does reveal two interesting trends. The strength tests (bench press, squat, and power clean) improvements were greater in the combined training group by 10, 5, and 7 lbs respectively. The complex training programme revealed superior increase in performance in a majority of the field-based tests compared to the combined training programme. Complex training athletes improved in the medicine ball 0.6 ft. more and in vertical jump by over an inch compared to the combined programme. The combined group decreased in its performance on the Omnikinetic machine, where the complex group maintained or slightly increased in performance, resulting in a 5% advantage in left and right relative crank power and 16 watt advantage in left absolute crank power and an 11 watt advantage in right absolute crank power for the complex group. These differences

may shallow as this was only a seven-week study. A 10 to 12 week study may have revealed more of a difference in improvements between groups.

The complex training and combined training programmes demonstrated true advantages at increasing volley ball performance, the data does reveal two interesting trends. The strength tests (bench press and half squat) improvements were greater in the complex training group by 6.76% and 8.18% respectively. The complex training programme revealed superior increases in performance in a majority of the field-based test compared to combined training programme. Complex training volley ball players improved in medicine ball 6.35% more and in vertical jump by overall 17.02% compared to combined training programme. The complex training programme also revealed superior increases in skill performance variables of serving ability, passing ability and overall playing ability compared to combined training volley ball players. Those differences may seem small, however this was only a twelve-week study. A 24 week study may have revealed more of a difference in improvements between groups.

Another reason for the use of and investigation into maximum power is the specificity of training speed seen in strength training. Earlier it was stated that power in athletics deal with speed of muscular contraction and strength (Yessis, 1994). Additional studies have shown that the strength gains in resistance are specific to the speed at which the training occurred (Canavcan et al., 1996; Garhammer, 1992; Hedrick 1996, Hedrick & Anderson, 1996, Newton & Kraemer, 1994; Stone, 1993; Yessis, 1994, Yessis, 1995). Therefore heavy resistance training at slow speeds will optimize force production in the slow portion of the force velocity curve while training at fast speeds will increase the force capacity of a muscle at the faster portion of the force velocity curve. In sport, this would lend support for both training techniques being utilized in conditioning.

Plyometrics include any exercise that utilizes the stretch reflex to produce an explosive movement (Chu, 1984). The stretch shortening cycle is essentially an eccentric contraction followed immediately by a concentric contraction (Chu, 1984; Henson, 1996). During the eccentric phase of a drill/exercise, kinetic energy is

generated and stored in the muscle and connective tissue, and muscle activation increases. This stored energy and increased muscle stimulation is used in the following concentric contraction for increased speed and force of the contraction (Adams, 1992; Chu, 1984; Gambetta, 1998; Newton, 1994). Plyometrics have been shown to be effective at increasing muscular power (Adams et al. 1992; Hedrick, 1994; Hedrick, 1996; Lyttle, 1996, Wathen, 1993; Yessis, 1995). It appears that weight training and plyometric training modify different capacities of the neuromuscular system, plyometric increase the muscle rate of eccentric force development, and resistance training increases concentric performance (Wilson, 1996).

Adaptations by the neuromuscular system are very specific. Therefore training programmes should include movements which mimic those used in sport. Slow contractions train the muscular system, while fast contractions stimulate the nervous system (Canavan, 1996). Also Wilson et al. (1996) proposed that plyometric and strength training train different components of the neuromuscular system. It is logical then, to train optimally for competition in power sports both fast and slow contractions as well as plyometrics should be included in the training program. This will ensure that all aspects of the neuromuscular system are addressed. This concept is being put to use today in combined resistance training and plyometric-type programs and have been shown in many studies to be more effective at improving muscular strength and power than either plyometrics or resistance training alone (Adams et al, 1992, Baker, 1996; Canavan et al., Garhammer & Gregor, 1992; Hedreick, 1996; Hedrick & Anderson, 1996; Newton & Kraemer, 1994; Stone, 1993; Yessis, 1994; Yessis, 1995). So it appears that training contractile and neural / elastic components of the musculature from combined training does in fact offer an improved training stimulus (Baker, 1996). It is this concept that the complex training has been selected in this study.

Complex training will result in an increased training intensity (though increased work per minute of workout with the super-set), which should benefit experienced lifters, but it may also provide a few other benefits. Integrating the

plyometrics with the resistance training requires the athlete to perform the plyometric exercise in a fatigued state, resulting potentially in increased power production (Hedrick, 1994; Hedrick, 1996). This also makes the activity more specific to what might be encountered in sport situations. Another benefit of complex training is that the muscle may "remember" the heavy weight performed prior to the plyometric or light load set, and will allow the lighter load to be moved quicker than without the heavy set prior to the light set. This should help develop power (Fleck & Kontor, 1986, Torcolacci, 1994). This increased speed of movement results in a high speed training specificity, and some researchers believe this perception of speed can be transferred to sport competition (Yessis, 1995).

The combination of plyometric exercises and weight training increased (Adams, et al.1992; Baur, et. al., 1990,, Behm, & Sale, 1993; Ioannis, et. al., 2000) or maintained unaffected vertical jumping performance (Stone, & O'Bryant, 1986). Adams et al. (Adams, et al. 1992) suggested that this combination may provide a more powerful training stimulus for the vertical jumping performance than either weight training or plyometric training alone. However, Clutch et al. (1983) did not reach similar conclusions and Ioannis, et. al. (2000) suggested that the combination of plyometric and weight training increased muscular strength. It seems that researchers have not come to an agreement about the relative effectiveness of plyometric training compared with weight training or the combination of both in the development of the vertical jumping ability. It seems likely that different durations of training periods, different training statuses of the subjects, or different training designs (i.e., training loads or volumes or exercises) might have caused the discrepancy in the results of previous studies.

This study illustrates that complex training of resistance training and matched plyometric training preceded with resistance training, complex training of resistance training and matched plyometric training and combination of resistance training and plyometric training significantly increase hip and thigh power production 21.46%, 17.02%, 13.54% respectively as measured by the vertical jump. This result is in accordance with previous studies (Adams, et al. 1992; Baur, et. al., 1990; Blakey, &

Southard, 1979; Ioannis, et. al., 2000). Improved muscle performance due to a plyometric training program may also be due in part to increased motor unit functioning. Previous studies have indicated that neuromuscular adaptations such as an increased inhibition of antagonist muscles as well as better activation and co-contraction of synergistic muscles may account for the improvements in power output (Komi, 1984; Lyttle, 1996.).

The results of the present study indicate that complex training preceded with resistance training produced improvements in muscle fitness variables of muscular strength, endurance and power and physiological parameters of anaerobic and aerobic power and skill performance variables of serving ability, passing ability and overall playing ability better than the other two training programmes. This is attributed to several reasons. First, the training experience level of the subjects might offer one explanation. The second explanation is the nature of the training protocol used in the present study that they were strength trained enough to be able to sustain complex training of resistance training exercises (high load) and plyometric training loads. One has to be weight trained to enjoy positive adaptations to Plyometric training.

Another interesting note is that, despite the fact that the subjects in the combination group performed plyometric and weight training on the same day, their performance was not impaired. This result is in accordance with Ioannis (Ioannis, et. al., 2000) who demonstrated that subject performance was not impaired in this procedure. NSCA and others (Chu, 1996; NSCA, 1993) do not recommend performing heavy strength and plyometric training on the same day, with the exception of track and field athletes, who might benefit from a combination of plyometric and weight training program, "complex training." In the present study, there was enough rest between the sessions to allow recovery of the neuromuscular and metabolic systems of the subjects.