Original Article

POTENTIAL ROLE OF CIRCUIT TRAINING AND LADDER TRAINING IN THE DEVELOPMENT OF ANAEROBIC POWER AND EXPLOSIVE PERFORMANCE OF SCHOOL STUDENTS

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Abstract

Objectives: To determine the potential role of circuit training and ladder training in developing anaerobic power and explosive performance of school students.

Design: The students were divided randomly into 3 groups' circuit training (CT; n = 15), ladder training (LT; n = 15) and control group (CG; n = 15).

Setting: The three groups did not significantly ($p > 0.05$) after randomisation in the dependent variable. The data obtained from the subjects are analysed statistically by applying analysis covariance (ANACOVA) at a 0.05 level of significance.

Participants: Forty-five boys students were selected age: 15.6 ± 1.2 years; body height: 175.4 ± 5.8 cm; body mass: 71.6 ± 6.2 kg; BMI: 23.1 ± 2.3).

Main Outcome Measures: Sprint performance was assessed using a sprint over 50 m and explosive power was assessed by using a standing broad jump.

Results: The study's findings indicated that 12 weeks of ladder training increased speed performance by 5.3% and that circuit training increased explosive power by 8.2%.

Conclusions: The circuit training method and the ladder training method are two ways that can improve explosive power and speed. But the ultimate result differs dramatically in both ways.

Keywords: Anaerobic power, Explosive power, Ladder training, Circuit training, Ancova.

INTRODUCTION

Agility ladders are athletic training equipment used to improve speed and agility **(Myrland, 1999).** Athletes run or jump using ladder equipment to increase speed, agility and quickness. Standard types of equipment of ladders are about 10 yards long using 18 inches each square, they can be constructed by using rope, plastics or tape **(Kusnanik & Rattray, 2017).** Different ladder training drills emphasize different rhythms or patterns of steps, jumps, hopes, bounds or combinations of these elements to teach control of the athlete's centre of gravity while in motion and to improve the athlete's foot speed and reaction time **(Myrland, 1999)**. Ladder training is the latest

method of the multidirectional training programme because the elements of motor components that are strength, power, agility, coordination, joint stability, foot speed, hand-eye coordination and reaction times are increasing **(Pramod & Divya, 2019).** Because of these causes nowadays, ladder training is a key part of many sports events for speed and agility development. Arbitrating from the motion of the body system, speed is the rudimentary ability of the central nervous system mobility and muscle device to play movements at a certain speed.

Ladder drills are better done early after warming up when the muscles have not experienced significant exhaustion or are still fresh to carry out good-quality movements **(Pandarwidi S et al., 2020)**. The ladder training starts with general development up to advanced skill development from a full range of motion to smaller, quicker and moving into fast, and more explosive movements as a teaching and learning progression will have a greater amount of success **(Rajendran, 2016**). The advantages of ladder drill exercises are speed legs that are needed by athletes to change direction quickly and also it can prevent injury, stabilisation, coordination and explosiveness **(Kusnanik & Rattray, 2017)**.

Speed is a combination of three elements: reaction time, the frequency of the movement per unit of time, and the speed of a certain distance **(Chandra et al., 2017).** Speed is the ability to move the body from one point to another or to work on a repetitive activity that is the same and continuous in the shortest time **(Nala, 1998**). Speed is used in sports for such muscle reactions that are characterised by the maximally quick alternation of muscle contraction and relaxation and the ability to execute motor actions under given conditions, in the minimum possible time **(Pratap et al., 2021)**.

Circuit training is a type of training that works on body conditioning by developing strength, endurance, flexibility and coordination all in one workout, it consists of a series of exercises that are performed in a row one after another with a minimal rest period in between. All these exercises are from one circuit **(Mohanta et al., 2019)**. The circuit includes several exercises, usually nine to twelve, selected to improve the general muscular condition, and circulatory and respiratory response **(ADAMSON, 1959)**. Circuit training is a form of body conditioning that involves endurance training, resistance training, high-intensity aerobics and exercises performed in a circuit, similar to high-intensity interval training **(Pratap et al., 2021).**

Anaerobic capacity is the ability of the muscles to adapt to workouts in the form of very short duration, maximal and super maximal physical activities **(Sözen & Akyıldız, 2018)**. Anaerobic activity cannot be sustained for a prolonged time. Because skeletal muscles are functioning way above the steady rate of oxygen metabolism and through anaerobic metabolism. This circumstance increases lactate levels in muscle and blood. The buffering of accumulated lactate increases the Co_2 release from the lungs. Fatigue presents itself in muscles due to a decrease in pH (pH=6.4) **(Jonathan & Euan, 1997)**. During the anaerobic muscular activities, the maximal generation of energy period is 90 seconds and most of the energy is delivered by the ATP-CP system and anaerobic breakdown of the muscle glycogen **(Sözen & Akyıldız, 2018; Weltman, 1995).** To increase the ATP-CP capacity, powerful and frequent short-term contractions are needed. These efforts must focus on training the muscles working during these movements. Metabolic capacity of the muscle fibrils, worked with these types of exercise, increases and the development of the nerve-muscle adaptation specific to the sport exercised is needed **(McArdle et al., 1991)**.

METHODS

Experimental Approach to the Problem

The study was conducted as a randomised control study. Forty-five subjects were randomly selected and assigned to two experimental and one control group. The control group (CG) was instructed to continue their regular activities and avoid vigorous physical activity during the study. The experimental groups were named circuit training (CT and ladder training (LT). Both the experimental groups completed 12-week exercise training 3 days a week. The performance pre-test and post-test were conducted before and after the training period. All the training and performance testing took place at the same venue and time to avoid circadian variation in performance. Four days of adaptation period before the beginning of the study to familiarise themselves with the training and testing procedure. All the subjects showed a cent percentage of obedience with testing and exercise training.

Subjects and Testing Procedure

Forty-five boys students were selected (mean ± SD; age: 15.6 ± 1.2 years; body height: 175.4 ± 5.8 cm; body mass: 71.6 ± 6.2 kg; BMI: 23.1 ± 2.3) to participate in this study after having concerns from their parents before the investigation. The students were divided randomly1 into 3 groups' circuit training (CT; n = 15), ladder training (LT; n = 15) and control group (CG; n = 15). Following randomisation, the three groups did not significantly ($p > 0.05$) in the dependent variable. To find the effect of circuit training and ladder training on anaerobic performance, we applied a testing procedure that included measurements of two specific motor qualities: sprint performance and explosive power. Sprint performance was assessed using a sprint over 50 m and explosive power was assigned by using a standing broad jump.

Table 1. Pre-test, Post-test Experimental Design

Sample	Pre-test	Treatment	Post-test
N	O_1	X_1	O_2
N	O_3	X_2	O_4
N	O_5	X_3	O_6

N = Random Sampling; X_1 = Experimental treatment Ladder Training; X_2 = Experimental Treatment Circuit Training; X_3 = Control Group; O_1 = Experimental class pre-test; O_2 = Experimental class post-test; O_3 = Experimental class pre-test; O_4 = Experimental class post-test; O_5 = Control class pre-test; O_6 = Control class post-test.

Training Procedure

The circuit training and ladder training groups were required to perform three training sessions per week on alternate days for 12 weeks. Thus the programme contains 36 training sessions for each subject in both experimental groups. Each training session started with 20 minutes of warming up including 10 minutes of jogging followed by free hand exercise and stretching followed by 60-minute workouts and ending with 15 minutes of limber down. The training programme employed by both experimental groups is outlined in Tables II & III. We specifically instructed all subjects to avoid any other type of training during the study and also all the subjects were advised to maintain their normal dietary practice throughout the study.

Table II. Training programme for the circuit training

Week	Exercise / Stations	Set x Reps.	Recovery - Set / Reps.
1 to 4	Hurdle jump 60 cm height Medicine ball chest pass Star jump Biceps curl Box jump 45 cm height	3 x 30 sec.	4 min / 45 sec.

	Rope skip jump		
	Medicine ball chest pass	3 x 45 sec.	4 min / 60 sec.
5 to 8	Bounding		
	Sit-ups		
	Biceps curl		
	Box jump 45 cm height		
	High knee		
	Sit-ups	3 x 45 sec.	4 min. / 60 sec.
9 to 12	Bounding		
	Push-ups		
	Box jump 45 cm height		
	Medicine ball chest pass		
	Hopping		

Table III. Training programme for ladder training

Week	**Exercise / Stations**	**Set x Reps.**	**Recovery - Set / Reps.**
	Lateral run		
	Zag hip twist		
1 to 4	Bunny hops	3 x 5	4 min. / 45 sec.
	High knee		
	Carioca step		
	Side reach run		
	Two-in two-out forward run		
	180 rotation		
5 to 8	Slalom jump	3 x 5	4 min. / 45 sec.
	Two-foot run		
	Bunny twist		
	Bunny hops		
	Zag hip twist		
	Bunny twist		
	Slalom jump		
9 to 12	High knee	3 x 5	4 min. / 45 sec.

	Bunny hops
	Side reach run
	Carioca step
	Lateral run

STATISTICAL ANALYSIS

The data about the variables under study have been examined by analyzing the variables separately to find the significant difference between the experimental groups and control groups on selected dependent variables namely Speed and Explosive power. And also determine the difference if any among groups (Control and Experimental groups) and in different stages (Pre and Post-test). In one first step, the descriptive statistics of Groups have been examined for pre-experimentation. When the differences are found to be significant by the analysis of covariance it can conclude with Scheef's post hoc test on selected variables. The data obtained from the subjects are analyzed statistically by applying analysis covariance (ANACOVA) at a 0.05 level of significance.

RESULTS OF THE STUDY

TABLE IV: Analysis of covariance for speed on circuit training, ladder training and control group students

	Circuit Training	**Ladder Training**	**Control Group**	**SOV**	**SS**	**df**	**M.Sq**	**'F'Ratio**	**Sig**
Pre Test Mean	7.47	7.52	7.67	B	0.32	2	0.16	0.44	
				W	15.30	42	0.36		0.647
S.D	0.78	0.38	0.58						
Post-test Mean	7.20	7.12	7.66	B	2.54	2	1.27	4.03*	
				W	13.25	42	0.315		0.025
S.D	0.76	0.25	0.56						
Adjusted Post-test Mean	7.28	7.14	7.55	B	1.29	2	0.647	28.67**	
				W	0.92	41	0.023		0.000

*****Significant at 0.05 level. The value for df 2, 42 at 0.05 level =3.21, and the value for df 2, 41 at 0.05 level =3.21

Table IV shows that the pre-test means in the speed of the circuit training group is 7.47, the ladder training group is 7.52, and the control group is 7.67 and they had an 'F' ratio of 0.44. Which is insignificant at a 0.05 level of confidence. The post-test means of the circuit training group is 7.20, the Ladder training group is 7.12, and the control group is 7.66 and which resulted in an 'F' ratio of 4.03. It shows there is a significant difference among the post-test means at a 0.05 level of confidence.

The adjusted means of the circuit training group (7.28), Ladder training group (7.14) and control group (7.55) were shown in the table. The calculated F ratio (28.67) is well above the table value. So it was significant at 0.05 level of confidence of the selected group in speed.

Figure I: Showing the Pre, Post and Adjusted Post Test Mean of Circuit training, Ladder Training and Control Groups on Speed

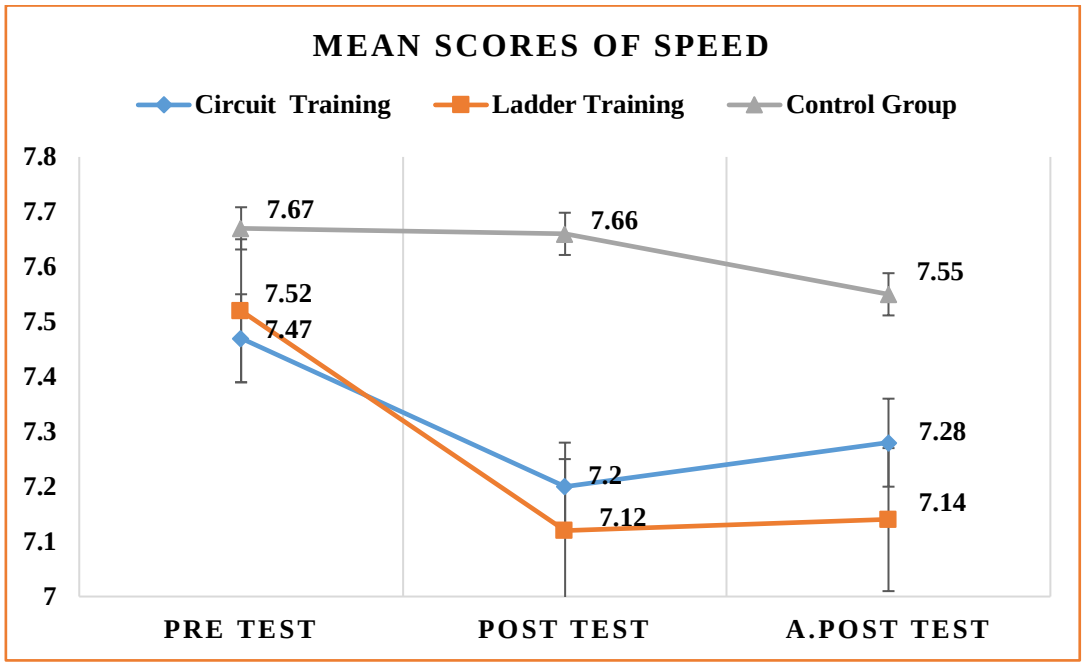

Table V: Scheffe's post-hoc test for paired mean difference among the groups for speed

Ladder Training Group	Circuit Group	Training	Control Group	Mean Difference	F Value
7.14	7.28			0.14	0.197
7.14			7.55	0.41*	
	7.28		7.55	0.30*	

*Significant at 0.05 level, Scheffe's F value 0.05 Level=0.197

Scheffe's Post hoc test showed that there is a significant difference between the control group and Ladder training with a mean difference of 0.41, also there is a significant difference between the control group and the circuit training group with a mean difference of 0.30. There is no significant difference between the circuit training group and the ladder training group with a mean difference of 0.14. Since the F value is 0.197

Table VI: Analysis of covariance for explosive power on circuit training, ladder training and control group students

	Circuit Training	Ladder Training	Control Group	SOV	SS	df	M.Sq	'F'Ratio	Sig
Pre-test Mean	2.06	2.08	2.06	B	0.003	2	0.002	0.027	.973
				W	2.678	42	0.064		
S.D	0.20	0.23	0.31						
Post-test Mean	2.23	2.20	2.08	B	0.193	2	0.096	1.67	
				W	2.416	42	0.058		0.20
S.D	0.16	0.216	0.31						
Adjusted Post-test Mean	2.24	2.19	2.08	B	0.187	2	0.094	31.18	
				W	0.123	41	0.003		0.000

*****Significant at 0.05 level

The value for df 2, 42 at 0.05 level =3.21, and the value for df 2, 41 at 0.05 level =3.21

Table VI shows that the pre-test means in the explosive power of the circuit training group is 2.06 ladder training group is 2.08, and the control group is 2.06 and they had an 'F' ratio of 0.027, which is insignificant at 0.05 level of confidence. The post-test means of the circuit training group is 2.23, the Ladder training group is 2.20, and the control group is 2.08 and which resulted in an 'F' ratio of 1.67. It shows there is no significant difference among the post-test means at a 0.05 level of confidence.

The adjusted means of the circuit training group (2.24), Ladder training group (2.19) and control group (2.08) were shown in the table. The calculated F ratio (31.18) is well above the table value. So it was significant at 0.05 level of confidence of the selected group in explosive power.

Figure II: Bar Diagram Showing the Pre, Post and Adjusted Post-test Mean of Ladder training, Circuit Training and Control group on Explosive power

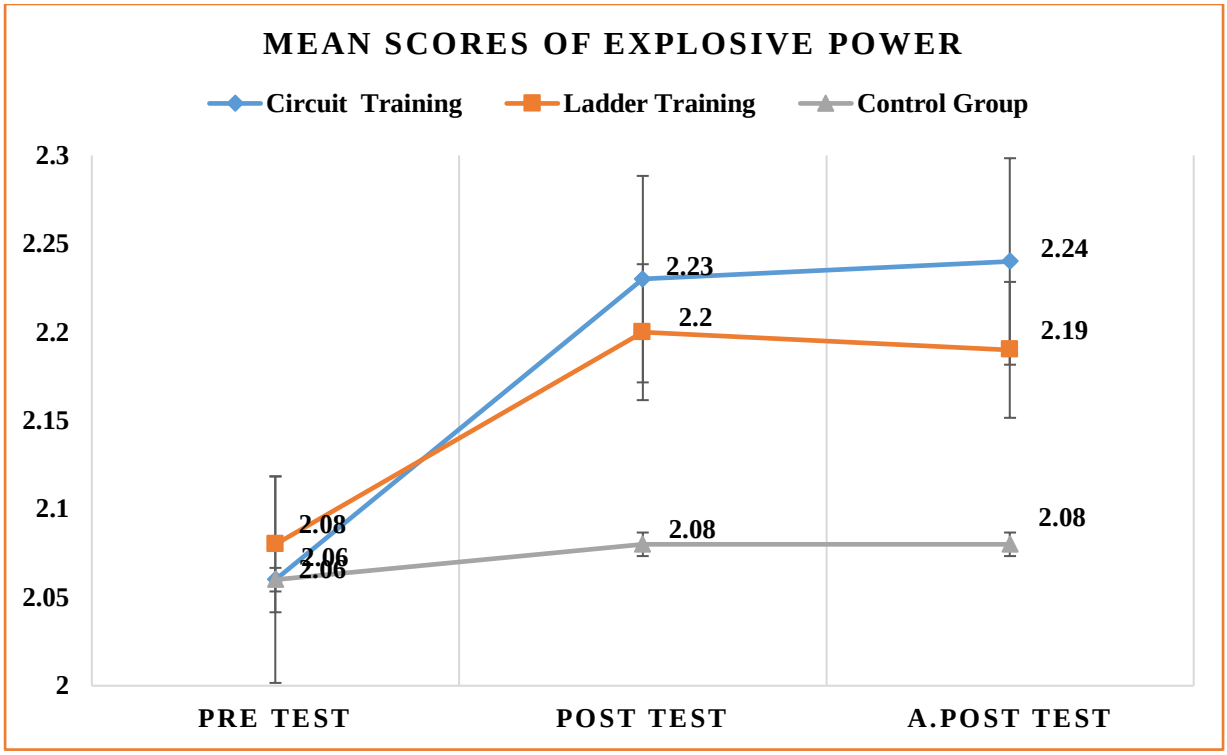

Table VII: Scheffe's post-hoc test for paired mean difference among the groups for explosive power

Circuit Training Group	Ladder Training Group	Control Group	Mean Difference	F Value
2.24	2.19		0.05*	0.05
2.24		2.08	0.16*	
	2.19	2.08	0.11*	

***Significant at 0.05 level, Scheffe's F value 0.05 Level=0.05

Scheffe's Post hoc test showed that there is a significant difference between the control group and the circuit training with a mean difference of 0.16, also there is a significant difference between the control group and the Ladder training group with a mean difference of 0.11 there is also a significant difference between circuit training group and the ladder training group with mean difference 0.05. Since the F Value is 0.05

DISCUSSION

The goal of the study was to investigate if circuit training and ladder training may help students enhance their anaerobic capacity and explosive performance. Following a 12-week training program, both training and examination modalities were successful in improving speed and explosive power. As well-designed training programs have repeatedly demonstrated, it was predicted that untrained individuals would exhibit increased speed and explosive power. The drills or stations used in this study's circuit training and ladder training included a

variety that helped participants increase their speed and explosive power. The findings of the current study proved that a 12-week ladder and circuit training program can help students develop their speed and explosive power. Ladder training and circuit training were used in earlier research, which showed a considerable gain in speed and explosive power.

The temporal efficiency of ladder training is demonstrated by the boys' students' 5.3% increase in speed after 12 weeks of ladder training. When circuit training is used, there is an 8.2% improvement in explosive performance following the same amount of time spent on circuit training with a standard rest period in between sets and exercises

The circuit training groups experienced an increase in explosive power. We believed that throughout the course of a lengthy training session, periodised circuit training would continue to produce an efficient exercise stimulus that would lead to a greater magnitude of change in muscle performance. Essentially, this was the investigation's main assumption since repeated circuit training sessions helped to increase explosive power**(Marx et al., 2001)**. The rise in explosive force demonstrated that leg power adaptations had occurred**(Thomas et al., 2009)**.

The findings of this study are consistent with those of a study by Yuliandra, which found that circuit training can enhance the leg muscles' explosive strength**(Yuliandra et al., 2020).** The gain in explosive power brought on by circuit training directly supports the study's present findings**(Myers et al., 2015)(Maniazhagu et al., 2017)**. In line with the current study, **(Hardiansyah et al., 2020; Mayorga-Vega et al., 2013)** discovered that circuit training can be used to maintain and enhance muscular strength and cardiovascular endurance. Other researchers reveal in their study that **(Diswar et al., 2016; Lehnert et al., 2015; Pari, 2019)** circuit training methods serve to develop the explosive power of individuals of various ages. These research studies significantly support the present research findings.

Ladder training has been used in several studies that have demonstrated improvements in a variety of motor fitness traits, including speed, agility, etc. According to the hypothesis testing, exercising with ladder drills had a substantial impact on running speed. Ladder training is a great way to increase the foot's overall speed, agility, and coordination **(Jamil et al., 2015)**Coordination ladder workouts are a great approach to increasing foot speed, agility, coordination, and general quickness. They are a magic tool that will make anyone quicker or more agile. They support a wide range of sports and events and are a crucial component of many speed, agility, and quickness regimens. Speed ladder exercises focus more on quality and form than they do on output. The exercises are not designed to exhaust muscles or make them short of breath, as shuttle runs, for instance, may. These exercises should be carried out following the warm-up at the beginning of a session. To achieve high-quality movement, the muscles should be in good condition. Additionally, since they won't fatigue, athletes may follow them up with some resistance or endurance training.

Sports talents that call for fast movements, stopping suddenly, and direction changes rely heavily on agility as a physical condition. Successful performance in any sport depends on agility **(Pratama et al., 2018).** The results of research Chandra et al also showed the results of speed and agility after being given ladder drill training **(Chandra et al., 2017).** The current study strongly supported the study of **(Pramod & Divya, 2019)** and proved that ladder training is helped to improve the speed of Egyptian students.

CONCLUSION

The increase in post-test data when compared to pre-test data shows that the circuit training method and the ladder training method are two ways that can improve explosive power and speed. But the ultimate result differs dramatically in both ways. Some of the previously mentioned factors are likely the reasons why the two types of exercise, circuit training and ladder training, did not significantly vary in how they improved speed and explosive power, respectively.

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