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Effects of Bicycle Ergometer Exercise and Blood Flow Restriction Training on Cardiopulmonary Variables in Gymers

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Abstract: ***Background: Resistance exercise training improves balance and muscle strength. Resistance training programmes are available in health clubs and gyms. Nowadays, blood flow restriction training (BFRT) is gaining ground in the world of exercise. It is beneficial for muscle health in normal individuals as well as a potential alternate training mode for populations who cannot tolerate high-intensity exercise. It involves exercising with an external constricting device (such as blood pressure cuffs) that is applied to the proximal limb musculature with the aim of restricting arterial blood flow and occlusing venous return. Objective: To evaluate the effects of bicycle ergometer exercise and blood flow restriction training along with bicycle ergometer exercise on cardiopulmonary variables in gymers. Research Methodology: In this experimental study, a total of 40 subjects were selected on the basis of inclusion and exclusion criteria and divided into two different groups of 20 subjects each. Group A exercised for 15-20 minutes on a bicycle ergometer. Group B exercised for 15-20 minutes on the bicycle ergometer with the application of BFRT. The pressure cuffs attach over the proximal portion of the thigh and inflate at a rate of 100 to 150 mm/hg. Both groups received training three days a week for four weeks. Measurement includes Thigh Girth measurement, pulmonary function test and blood pressure. These measurements were taken before and after the completion of the training period. Results: In Group A, there is a significant improvement in FVC, SBP and DBP as the value of $p < 0.05$ but there is no significant improvement in PIFR, PEFR, Right and Left thigh girths as the value of $p > 0.05$. In Group B, there is a highly significant improvement in all the variables like FVC, PIFR and PEFR, SBP, DBP, Right and Left thigh girth as the value of $p < 0.05$. Conclusions: This study shows that PFT is improved with the use of BFRT. There is an improvement in BP in both groups, but more in Group B. In the thigh girth measurement, there was no increase in thigh girth size in Group A, and highly significant increase in thigh girth size of both the legs with the BFRT.***

Keywords: Blood flow restriction technique, forced vital capacity, peak Inspiratory flow rate, peak expiratory flow rate, pulmonary function test, blood pressure.

1. Introduction

Physically inactivity of individuals creating health issues in masses which adversely results in the enlargement of the national health care cost. The health issues include coronary artery disease, stroke, depression and type 2 diabetes [1]. A sedentary lifestyle is highly common in the middle-aged and elderly populations which lead to loss or decrease of muscle strength. This results in falls, functional disability, and impaired mobility [2].

Nowadays trends of health clubs and the sports industry are increasing and becoming more popular in the youth fitness market. Health clubs and fitness training centers are the safe, effective and enjoyable means for youth of today [3]. Gyms and fitness centers play a pivotal role for individuals to work on their muscle strength and to improve their physical conditioning and general wellbeing. Male gymers are using dietary supplements to increase their muscles mass and strength. Female gymers are also using dietary supplements to boost energy and prevent nutritional deficiency [4]. Gyms are also playing an important role in promoting mental health via daily social interactions with different individuals in the gym [1]. The youth must practice physical activity routine approximately for 60 minutes per day. Physical activity is not only necessary for normal health, but it is imperative for reducing the risk of developing some chronic diseases in later life. Many research articles indicate that resistance training can have a number of benefits for children and adolescents [3]. Resistance exercise training improves balance performance, muscle strength, functional status, depression and symptoms in middle aged and elderly adults [2].

Properly designed and supervised resistance training programs is relatively safe for youth and also stimulates daily exercise habit. The chances of injury occurrence in gyms are very minimal as compared to other sports like football, wrestling etc [3]. There is no evidence of adverse results for practicing resistance training on growth or development in childhood and adolescence [3]. These resistance training programs are available in health clubs and gyms [2]. There are no age criteria for children to start resistance exercise training. The only essentiality for Participants is to be mentally and physically ready for a training program [3]. Coaches should have proper knowledge and expertise to properly instruct this type of training [3]. While designing a resistance training program trainer should consider regarding Warm-up and cool-down, Choice and order of exercise, Training intensity and volume, Rest intervals between sets, Repetition velocity, Training frequency and Program variations [3].

Nowadays Blood-flow restriction training (BFRT) is gaining ground in the world of exercise. It is beneficial for muscle health in normal individuals as well as a potential alternate

training mode for populations who cannot tolerate high-intensity exercise [5, 6]. The origin of the BFRT in Japan in the 1960's and the other name of is KAATSU training [6, 7]. BFRT includes exercising with an external device (such as blood pressure cuffs, elastic muscle wraps, or tourniquets) applied to the proximal limb musculature with the goal of restricting arterial blood flow and occlusive venous return. BFR training is done 2-3 times per week on the same muscle or muscle group [9]. The collaboration of BFRT and aerobic exercises like walking and cycling gives highly significant outcomes such as increases in muscle cross-sectional area, improved cardio-respiratory fitness and maximum oxygen uptake levels [6]

The major mechanisms behind this are cell swelling and metabolite-induced fatigue. The restriction due to BFRT may lead to inducing a swelling response. Cell swelling inhibits protein breakdown or increases protein synthesis, resulting in a positive protein balance [17]. Exercise with blood flow restriction results in buildup of metabolic byproducts in the working limb. Metabolites may directly contribute to muscle growth by stimulating anabolic hormonal pathways. The role of metabolites and muscle growth found that an average 8-week of training protocol [17]. There is also an increase in hormone levels such as growth hormone and testosterone by blood flow resistance training. These hormones are important for increasing skeletal muscle size [17].

BFR training is not recommended if an individual is suffering from blood pressure of 180/100 mmHg or higher, cardiothoracic ratio of 55% or higher, life-threatening arrhythmia, ischemic changes on ECG, uric protein of 100 mg/dl, diabetes or fasting blood glucose of 250 mg/dl or higher, BMI of 30 or higher, history of deep-vein thrombosis, hereditary thrombotic tendency, anti-phospholipid antibody syndrome, Pregnancy, Varicose veins, atrial fibrillation, heart failure, People aged over 60 years old, Hyperlipidemia, Malignancy, Using oral contraceptives or adrenocortical steroids and having high haemoglobin levels [19] Although BFR training has a lot of benefits for practitioners, it also has some adverse effects, such as prolonged ischemia leads to necrosis of muscle tissue, thrombus formation because of the pooling of blood in the extremities [9].

2. Methods

Participants

A total of 40 male subjects were recruited for this study, with an age range of 15 to 25 years. All participants had been going to the gym for the last 6 months. Recruitment was conducted at different gyms in the city of Amritsar. All subjects were free from hypertension, musculoskeletal disease, hyperlipidemia, cardiopulmonary disease, peripheral vascular disorders, and neurological imbalances involving lower limbs.

Protocol

These 40 subjects were divided into two different groups of 20 subjects each. Group A (control group) exercised for 15-20 minutes on a bicycle ergometer, including a warm-up and cool-down phase. Group B (BFRT GROUP) exercised for 15-20 minutes on the bicycle ergometer, including a warm-up and cool-down phase with the application of blood flow restriction training (BFRT). The pressure cuffs, or tourniquets, attach over the proximal portion of the thigh and inflate at a rate of 100 to 150 mm/hg. Both groups received training three days a week for four weeks. Exercise intensity and duration were constant throughout the training period. The measurements include a thigh girth measurement, pulmonary function test, and systolic and diastolic blood pressure was taken before and after the completion of the training period.

Measurements

After completion of the cool down phase, subjects were taken to rest for 2 minutes, and then they underwent a spirometry test (RMS Helios-401 Spirometer). During a spirometery test, the subject was in a chair-sitting position, then given the command to attach the nose clip over their nose and to perform a long exhale and inhale through a disposable mouth piece that is attached at the tip of the spirometer. The subjects saw a graph over the laptop screen for visual feedback at the time of inhale and exhale, in order to perform well. After completion of the test, that disposable mouth piece was immediately discarded in order to avoid the spread of any infection.

During blood pressure measurement, the subject was in a chair-sitting position and placed one arm over the table. The level of the heart, table, and blood pressure apparatus were all in the same direction. Then measure the systolic and diastolic blood pressure with a sphygmomanometer. Thigh girth measurement

During thigh girth measurement, the subject was standing with one foot on a chair, so the knee was flexed at 90 degrees. A measure was taken midway between the inguinal crease and the proximal border of the patella, perpendicular to the long axis with the help of a flexible inch tape. This procedure was the same for both the right and left thigh.

3. Results

Pulmonary function test

In Group A, there is improvement in forced vital capacity as the value of $p < 0.05$ but there is not any significant improvement in peak inspiratory flow rate and peak expiratory flow rate as the value of $p > 0.05$. In Group B, there is highly significant improvement in forced vital capacity, peak inspiratory flow rate and peak expiratory flow rate as the value of $p < 0.05$.

Blood Pressure

In Group A, there is significant improvement in systolic blood pressure and diastolic blood pressure as the value of $p < 0.05$.

In Group B, there is highly significant improvement in systolic blood pressure and in diastolic blood pressure as the value of $p < 0.05$.

Thigh girth measurement

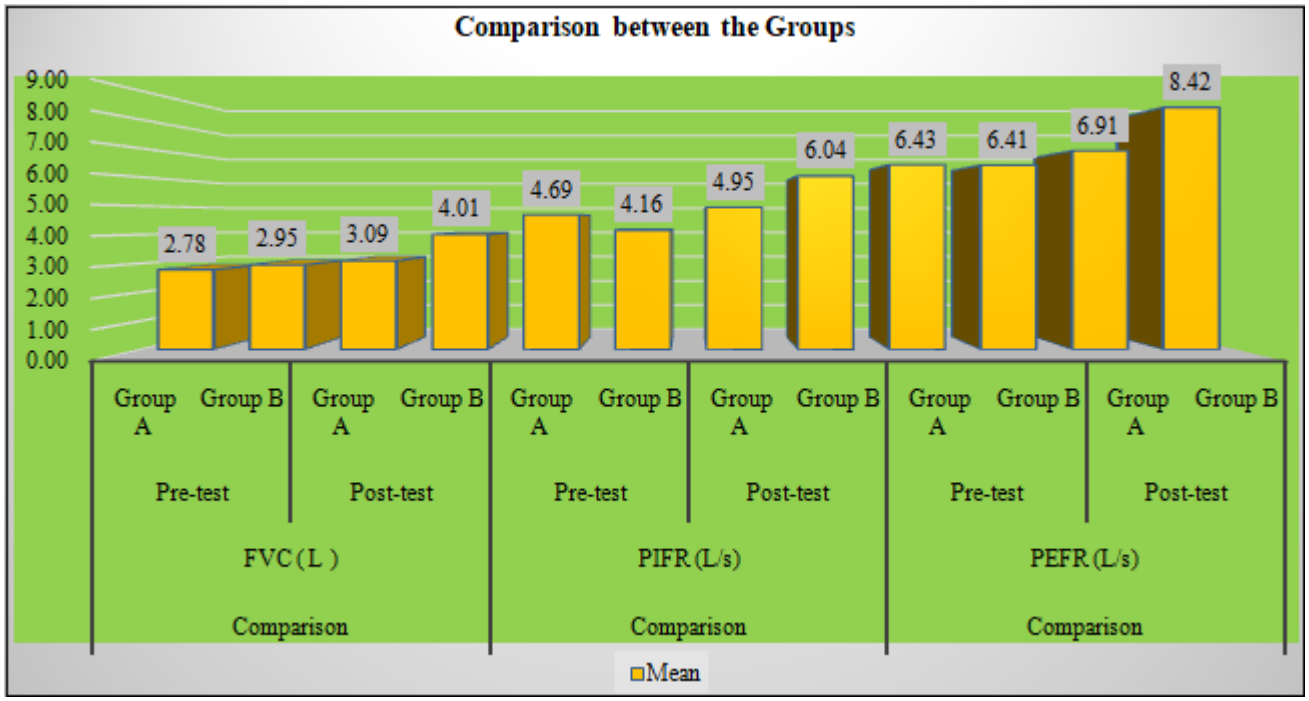
In Group A, there is not any significant improvement in right thigh girth and left thigh girth measurements as the value of $p > 0.05$.

In Group B, there is highly significant improvement in right and left thigh girth as the value of $p < 0.05$.

Table 1: Comparison of Mean and Standard deviation of FVC, PIFR and PEFR, pre intervention and post intervention between group A and group B

Unpaired T Test	Comparison				Comparison				Comparison			
	FVC (L)				PIFR (L/s)				PEFR (L/s)			
	Pre-test		Post-test		Pre-test		Post-test		Pre-test		Post-test	
	Group A	Group B	Group A	Group B	Group A	Group B	Group A	Group B	Group A	Group B	Group A	Group B
Mean	2.78	2.95	3.09	4.01	4.69	4.16	4.95	6.04	6.43	6.41	6.91	8.42
S.D.	0.639	0.487	0.599	0.631	1.221	0.855	1.046	1.247	1.364	1.285	1.042	0.941
Unpaired T Test	0.955		4.763		1.588		2.985		0.056		4.808	
P value	0.3457		0.0000*		0.1205		0.0049*		0.9556		0.0000*	

(Note: * mark indicates that $p < 0.05$)

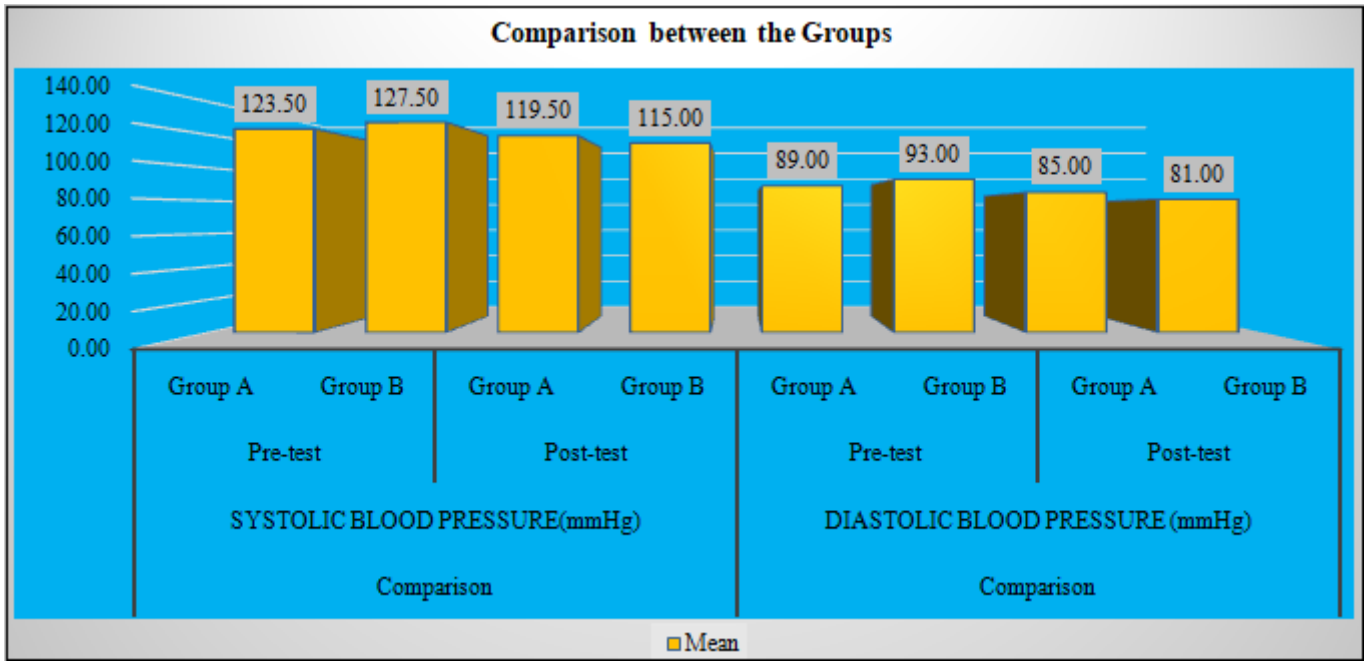


Graph 1: The graphical representation of comparison of Mean of FVC, PIFR and PEFR, pre intervention and post intervention between group A and group B

Table 2: Comparison of Mean and Standard deviation of Systolic blood pressure and Diastolic blood pressure, pre intervention and post intervention of between group A and group B

Unpaired T Test	Comparison				Comparison			
	Systolic Blood Pressure(mmHg)				Diastolic Blood Pressure (mmHg)			
	Pre-test		Post-test		Pre-test		Post-test	
	Group A	Group B	Group A	Group B	Group A	Group B	Group A	Group B
Mean	123.50	127.50	119.50	115.00	89.00	93.00	85.00	81.00
S.D.	8.127	7.164	6.048	5.130	7.182	10.809	5.130	4.472
Unpaired T Test	1.651		2.538		1.378		2.629	
P value	0.1069		0.0154*		0.1761		0.0123*	

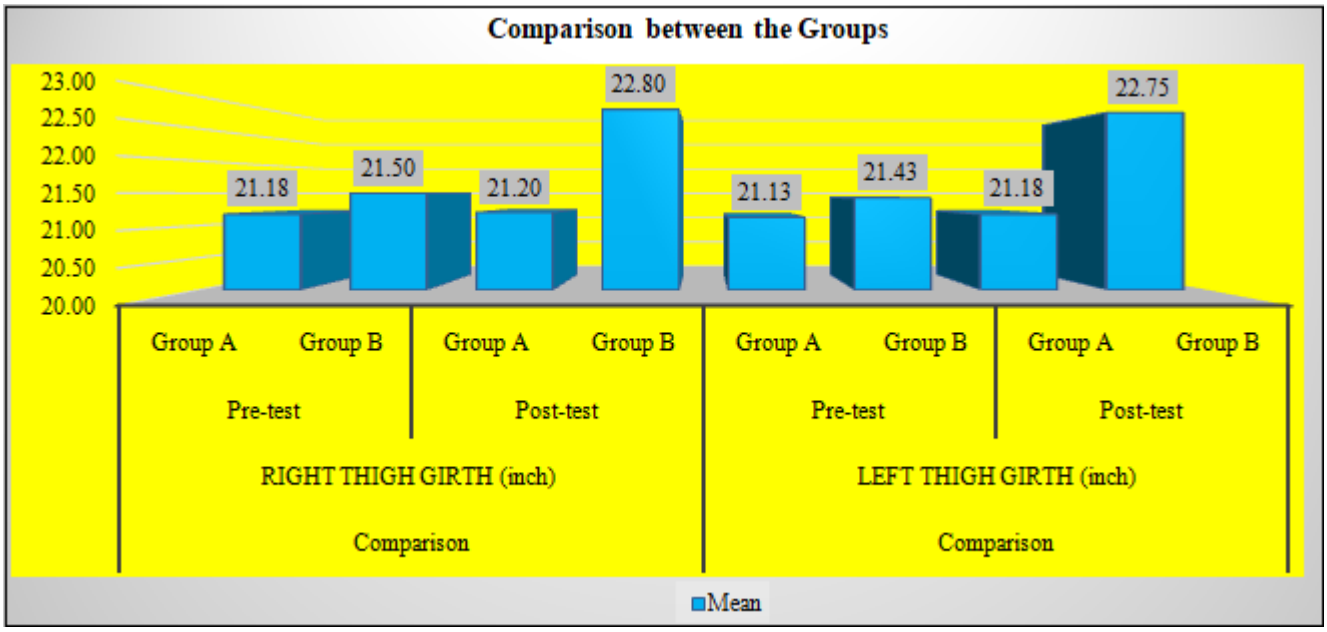
(Note: * mark indicates that $p < 0.05$)



Graph No. 2: The graphical representation of comparison of Mean of Systolic and Diastolic Blood Pressure, pre intervention and post intervention between group A and group B.
(Note: * mark indicates that $p < 0.05$)

Table No. 3: Comparison of Mean and Standard deviation of Right Thigh Girth and Left Thigh Girth measurements, pre intervention and post intervention between group A and group B

Unpaired T Test	Comparison				Comparison			
	RIGHT THIGH GIRTH (inch)				LEFT THIGH GIRTH (inch)			
	Pre-test		Post-test		Pre-test		Post-test	
	Group A	Group B	Group A	Group B	Group A	Group B	Group A	Group B
Mean	21.18	21.5	21.2	22.8	21.13	21.43	21.18	22.75
S.D.	1.092	1.367	1.081	1.446	1.075	1.398	1.055	1.569
Unpaired T Test	0.831		3.964		0.761		3.726	
P value	0.4112		0.0003*		0.4514		0.0006*	



Graph 3: The graphical representation of comparison of Mean of Right Thigh Girth and Left Thigh Girth measurements, pre intervention and post intervention between group A and group B.

4. Discussion

The purpose of this study was to examine and compare the effects of a cycle ergometer with and without the use of a blood flow restriction technique on cardiopulmonary variables. These variables include pulmonary function testing, blood pressure, and thigh girth measurement.

The results of the present study show a highly significant improvement in pulmonary function tests through the use of a bicycle ergometer with the application of the blood flow restriction technique for a period of 1 month. This study also signifies that there is not as much improvement seen in pulmonary function testing with the practise of cycle ergometer alone for a period of one month. The pulmonary function test includes the parameters FVC, PIFR, and PEFR. The mechanism behind this improvement is that improved pulmonary functions with the association of exercise is due to decreased airway resistance, increased airway caliber, and strengthened respiratory muscles as well as improved lung and thorax elasticity. Hormonal changes are also there, and the roles of cortisol and adrenaline are to be achieved. There is decreased lung retractability and induced vasodilatation of pulmonary vessels due to an increased activation of the adrenaline system during exercise training. Vasodilatation of pulmonary vessels occurs and leads to a decreased resistance to airflow and an improved FEV1 and FVC ratios through increasing airflow. Serum cortisol also plays a role in bronchodilatation and lung surfactant generation [23]

Nourry et al. (2005) reported a significant improvement in the FVC of healthy children after 8 weeks of high-intensity intermittent running training. Farid et al. (2005) found significant changes in FVC after 8 weeks of aerobic exercise (3 sessions per week, 20 min/session, 15 min warm up). Tartibian et al. (2010) found a significant increase in VC and FVC after wrestling training (12 weeks, 3 times/week, 90-120 min/day to 70-85% of HRmax in the first 6 weeks, and to 85-95% of HRmax in the two to six weeks) [23.] Enright et al. (2011) found an improvement in VC after an 8-week IMT programme (80% of sustained maximum inspiratory effort, 3 times/week). Shaw and Brown et al. (2011), after 16 weeks of aerobic (45 min at 60%HRmax), resistance (8 exercises, 60%1RM, 3 sets, 15 repetitions) and concurrent training, found that both aerobic and concurrent training had an effect on improvement of some pulmonary functions and had concurrent training effects on improvement of FVC, FEV, PEF, and FEF. Maryam et al. found that the PEF ratio is greater after 8 weeks of training. Nourry et al. (2005) observed a significantly increased PEF after running training. Farid et al. (2005) found there is also an improvement in PEF after eight weeks of aerobic exercise [23].

Mechanism behind improvement of blood pressure is that it is due to changes in cardiac output and total peripheral resistance [13]. There is increased total peripheral resistance during BFR exercise, which also results in blood pressure changes [13.] A norepinephrine-induced vasoconstrictor causes increased total peripheral resistance. At rest and during low-intensity BFR exercise, the levels of serum norepinephrine are increased. Everton et al. found that blood pressure effects after exercise with BFR are lower in SBP and DBP values than traditional exercise in the 30 to 60 minute period [8.] K. Kumagai et al. state that blood pressure decreased gradually with BFR from 10 to 30 min of exercise. Song-young et al. found that BFR gives rise to changes in blood pressure as compared to traditional training [13].

The present study also shows that there is a high improvement in the thigh girth size of both legs. Both the right and left thigh girths improved significantly in group B. In group A, there were no significant results in either thigh. The mechanism behind that is that there is a metabolite accumulation (lactate) that leads to increase in growth hormone (GH), which results in collagen synthesis for tissue repair and recovery. A rise in GH increases insulin-like growth factor-1 production, a protein linked to muscle growth. IGF-1 has anabolic effects that boost cell proliferation and therefore increase muscle mass[16,17.] Oliveira et al. reported that hypertrophy occurs due to type 2 fibres. So in the scenario of BFRT, there is a force generation is low during exercise, so BFR gives rise to the activation of number of fast-twitch fibres, which are the primary requirements for the acquisition of muscular size and strength [15.] Aditya et al. also found that VO2max and thigh muscle girth improved significantly in the experimental group as compared to the group with a conventional mode of training. Abe et al. demonstrated that thigh muscle hypertrophy, isometric and dynamic strength of the knee extensor are increased through slow walk training combined with BFR training[7]. McCarty et al. state that there is no significant change in isokinetic or isometric strength by cycling alone, but when cycling is performed with BFR, there is an increase in knee extension strength[7].

5. Conclusion

It has been found from this study that pulmonary function test as well as lung functions can be improved with the use of a bicycle ergometer along with blood flow restriction technique when compared to exercise alone on a bicycle ergometer. This study also shows that there is an improvement in blood pressure in both groups, but more in Group B. There was no increase in thigh girth size with bicycle ergometer exercise, but the study showed a highly significant increase in thigh girth of both the legs with the blood flow restriction technique.

6. Future Scope

1) The age group can be extended above 25 years.
2) This study can be carried out with a large sample size.
3) This protocol can also be used in different populations.
4) The impact of a treadmill can also be checked instead of a bicycle ergometer.
5) Blood flow restriction training can be performed for more than 4 weeks

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