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Influence of strength training endurance training and their combination on selected physical fitness variables

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Abstract
The purpose of the study was to find out the effect of resistance, endurance trainings and their combination on selected physical fitness variables. Sixty female college students were divided into four equal groups (n = 15), in which group I underwent resistance training, group II underwent endurance training and group III underwent the combination training for 3 days per week for 12 weeks, and group IV acted as control. The subjects were tested on selected criterion variables such as leg strength, muscular endurance and cardio-respiratory endurance at prior to and immediately after the training. For testing the leg strength, the dynamometer was used, bent knee sit-up test was administered to test muscular endurance and for cardio-respiratory endurance the Cooper's 12 minutes run/walk test was administered. The analysis of covariance (ANCOVA) was used as statistical tool and since four groups were involved in the present study, the Scheffé *S* test used as post-hoc test. The selected criterion variables were improved significantly for all the training groups when compared with the control group and the leg and muscular endurance were improved significantly for strength training group and the endurance training group has improved cardio-respiratory endurance significantly.

Keywords: Resistance training, endurance training, combined training, physical fitness, leg strength, muscular endurance and cardio-respiratory endurance.

Introduction
Physical training is focuses on mechanistic goals. The overall muscles and some specific skill will develop within particular period of time after the physical training. Physical fitness will be improved by the most of the physical training programme [1]. Dale S. Beach [2] defines training as 'the organized procedure by which people learn knowledge and/or skill for a definite purpose'. It is a process of teaching of particular skill to somebody, either human or animal and the aim is to improve the capacity, performance capacity or productivity of an individual [3].

Physical training is the most important ingredient to achieve high level of performance of athlete. It's objectives are to increase the highest standards of an athletes' physiological potential and biomotor abilities [4]. Physical training should be given to the athlete on the basis of scientific principles and which, through systematic development of mental and physical efficiency, capacity and motivation, which help the athlete to produce outstanding and record breaking performances [5].

During a specific period of time, an organized training which involves increasing cycle of training programme which enhance the performance of an individual is called as periodization [6]. During the periodization, the competitor gets optimum adaptation before an important event. Instead of performing the regular routing workouts month after month, the athlete change his or her program with regular periods or interval to work harder with adequate rest [7]

A study was conducted at Human Performance Laboratory, Ball State University shown that there was a significant difference was found in favour of periodized strength training programme than the non-periodized program [8].

The strength training also refers as a type of physical exercise, uses of resistance which enhance the muscular contraction which contributes the strength, increase the size of skeletal muscle and anaerobic endurance.

It can improve the overall health and well-being, including the size of muscle, tendon, strengthen and improves the toughness of ligament and joint function, reduced for injury [9]. Increased the bone density, fitness, metabolism and cardiac function [10, 11].

Training the aerobic system is called as endurance training which is opposed to the anaerobic system, which is divided into two categories, general and specific endurance [12]. Endurance fitness which sustain the necessary activity level for a specific competitive sport, which includes both cardiovascular and muscular endurance required for the sport [13]. In physiological aspect, it requires the circulatory and respiratory systems to supply energy to the working muscles to support sustained physical activity. Endurance requires the circulatory and respiratory systems to supply energy to the working muscles in order to support sustained physical activity [14]. Indeed, high levels of muscular strength and aerobic endurance are key determinants of success in many sports [19, 20].

Material and Methods

In this study it was aimed to find out the effect of resistance training, and endurance training on leg strength, muscular endurance and cardio-respiratory endurance. To achieve the purpose sixty female students from faculty of Agriculture of Annamalai University, Annamalainagar, and Tamilnadu were selected as subjects at random from the total population of 143 students. They were divided into four equal groups of fifteen each and further divided as three experimental groups and one control group, in which the group I (n=15) underwent resistance training, group II (n = 15) underwent endurance training and group III (n = 15) underwent the combination training for three days (alternative days) per week for twelve weeks, and group IV (n=15) acted as control which did not participate in any special training apart from the regular curricular activities.

For every training programme there would be a change in various structure and systems in human body. So, the researchers consulted with the experts and then selected the following variables as criterion variables: 1. Leg strength 2. Muscular endurance and 3. Cardio-respiratory endurance.

Analysis of the Data

Analysis of covariance was used to determine the differences, if any, among the adjusted posttest means on selected criterion variables separately. Whenever the 'F' ratio for adjusted posttest mean was found to be significant, the Scheffé *S* test was applied as post-hoc test. The level of significance was fixed at. 05 level of confidence to test the 'F' ratio obtained by analysis of covariance.

Table 1: Analysis of Covariance and 'F' ratio for Leg Strength, Muscular endurance and Cardio-respiratory Endurance of Resistance Training Group, Endurance Training Group Combined Training Group and Control Group

Variable Name	Group Name	Resistance Training Group	Endurance Training Group	Combined Training Group	Control Group	'F' Ratio
Leg Strength (in Kgs.)	Pre-test Mean± S.D.	38.46 ± 1.0	37.20 ± 1.8	38.19 ± 1.2	39.81 ± 1.9	1.098
	Post-test Mean± S.D.	40.26 ± 1.4	38.55 ± 1.5	39.73 ± 1.9	38.53 ± 1.6	5.86*
	Adj. Post-test Mean	41.85	39.29	40.27	38.11	25.43*
Muscular Endurance (in Nos/min)	Pre-test Mean± S.D.	12.86 ± 0.93	13.11 ± 0.11	12.33 ± 0.81	12.73 ± 0.9	0.993
	Post-test Mean± S.D.	15.53 ± 0.32	14.87 ± 0.86	15.86 ± 0.97	12.31 ± 0.86	7.26*
	Adj. Post-test Mean	16.76	15.61	16.95	12.45	31.61*
Cardio-respiratory Endurance (in Meters)	Pre-test Mean± S.D.	1086.31 ± 122	1067.51 ± 236	1079.86 ± 183	1081.36 ± 154	1.371
	Post-test Mean± S.D.	1209.73 ± 145	1408.33 ± 171	1413.45 ± 201	1033.51 ± 122	12.33*
	Adj. Post-test Mean	1210.22	1433.86	1406.87	1054.23	38.63*

* Significant at. 05 level of confidence. (The table value required for significance at. 05 level of confidence with df 3 and 56 and 3 and 55were 2.77 and 2.78 respectively).

Table 1 shows that pre and posttest means 'f' ratio of resistance training group, endurance training group, combined training group and control group on leg strength was 1.098, which is insignificant at 0.05 level of confidence. The post and adjusted posttest mean 'f' ratio value of experimental groups and control group was 5.86 and 25.43 which was significant at 0.05 level of confidence. The pretest means 'f' ratio of resistance training group, endurance training group, combined training group and control group on muscular endurance was 0.993, which is insignificant at 0.05 level of confidence. The post and adjusted posttest mean 'f' ratio value of experimental groups and control group was 7.26 and 31.61, which was significant at 0.05 level of confidence. The pretest means 'f' ratio of resistance training group, endurance training group, combined training group and control group on cardio-respiratory endurance were 1.371 which is insignificant at 0.05 level of confidence. The posttest and adjusted posttest mean 'f' ratio value of experimental groups and control group were 12.33 and 38.63, which was significant at 0.05 level of confidence. The overall study shows that there was a significant increase in leg strength, muscular strength and cardio-respiratory endurance. Further, to find out which of the paired mean significantly differ, the Scheffĕ *S* test was applied and presented below.

Table 2: Scheffĕ *S* Test for the Difference between the Adjusted Post-Test Mean of Leg Strength Muscular endurance and Cardio-respiratory Endurance

Adjusted Post-test Mean for Leg Strength					
Resistance Training Group	Endurance Training Group	Combined Training Group	Control Group	Mean Difference	Confidence Interval at 0.05 level
41.85	39.29			2.56*	1.07
41.85		40.27		1.58*	1.07
41.85			38.11	3.74*	1.07
	39.29	40.27		0.98	1.07
	39.29		38.11	1.18*	1.07
		40.27	38.11	2.16*	1.07

Adjusted Post-test Mean for Muscular Endurance					
16.76	15.61			1.15*	0.94
16.76		16.95		0.19	0.94
16.76			12.45	4.31*	0.94
	15.61	16.95		1.34*	0.94
	15.61		12.45	3.16*	0.94
		16.95	12.45	4.50*	0.94
Adjusted Post-test Mean for Cardio-respiratory Endurance					
Resistance Training Group	**Endurance Training Group**	**Combined Training Group**	**Control Group**	**Mean Difference**	**Confidence Interval at 0.05 level**
1210.22	1433.86			223.64*	28.18
1210.22		1406.87		196.65*	28.18
1210.22			1054.23	155.99*	28.18
	1433.86	1406.87		26.99	28.18
	1433.86		1054.23	379.99*	28.18
		1406.87	1054.23	352.64*	28.18

* Significant at 0.05 level of confidence.

Table – 2 shows that the Scheffẽ *S* Test for the difference between adjusted post-test mean of resistance training group and endurance training groups (2.56), resistance training group and combined training group (1.58), resistance training group and control group (3.74), endurance training group and control group (1.18) and combined training group and control group (2.16), which were significant at 0.05 level of confidence. But there was no significant difference between endurance training group and combined training group (0.98) on leg strength after the respective training programme.

Table – 2 also shows that the Scheffẽ *S* Test for the difference between adjusted post-test mean difference in muscular endurance between resistance training group and endurance group (1.15), resistance training group and control group (4.31), endurance training group and combined training groups (1.34), endurance training group and control group (3.16), combined training group and control group (4.50) were significant at 0.05 level of confidence. But there was no significant difference between resistance training group and combined training group (0.19) on muscular endurance after the training programme.

Table – 2 shows that the Scheffẽ *S* Test for the difference between adjusted post-test mean difference in cardio-respiratory endurance between resistance training group and endurance group (223.64), resistance training group and combined training group (196.65), resistance training group and control group (155.99), endurance training group and control group (379.99) combined training group and control group (352.64) were significant at 0.05 level of confidence. But there was no significant difference between endurance training group and combined training group (26.99) on cardio-respiratory endurance after the respective training programme.

Conclusions

The result of the present study shows that the leg strength has improved all the training groups except, endurance training group. Findings of Yiannis *et al*. [15] and Bartholomew *et al*. [16] supports the results of the present study. Roelants, *et al*. [17] found that there was a significant improvement in leg strength after 24 weeks whole body vibration and standard fitness training programme (strength and cardio-vascular training). Hong *et al*. [18] reported that, an improvement was found in muscular endurance and strength after the resistance training programme.

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