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## A comparative study of low intensity aerobic blood flow restriction training and conventional aerobic training on vo2max and thigh muscle girth in healthy 18-25-year-old adults

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### Abstract

**Background:** Blood Flow Restriction as a part of exercise training is achieved using blood flow restriction cuffs which on application produces mechanically induced low oxygen tension in the muscles distal to the cuff application. Thus, when exercises are performed using this training device, fatiguing of the muscles is hastened and the low oxygen tension in the muscles distal to the cuffs leads to a cascade of hypertrophy, causing improvements in muscle mass. The present study was undertaken for comparison between the effect of Low Intensity Aerobic Blood Flow Restriction Training vs. Conventional Aerobic Training on Thigh Girth and VO<sub>2</sub>max in the healthy young adults in the age group of 18-25 years.

**Method:** The study was a Cross Sectional Comparative Study between Low Intensity Aerobic Training Combined with Blood Flow Restriction and Conventional Training. The study was carried out in 30 samples who were randomly selected and divided on an equal basis in two equal groups, viz. group A (AE-BFRT) and Group B (Conventional). In this study we used an adapted sphygmomanometer for achieving partial [70%-80%] blood flow restriction. The study was carried out for 4 weeks and the data analysis was done using paired and unpaired students t- tests.

**Result:** Comparison of Pre and Post Training Thigh Girth values of Group A was extremely significant. Comparison of Pre and Post Training Thigh Girth values of Group B was extremely significant. Comparison of Mean of Difference of Thigh Girth of Group A and Group B for both the legs of Group A as well as Group B was highly significant. Comparison of the Post-Training values of VO<sub>2</sub>max was done between both groups and the study was extremely significant. However, comparison of Pre and Post Training VO<sub>2</sub>max values of Group A as well as Group B was not statistically significant, respectively.

**Conclusion:** There is significant effect of low intensity aerobic blood flow restriction training on VO<sub>2</sub>max and Thigh Girth in healthy 18-25-year-old adults.

**Keywords:** VO<sub>2</sub>max, blood flow restriction, aerobic training, hypertrophy, BFRT, AE-BFRT

### Introduction

Though a person can be defined healthy by a lot of different parameters combined together, his/her maximum oxygen uptake (VO<sub>2</sub>max) is considered to be the gold standard for determination/categorization of cardiovascular fitness. A person's oxygen uptake is estimated to be 3.5 ml/min/kg at rest and this value keeps on increasing proportionately with an increase in exercise intensity and the point at which a person's VO<sub>2</sub> is no longer able to increase is defined as the VO<sub>2</sub>max. Examples of aerobic exercises include cardio machines, spinning, running, swimming, walking, hiking, aerobics classes, dancing [2]. All these vary from low to moderate to high levels of training intensities resulting in different health benefits, respectively. All of these modes of exercise may or may not be possible to be performed similarly by the youth, the elderly and the failed individuals. Training at higher intensities may or may not be possible for the youth or either the elderly. But however lower levels of training intensities can be performed similarly by both the population groups. The end results of lower intensities will differ from that of training at higher intensities and it takes longer than higher intensity training but lower intensities will be more feasible for both the population groups and even appropriate if the performers are elderly. A method called as Blood Flow Restriction Training can be a feasible method of training for both the population groups. BFR training was

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initially developed within the 1960's in Japan and referred to as KAATSU<sup>[3]</sup> training. It is the technique that combines low intensity training and blood occlusion that gives the end results similar to that of high intensity training within a shorter duration of time. It involves the application of a pneumatic cuff (tourniquet) proximally to the muscle that is being trained. The cuff is then inflated to a personalized pressure with the aim of achieving partial arterial and complete venous occlusion. It creates muscle hypertrophy. High load resistance training has been shown to be the foremost successful means in improving muscular strength and obtaining muscle hypertrophy. The problem that exists is that in certain populations that need muscle strengthening e.g. Chronic Pain Patients or post-operative patients, high load and high intensity exercises might not be clinically appropriate. A lot of studies show the effectiveness of aerobic training on improving physical endurance. But there is no study that shows the effect of Blood Flow Restriction Training on VO<sub>2</sub> MAX in healthy young adults within a short duration of time. This training will really be useful because of its shorter duration for gaining the end results. The lighter loads that this training method uses is also helpful for those going into rehab post serious surgeries where dealing with lighter loads would lead to loss of muscle mass, which populations such as athletes cannot opt for. Thus, it will be very advantageous to form a training protocol that uses lighter loads and even lighter training intensities for rehab purposes in the concerned population.

### Materials and Methods

**Participants:** An approval for the study was obtained from the Institutional Ethical Committee. The study was conducted in the OPD setting of DR. APJ Abdul Kalam College of Physiotherapy. 30 participants aged between 18-25 years, both males and females, non-smokers, non-hypertensives, without any peripheral vascular disorders, willing to participate were included. Exclusion consisted of any past history of lower limb surgeries, pathologies affecting the lower limbs, neurological imbalances involving the lower limb, history immobilization of more than 24 hours in the past 2 months. The written consent was obtained prior to the study.

30 participants were then divided and allocated into two groups, Group A (AE-BFRT) and Group B (CONVENTIONAL), according to random sampling.

### Measurements and Outcome Measures

The outcome measures of the study were Thigh Girth and VO<sub>2</sub>max. Demographic data was collected and tests for evaluation of VO<sub>2</sub>max using Cooper's 12-minute Run Test and Ankle Brachial Index for both the groups and Absolute Occlusion Pressure (AOP) for Group A, specifically. Thigh Girth was measured in both the Groups of the study

### Procedure

Each study session included a warm up phase prior, then the application of the pressure cuffs on the thighs. Each sample had to train at a rate of 40%-50% of respective HRR which was calculated using the formula  $[220 - \text{Age}]$ .

### Protocol for group a [AE-BfRT]

In the Aerobic Blood Flow Restriction Training Group each study included a warm up phase prior to the training, then the application of the pressure cuffs on the thighs was done. The pressure of the cuffs was inflated up to 70% - 80% of the calculated AOP. Each sample had to train at a rate of 40%-50% of respective HRR which was calculated using the formula  $[220 - \text{Age}]$ . Each training session included of five 2-minutes bouts with a 1-min interval between each 2-minute bout, accounting for a total of 15-20 minutes of training including warm up and cool down phases. Data collection was done Pre and Post 4 weeks of the study.

### Protocol for group B [Conventional]

Each study session included a warm up phase prior to the training. The participants then underwent a treadmill training protocol at 40%-50% of their respective Heart Rate Reserves [HRR] for 20 minutes on the first week with a 5-minute increase every week. The intensity was the same for the entire study. The conventional study sessions were performed for 4 weeks with each training session 7 days apart from the previous session.



Treadmill training protocol

### Procedure for assessment of absolute occlusion pressure

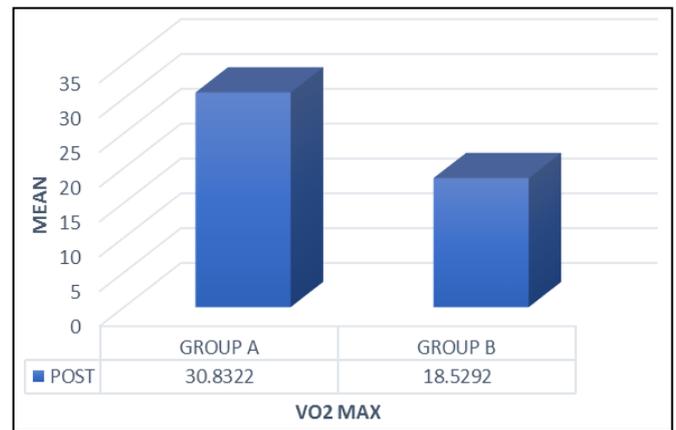
The participants in Group A had to undergo an Ultrasonic procedure for the determination of absolute occlusion

pressure, in mmHg, using the Toshiba Xario 200 of The Radiology Department of Pravara Institute of Medical Sciences, Loni, BK. The participants were positioned in hook

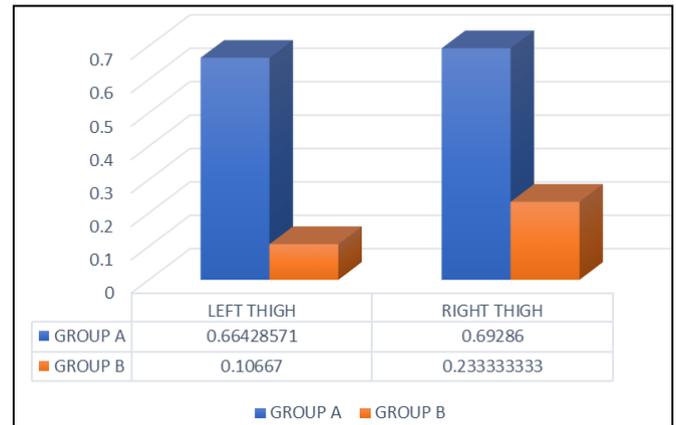
lying position and the restriction cuffs were applied to both the thighs of the participant. The doppler probe was then placed over the dorsalis pedis artery. The pressure cuffs were inflated until the blood flow of the artery was occluded and that pressure at which the blood flow was occluded was noted. The cuffs were immediately deflated.

**Results**

Comparison of Pre and Post Training Thigh Girth values of Group A was done using paired t test and it showed the study to be extremely significant. ( $p = <0.0001$ ) No significant change was seen clinically in the values measured using an inch tape. Comparison of Pre And Post Training Thigh Girth values of Group B was done using paired-t test and it shows that the study is extremely significant. ( $p = <0.0001$ ) No significant change was seen clinically in the values measured using an inch tape. Comparison of Mean of Difference of Thigh Girth of Group A and Group B for both the legs of Group A as well as Group B was done using Unpaired t test and it showed that the study is highly significant. ( $p = <0.0001$ ) Though the statistics show the study to be highly significant, the actual improvements that were measured using an inch tape for Post-training values of Group A and Group B were  $0.664285714 \pm 0.256026269$  and  $0.106666667 \pm 0.025819889$ , respectively. Comparison of Pre and Post Training VO2max values of Group A was done using paired-t test and it showed the study to be not significant ( $p = 0.2292$ ). Comparison of Pre And Post Training VO2max values of Group B was done using paired-t test and it showed the study to be not significant ( $p = 0.1106$ ) Comparison of the Post-Training values of VO2max was done between both groups. The analysis was done using unpaired-t test and it showed that the study is extremely significant. ( $p = <0.0001$ )



Comparison Post-Training Values Vo2max



Comparison of Means of Both Groups



Pre and Post Comparison Group A



Pre and Post Comparison Group B

**Discussion**

The present study was guided and carried out in the path for investigating the effects of Low Intensity Aerobic training combined with Partial Blood-Flow Restriction (AE-BFRT) as an alternative mode of training to the Conventional Training Mode, within a short duration of 4 weeks. The main findings of the present study were that the VO2max and thigh muscle girth improved significantly in the experimental group as compared to the group with conventional mode of training. This study demonstrated that low-intensity (40%-50% of VO2max), short-duration (15-20 min) aerobic training combined with BFR performed for 2-3 times a week for 4 weeks, can elicit improvements in muscle volume and also in VO2max in healthy young subjects. Previously, concurrent improvements in muscular strength and aerobic capacity by a single mode of exercise have been achieved after high-intensity and long-duration exercise training (Hass *et al.*, 2001; Tabata *et al.*, 1990). However, none of the studies demonstrated significant muscular hypertrophy, which suggests that the increased strength was due mainly to neural adaptations. A previous study (Abe *et al.*, 2006) demonstrated that slow walk training combined with BFR not only produced thigh muscle hypertrophy but also increased isometric and dynamic strength of the knee extensors. The increase in the thigh muscle girth, measured via an inch tape, can be attributed to higher recruitment of type II muscle fibres. This recruitment of the fast twitch fibres may be because of fatiguing of the muscles that were under mechanical tension produced by application of the adapted blood flow restriction cuffs along with the low intensity walk training. Suga *et al.* [5] showed that the recruitment of fast-twitch fibre, evaluated by Pi-splitting, was induced by supplementing the low-intensity resistance exercise with

blood flow restriction. In addition, the study also showed that recruitment of fast fibres in BFR-RT was similar to HI-RT<sup>5</sup>. The mechanism by which fatigue can increase the recruitment of motor units is not well understood. It is suggested that the partial restriction of blood flow during RT causes low oxygen supply to the active skeletal muscle<sup>6</sup>, promoting increased metabolite accumulation and decreased intramuscular pH. This in turn results in altered motor unit firing rate and recruitment patterns<sup>7</sup>. Therefore, a main contributor of increase in muscle CSA post BFR training is because of this recruitment, which surpasses the neural adaptation, such as fibre recruitment patterns. The equipment used in our BFR-model is an adapted sphygmomanometer that is able to restrict the thigh blood flow. Thus, this simple and inexpensive device may be used in health clubs, fitness clubs, and so on. This suggestion is further supported by the fact that a couple large-scale studies have attested to the safety of BFR-RT method, even for the elderly<sup>8,9,10</sup>.

### Conclusion

According to this study, we can conclude that those four weeks of Aerobic Blood Flow Restriction Training have shown to improve Thigh Girth and VO<sub>2</sub>max in Young Adults in the age group of 18 to 25 years. Thus, four weeks of Aerobic Blood Flow Restriction Training can be used as a training protocol for achieving results, in a shorter duration of time, and can be prescribed for Young Adults as well as Athletes.

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