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EFFECTIVENESS OF DIFFERENT INTENSITY OF RESISTANCE TRAINING: AN EMPIRICAL STUDY

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Abstract
This study investigates the effectiveness of low, moderate and high intensity resistance training in improving back strength and strength endurance. Sixty female participants, with an Age: 18.54± 0.29, Height: 165.22 ±0.73, Weight: 62.26 ±1.18 and BMI 22.81±0.55 were randomly assigned to one of three groups: the Low Intensity Resistance Training Group (LIRTG), Medium Intensity Resistance Training Group (MIRTG), High Intensity Resistance Training Group (HIRTG) or the Control Group (CG). The training period was limited to three days per week for twelve weeks. Among the motor ability components back strength and strength endurance were selected as dependent variables. Back strength was measured by Dynamometer and Strength Endurance was measured by Bent knee Sit-up Test. All the subjects were tested prior to and immediately after the experimental period on the selected dependent variable. The data obtained from the experimental groups and control group before and after the experimental period were statistically analyzed with dependent t-test and Analysis of covariance (ANCOVA). Whenever the 'F' ratio for adjusted posttest means was found to be significant, the Scheffe's Post hoc test was applied to determine the paired mean differences. The level of confidence was fixed at 0.05 level for all the cases. In conclusion, the 12 weeks of the LIRTG, MIRTG and HIRTG programs effectively enhance back strength and strength endurance in college women athletes

Keywords: Low Intensity Resistance Training, Medium Intensity Resistance Training, High Intensity Resistance Training, Back Strength, Strength Endurance

INTRODUCTION

In sports training programs, resistance training -a tried-and-true technique for increasing strength and power—has been used extensively to improve athletic performance[1]. Exercises that cause muscle contractions in response to resistance to an external force are referred to as resistance exercises. Numerous earlier studies have validated the different effects of resistance training; overload stress after resistance training is said to improve muscle function and increase muscle strength and the cross-sectional area of muscle fibers (Moore et al., 2004). Exercise interventions have been shown to be more effective than traditional resistance training (RT) at improving fall-related physical function and cognition in older adults. This is especially true of high-speed resistance training (HSRT) interventions, which emphasize explosive concentric muscle actions with low-to-moderate loads [2,3,4,5].

It is commonly acknowledged that resistance training is an effective way to improve physical function, lower the risk of falls, and increase older adults' general health, independence, and well-being [6]. In order to challenge the muscles and increase strength, resistance training uses machines, free weights, or resistance bands. Weight training is a type of resistance training that focuses on increasing muscle strength and power by using free weights or machines. Both WT

and RT have been extensively used to enhance athletic performance in a variety of sports, including handball.

In sports, strength is essential because it improves performance by boosting power and force production, which results in quicker movements, higher jumps, and improved agility. Strength training also lowers the risk of injury by fortifying the joints and muscles that support it. There are several types of strength, including maximal strength, power, and endurance; the type that is most appropriate for a given sport will depend on its requirements [7]. In sports, endurance is the ability to maintain physical activity for a prolonged amount of time while using aerobic metabolism to generate energy. It includes both specific endurance, which is the ability to withstand fatigue under the demands of a specific sport, and general endurance, which is the overall ability to withstand fatigue. To succeed in endurance sports like swimming, cycling, and marathon running, one needs a lot of training and a mix of mental and physical fortitude [8].

RELATED WORKS

One repetition maximum significantly increased from PRE to POST ($p \leq 0.001$) and FU ($p \leq 0.05$) in both groups. The 30 s-CS significantly improved only in the RT-ST group at FU ($p \leq 0.001$), with higher values compared with the RT group at POST ($p \leq 0.05$) and FU ($p \leq 0.05$). Time up and go test duration decreased in both groups ($p \leq 0.001$), with RT-ST completing the test faster than RT ($p \leq 0.05$). Incorporating positive motivational self-talk into a high-intensity progressive RT program led to significant improvements in functional performance, suggesting that its benefits go beyond improving muscle strength and may positively impact the activities of daily living in older adults [9].These findings demonstrate that both strength, speed or a combination of these modalities significantly enhance sprinting speed and mechanical capabilities in youth soccer players, influencing key FVP profile characteristics, without substantially affecting maximum velocity [10].

Assuncao et al., [11] compared the effects of high-load, low-repetition maximum (LRM) and low-load, high-repetition maximum (HRM) resistance training regimens on muscular fitness in untrained adolescents. Forty-five untrained adolescents of both sexes (13.7±0.8 years; 161.3±7.5 cm, 56.8±13.4 kg) were randomly assigned into one of three groups: 1) LRM (n = 17): volunteers performed three sets of 4-6-repetition maximum (RM); 2) HRM (n = 16): volunteers performed three sets of 12–15 RM; and 3) control (CON, n = 12). Training was performed two times a week for 9 weeks. After training, there were significant increases in 1 RM chest press (LRM = 14.8% and HRM = 14.2%, $p<0.05$) and squat (LRM = 26.4% and HRM = 25.7%, $p<0.05$), with no differences between the LRM and HRM groups ($p>0.05$). Additionally, muscular endurance increased significantly for the chest press (LRM = 14.5% and HRM = 21.8%, $p<0.05$) and squat test (LRM = 31.4% and HRM = 32.4%, $p<0.05$) following resistance training, with no difference between the LRM and HRM groups ($p>0.05$). These results suggest that both high-load, low-repetition and moderate-load, high-repetition resistance training can be prescribed to improve muscular fitness in untrained adolescents.

Katharine et al., [12] determined the effects of resistance training combined with either moderate-intensity endurance or low-volume high-intensity interval training on cardiovascular risk profiles in patients with coronary artery disease. Nineteen patients were randomized into moderate-intensity endurance ($n = 10$) or high-intensity interval ($n = 9$) groups, and attended

2 supervised exercise sessions a week for 6-months. The first 3-months involved exclusive moderate-intensity endurance or high-intensity interval exercise, after which progressive resistance training was added to both groups for the remaining 3-months. Fitness (VO_2peak), blood pressure and heart rate, lipid profiles and health related quality of life assessments were performed at pretraining, 3 and 6-months training. VO_2peak increased from pretraining to 3-months in both groups (moderate-intensity endurance: 19.8 ± 7.3 vs. 23.2 ± 7.4 ml kg^{-1} min^{-1}; high-intensity interval: 21.1 ± 3.3 vs. 26.4 ± 5.2 ml kg^{-1} min^{-1}, $p < 0.001$) with no further increase at 6-months. Self-evaluated health and high-density lipoprotein were increased following 6-months of moderate-intensity endurance exercise, while all remaining indices were unchanged. Low-volume high-intensity interval exercise did not elicit improvements in lipids or health related quality of life. Blood pressures and heart rates were unchanged with training in both groups. Findings from our pilot study suggest improvements in fitness occur within the first few months of training in patients with coronary artery disease, after which the addition of resistance training to moderate-intensity endurance and high-intensity interval exercise elicited no further improvements. Given the importance of resistance training in cardiac rehabilitation, additional research is required to determine its effectiveness when combined with high-intensity interval exercise.

METHODS AND MATERIALS

Study Design

Table 1 below shows the participants' demographics.

TABLE 1
Participant Demographics

Demographics Characteristic	**LIRTG**	**MIRTG**	**HIRTG**	**CG**	**Overall Average**
Number of Participants	15	15	15	15	15
Average Age (Years)	18.47	18.57	18.55	18.57	18.54
Average Height (Cm)	165.33	165.07	165.27	165.2	165.22
Average Weight (Kg)	62.18	62.31	62.22	62.34	62.26
BMI (kg/m^2)	22.76	22.87	22.78	22.84	22.81

This study's main goal was to ascertain which exercise LIRTG, MIRTG or HIRTG is better at increasing back strength and strength endurance when compared to a control group. To assess

the effects of three training techniques, the study employed a quasi-experimental design with a 12-week intervention period with a pre-test and post-test control group model. Training type, classified as either LIRTG, MIRTG or HIRTG was the independent variable. The dynamometer was used to measure back strength and strength endurance was assessed via bent knee sit up test. The analysis's covariates were the pre-test results.

Participants

Sixty (N=60) women participants were recruited for the study. The age, standing and body height of the subjects was ranged between Age:18.54± 0.29 years, Height: 165.22 ±0.73 meters, Weight: 62.26 ±1.18 kilograms and BMI:22.81±0.55 kg/m^2 respectively. The researchers used random sampling as the sampling technique. All participants were healthy athletes with no prior history of any health issues. They regularly engaged in physical activities but had not participated in structured specific training. To make sure the participants fulfilled the inclusion and exclusion criteria, the researchers performed an initial screening using questionnaires, enrollment forms, and preliminary interviews. For validation and verification, they also asked for supporting documentation, including medical records, exercise records, and parental consent.

Four groups of 15 participants each were randomly assigned: the Low Intensity Resistance Training Group (LIRTG), Medium Intensity Resistance Training Group (MIRTG), High Intensity Resistance Training Group (HIRTG) or the Control Group (CG). All participants maintained a 91% attendance rate throughout the research implementation; none were turned away from the training. Each of the 60 participants came from the same geographical area and gave their all to the research activities.

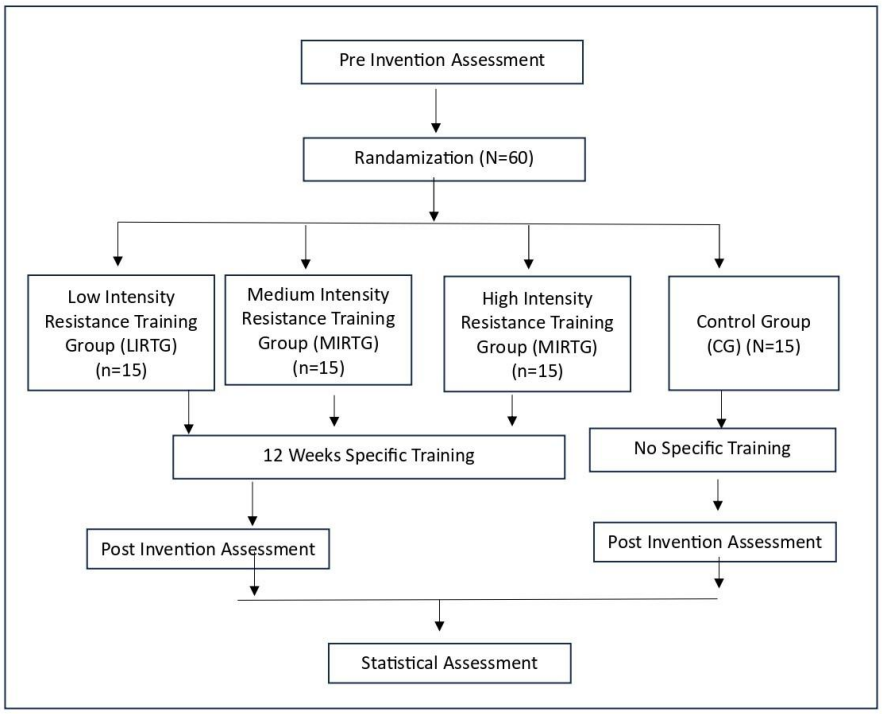

FIGURE 1 Flow diagram of study group randomisation

Training procedures

All subjects were briefed on the study's personnel and all experimental procedures prior to the study's start. They were then tested on their training field for a single day. On the testing day, a dynamometer was used to measure back strength in the morning, and bent knee sit-ups were used to measure strength endurance in the evening. An athlete's back strength and endurance are tested in this test, and the assistant is in charge of taking the measurement. A trainer who oversaw all the procedures and respected the participants' privacy while enhancing their comfort level throughout the evaluation described this process. Specially trained researchers and coaching staff conducted all measurements under controlled conditions. Notably, in order to reduce variability, the same researcher performed measurements both before and after the test. Following the observation period, the measurements were taken at the same time every day to prevent circadian variation in the parameters. Coaches also advised participants to abstain from alcohol, caffeine, and strenuous exercise for 12 hours before the pre-test day in order to remove outside influences.

Data analysis

The data collected from the experimental groups and control group on prior and after experimentation on selected variables were statistically examined by dependent t- test on selected criterion variables separately. In all the cases 0.05 level of significance was fixed.

Back strength

In order to examine the significance differences among Low Intensity Resistance Training group (LIRTG), Medium Intensity Resistance Training group (MIRTG), High Intensity Resistance Training group (HIRTG) and Control group (CG) of back strength dependent t- test was applied and it was presented in the Table-2.

TABLE -2

Dependent sample t-test

Test	LIRTG	MIRTG	HIRTG	CG
Pre- Assessment	92.13±2.12	92.33±1.01	92.20±1.90	92.13±1.45
Post- Assessment	95.53±0.88	97.13±0.88	95.47 ±0.77	92.33±1.45
't'-test	5.72*	13.84*	5.94*	0.38
p- value	0.000	0.000	0.000	0.707

* Significant at 0.05 level.

(Table value required for significance at .05 level for 't'-test with df 14 is 2.15)

The table-2 shows that the pre-assessment means and standard deviation of back strength for LIRTG, MIRTG, HIRTG and CG are 92.13±2.212, 92.33±1.01, 92.20±1.90 and 92.13±1.45 respectively. The post- assessment mean is 95.53±0.88, 97.13±0.88, 95.47±0.77 and 92.33±1.45 respectively. The obtained independent t-ratio and p-values between the pre and post assessment means on back strength of LIRTG, MIRTG, HIRTG and CG are (t=5.72, p=0.000), (t=13.84, p=0.000), (t=5.94, p=0.000) and (t=0.38, p=0.707) respectively.

The table value required for significant difference with df 14 at 0.05 level is 2.15. It was concluded that experimental groups such as LIRTG, MIRTG and HIRTG had registered significant improvement in back strength.

In order to examine the significance improvement among LIRTG, MIRTG, HIRTG and CG of back strength, analysis of covariance (ANCOVA) was applied. Whenever the 'F' ratio for adjusted posttest means was found to be significant, Scheffe's test was followed as a post hoc test to determine which of the paired means difference was significant.

TABLE 3
Computation of analysis of covariance of experimental groups and control group on back strength

Test	LIRTG	MIRTG	HIRTG	CG	Source of Variance	Sum of Squares	df	Mean Squares	F ratio	p-value
Pre-Assessment Mean	92.13	92.33	92.20	92.13	Between	0.40	3	0.13	0.04	0.989
					Within	169.20	56	3.02		
Post Assessment Mean	95.53	97.13	95.47	92.33	Between	181.65	3	60.55	49.48*	0.000
					Within	68.53	56	1.22		
Adjusted Post Assessment Mean	95.55	97.10	95.47	92.35	Between	177.95	3	59.32	58.34*	0.000
					Within	55.92	55	1.02		

Note: Significant at 0.05 level of confidence,* Back Strength Sc ores in Kilograms, *Table value for df (3, 56) at 0.05 level = 2.76*
Table value for df (3, 55) at 0.05 level = 2.78

The table-3 shows that the pre assessment means values on back strength of LIRTG, MIRTG, HIRTG and CG are 92.13, 92.33, 92.20 and 92.13 respectively. The obtained 'F' ratio for pre assessment scores was lesser than ($F=0.04$, $p>0.989$) the table value of 2.76 for degrees of freedom 3 and 56 required for significance at 0.05 level of confidence on back strength.
The post assessment means values on back strength of LIRTG, MIRTG, HIRTG and CG are 95.53, 97.13, 97 and 92.33 respectively. The obtained 'F' ratio for post- assessment scores was higher than ($F=49.48$, $p<0.000$) the table value of 2.76 for degrees of freedom 3 and 56 required for significance at 0.05 level of confidence on back strength.
The adjusted post-assessment means on back strength of LIRTG, MIRTG, HIRTG and CG 95.55, 97.10, 95.47 and 92.35 respectively. The obtained 'F' ratio for adjusted post-assessment scores was higher than ($F=58.34$ $p<0.000$) the table value of 2.78 for degrees of freedom 3 and 55 required for significance at 0.05 level of confidence on back strength.
The results of the study indicate that there are significant differences among the adjusted post assessment means of LIRTG, MIRTG, HIRTG and CG in back strength performance.
To determine which of the paired means have a significant difference, the Scheffe's test is applied as Post hoc assessment and the results are presented in Table – 3.

TABLE – 3

The Scheffe's test for the differences between the adjusted post assessments paired means on back strength

Adjusted Post-test Means				Mean Difference	Confidence Interval
LIRTG	MIRTG	HIRTG	CG		
95.55	97.10			1.55*	1.06
95.55		95.47		0.08	1.06
95.55			92.35	3.20*	1.06
	97.10	95.47		1.63*	1.06
	97.10		92.35	4.75*	1.06
		95.47	92.35	3.12*	1.06

Note: * Significant at 0.05 level of confidence

The table-3 shows the pair wise comparison on hip flexibility of different groups.

- The results indicated that there were significant differences were found in LIRTG and MLIRTG, LIRTG and CG, MIRTG and HIRTG, LIRTG and CG, HIRTG and CG.
- The results indicated that there were no significant differences were found in LIRTG and HIRTG.

The graphical representation of pre, post and adjusted post assessment mean value are represented in the Figure.1.

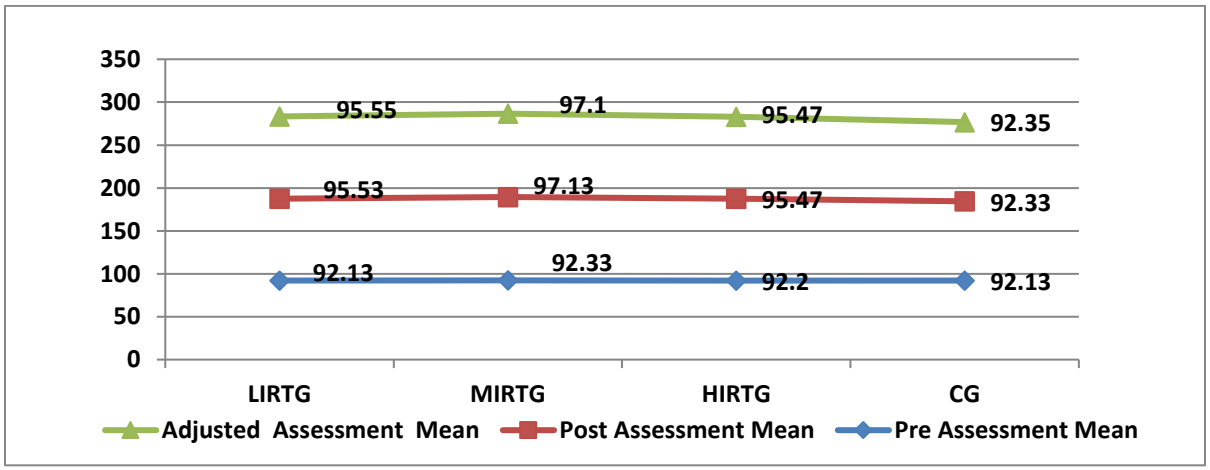

FIGURE 2

Mean diagram on back strength (Measures in Kilograms)

Strength endurance

In order to examine the significance differences among Low Intensity Resistance Training group (LIRTG), Medium Intensity Resistance Training group (MIRTG), High

Intensity Resistance Training group (HIRTG) and Control group (CG) of strength endurance dependent t- test was applied and it was presented in the Table-4.

TABLE -4
Dependent sample t-test

Test	LIRTG	MIRTG	HIRTG	CG
Pre- Assessment	14.33±1.93	14.40±1.99	14.60±2.15	14.73±1.81
Post- Assessment	18.53±1.75	19.88±2.83	18.60±1.85	15.00±2.07
't'-test	3.91*	4.11*	3.55*	0.24
p- value	0.002	0.001	0.003	0.814

* Significant at 0.05 level.
(Table value required for significance at .05 level for 't'-test with df 14 is 2.15)

The table-4 shows that the pre-assessment means and standard deviation of strength endurance for LIRTG, MIRTG, HIRTG and CG are 14.33±1.93, 14.40±1.99, 14.60±2.15 and 14.73±1.81 respectively. The post- assessment mean is 18.53±1.75, 19.88±2.83, 18.60±1.85 and 15.00±2.07 respectively. The obtained independent t-ratio and p-values between the pre and post assessment means on strength endurance of LIRTG, MIRTG, HIRTG and CG are (t=83.91, p=0.002), (t=4.11, p=0.001), (t=3.55, p=0.003) and (t=0.24, p=0.814) respectively. The table value required for significant difference with df 14 at 0.05 level is 2.15. It was concluded that experimental groups such as LIRTG, MIRTG and HIRTG had registered significant improvement in strength endurance.
In order to examine the significance improvement among LIRTG, MIRTG, HIRTG and CG of strength endurance, analysis of covariance (ANCOVA) was applied. Whenever the 'F' ratio for adjusted posttest means was found to be significant, Scheffe's test was followed as a post hoc test to determine which of the paired means difference was significant.

TABLE 5
Computation of analysis of covariance of experimental groups and control group on strength endurance

Test	LIRTG	MIRTG	HIRTG	CG	Source of Variance	Sum of Squares	df	Mean Squares	F ratio	P value
Pre-Assessment Mean	14.33	14.40	14.60	14.73	Between	1.52	3	0.51	0.12	0.948
					Within	235.47	56	4.21		
Post Assessment Mean	15.83	19.80	18.60	15.00	Between	193.25	3	64.42	12.80*	0.000
					Within	281.73	56	5.03		
Adjusted	18.68	19.90	18.53	14.82	Between	215.80	3	71.93	32.52*	

Post Assessment Mean					Within	121.68	55	2.21		0.000

Note: Significant at 0.05 level of confidence,* Strength endurance Scores in Numbers, *Table value for df (3, 56) at 0.05 level = 2.76 Table value for df (3, 55) at 0.05 level = 2.78*

The table-5 shows that the pre assessment means values on strength endurance of LIRTG, MIRTG, HIRTG and CG are 94.40, 94.33, 93.80 and 93.40 respectively. The obtained 'F' ratio for pre assessment scores was lesser than (F=0.12, p>0.948) the table value of 2.76 for degrees of freedom 3 and 56 required for significance at 0.05 level of confidence on back strength.

The post assessment means values on strength endurance of LIRTG, MIRTG, HIRTG and CG are 114.60, 120.80, 110.27 and 94.33 respectively. The obtained 'F' ratio for post- assessment scores was higher than (F=12.80, p<0.00) the table value of 2.76 for degrees of freedom 3 and 56 required for significance at 0.05 level of confidence on strength endurance.

The adjusted post-assessment means on strength endurance of LIRTG, MIRTG, HIRTG and CG 114.52, 120.73, 110.30 and 94.44 respectively. The obtained 'F' ratio for adjusted post-assessment scores was higher than (F=32.52, p<0.000) the table value of 2.78 for degrees of freedom 3 and 55 required for significance at 0.05 level of confidence on strength endurance.

The results of the study indicate that there are significant differences among the adjusted post assessment means of LIRTG, MIRTG, HIRTG and CG in strength endurance performance.

To determine which of the paired means have a significant difference, the Scheffe's test is applied as Post hoc assessment and the results are presented in Table – 6.

TABLE – 6

The Scheffe's test for the differences between the adjusted post assessments paired means on strength endurance

Adjusted Post-test Means				**Mean Difference**	**Confidence Interval**
LIRTG	**MIRTG**	**HIRTG**	**CG**		
18.68	19.90			1.21	1.57
18.68		18.53		0.15	1.57
18.68			14.82	3.86*	1.57
	19.90	18.53		1.36	1.57
	19.90		14.82	5.07*	1.57
		18.53	14.82	3.71*	1.57

Note: * Significant at 0.05 level of confidence

The table-6 shows the pair wise comparison on strength endurance of different groups.

- The results indicated that there were significant differences were found in LIRTG and CG, MIRTG and CG, & HIRTG and CG

- The results indicated that there were no significant differences were found in LIRTG and MIRTG, LIRTG and CG & MIRTG and HIRTG.

The graphical representation of pre, post and adjusted post assessment mean value are represented in the Figure.3.

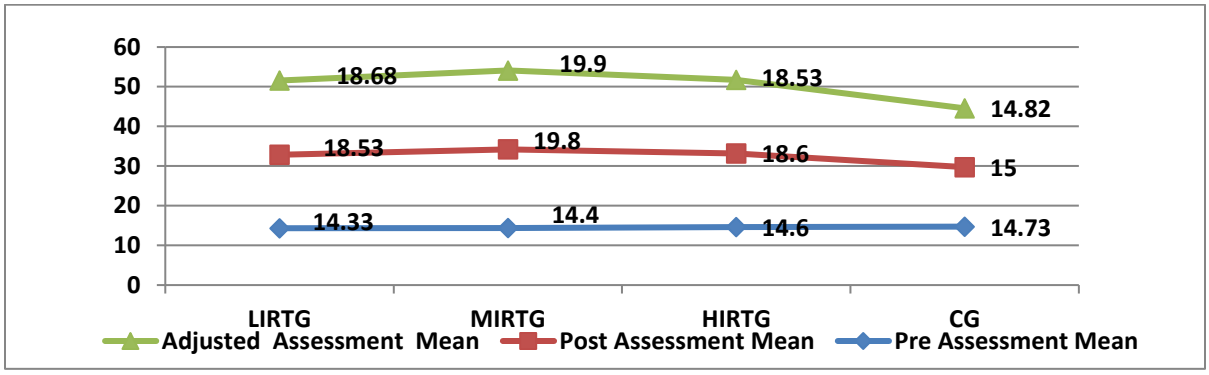

FIGURE 3
Mean diagram on strength endurance (Measures in Numbers)

RESULTS AND DISCUSSION OF FINDINGS

The result of the study indicates that LIRTG, MIRTG and HIRTG resulted a significant improvement in developing the back strength and strength endurance. The difference between adjusted post - test means between plyometric PEG and YPG.is found to be not significant at However, the mean of MIRTG group is better than LIRTG and HIRTG. The results of the study also showed that there was a significant difference between LIRTG, MIRTG, HIRTG and CG on back strength and strength endurance. The results were in confirmation with the findings of numerous studies published recently [13,14,15,16] back strength and strength endurance improved through MIRTG.

CONCLUSIONS

Based the limitations of the study, the following outcomes were drawn. Significant differences were found between Low Intensity Resistance Training group (LIRTG), Medium Intensity Resistance Training group (MIRTG), High Intensity Resistance Training group (HIRTG) and Control group (CG) on back strength and strength endurance. Further the results showed that Medium Intensity Resistance Training group (MIRTG), conveyed positive effects on the increase of back strength and strength endurance.

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