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Can Blood Flow Restriction Exercise Cause Blood Pressure Alterations in Healthy Young Adults

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Abstract

Background: Blood flow restriction (BFR) training is a trendy alternative for standard resistance exercise since it can enhance muscular strength and diameter without requiring training with high-load. Some individuals who use BFR at low loads need to attenuate their cardiovascular response to exercise; contraction patterns may be one of the factors that can affect the cardiovascular response.

Aim of Study: The current study attempted to assess the acute cardiovascular response of healthy young individuals to lower body resistance exercise with blood flow restriction training (BFR).

Subject and Methods: The participants were selected from benha university students, study was conducted over a 6-month period from September 2022 to March 2023 This was a randomized controlled, pre-test, and post-test study. Subjects who met the selection criteria divided randomly into 3 groups. Group A: 40 participants performed a single trial of unilateral pattern of resistance exercise with blood flow restriction (UIL-BFR) with 40% of arterial occlusion pressure (AOP) 30% of one-repetition maximum (1RM) Group B: 40 participants performed a single trial of bilateral pattern of resistance exercise with blood flow restriction (BIL-BFR) 40% of arterial occlusion pressure (AOP) and 30% of one-repetition maximum (1RM). Group C: 20 participants performed single trial of resistance exercise 30% of one-repetition maximum.

Results: There was significant rise in Systolic blood pressure following exercise in the (UIL-BFR) group (p-value <0.001). In the (BIL-BFR) group, there was a significant reduction in Systolic blood pressure after exercise compared to before exercise (p-value <0.001).

Conclusion: These results suggested that those who want to decrease risk of a cardiovascular incident may choose (BIL-BFR) over (UNI-BFR).

Key Words: *Blood flow restriction – Kaatsu training – Blood pressure-hemodynamics– Cardiovascular – Heart rate – Resistance exercise.*

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Introduction

BLOOD flow restriction (BFR) training is a novel strategy that induces physiological changes similar to those seen in response to high-intensity resistance, but at lower exercise intensities (20% to 50% of one-repetition maximum) and in a shorter time frame (4-6 weeks) **[1]**.

In order to achieve a considerable increase in muscle strength and growth, the American College of Sports Medicine recommends performing resistance exercise (RE) at intensities more than or equal to 60% of one-repetition maximum (1RM). It is assumed that any training intensity below that hardly produces considerable stimulus and subsequently muscle strength and hypertrophy adaptations **[2]**.

Great stress placed on joints and tissues in case of applying high resistance which can be unsafe and sometimes hard to be tolerated bymany cases such as the elderly, injured populations, patients after surgeries and patients undergoing cardiac rehabilitation **[3]**.

The low intensities and few exercise sessions is ultimately beneficial especially for frail people, such as inactive people, patients with chronic diseases, persons with injuries and in post-surgical rehabilitation to promote muscle strength and hypertrophy **[4]**.

Blood flow restriction training alone can decrease muscular weakness that occurs after disuse, when BFR is accompanied by passive exercise it can minimize muscle atrophy **[5]** and it also increases muscle size and maximal oxygen consumption when it added to aerobic exercise **[6]**.

In spite of the rising evidence for the efficiency of low-intensity BFR application, the relative safety of BFR exercise has not been acknowledged. As itwasfound that ischemia provoked by BFR may increase myocardial oxygen demand and blood pressure by activatingsystemic and regional vascular resistance besides the buildup of metabolites and the resulting stimulation of chemoreflex [7].

To decrease these cardiovascular events researchers recommended performing blood flow restriction (BFR) training with lower occlusion pressure and lifting lower loads during training besides that, researchers suggests That we may have the chance to gain more attenuation of the cardiovascular response through exercising with specific contraction pattern [8].

So, further studies were needed to be done on BFR during the different contraction patterns such as unilateral (UNI), and bilateral pattern (BIL) as each pattern may produce different responses so the aim of this study was to provide information to help in establishing and improving the safety guidelines of blood flow restriction training.

Subjects and Methods

Subjects:

100 young adults participated in this study. The participants were selected from Benha University students, study was conducted over a 6-month period from September 2022 to March 2023 Before beginning the training approach, each participant must sign a consent form as an agreement for participation in the current study. Each individual was given an in-depth description of the technique and measurement devices, And the study's goal was explained to each participant. The Ethical Committee for Scientific Researches of the Faculty of Physical Therapy, Cairo University, approved all study protocols with approval number (P.T.REC/012/004553).

Inclusion criteria: All participants in this study ranged in age from 18 to 25 years, with BMIs ranging from 18.5k g/m^2 to 24.9kg/m^2.

Exclusion criteria:

The excluded participants were Smoker's, subjects with cardiovascular disease, peripheral vascular disease, renal disease, Neurological disorders, Acute muscular pain, History of limb surgery or fracture, Instability of joints or soft tissue contracture, Psychological or mental impairments, individuals with resting systolic/diastolic BP ≥120/80 mmHg, subjects who were exercising regularly and participants who were taking medications that influence HR and/or blood pressure.

Group design of participants:

This is a randomized, controlled, pre-test and post-test study.

Subjects who metthe selection criteria divided randomly into 3 groups:

Group A: 40 participants performed a single trial of unilateral pattern of resistance exercise with blood flow restriction (UIL-BFR) 40% of arterial occlusion pressure (AOP) and 30% one-repetition maximum (1RM).

Group B: 40 participants performed a single trial of bilateral pattern of resistance exercise with blood flow restriction (BIL-BFR) with 40% of (AOP) arterial occlusion pressure and 30% one-repetition maximum (1RM).

Group C: 20 participants will perform single trial of resistance exercise with (30% one-repetition maximum).

Materials:

Evaluation equipment:

Fetal Doppler ultrasound, PulsFit Pulse Oximeter Model NumberÅFBO-600/BO-650/BO-800 Reliably made in Japan, Sphygmomanometer ALPK2-300VSN made in japan.

Intervention equipment:

Pneumatic nylon cuff (SC10D; Hokanson, Bellevue, WA) Quadriceps chair.

Procedures:

Preparation:

- A medical history was obtained in order to collect information about the volunteers' general health, physical activities, and current medications.
- All of the subjects' medical and demographic information was acquired.

The correct technique to perform the exercise was demonstrated to the participants.

Evaluation procedures:

- Blood pressure (BP) were measured 5-minute before the beginning of training using sphygmomanometer.
- BP was measured again after exercise.

Intervention procedures:

- Before the beginning of the treatment, in a seated position, subjects were given a 15-minute rest period. A nylon cuff was placed on the proximal

part of each leg for blood flow restriction, and BFR was applied at 40% AOP. All participants completed four sets for each leg, beginning with a set of 30 repetitions and ending with three sets of 15 repetitions at 30% 1RM. Resistance was given during knee extension using a quadriceps chair, with 30 seconds rest between sets.

• *Participants in the (UNI-BFR) protocol:*

On the exercising leg, the pressure cuff was first affixed and inflated. The cuff was deflated after completing all sets on the first leg. The pressure cuff was then affixed and inflated on the opposite leg, and the exercise began.

• *Participants in the (BIL-BFR) protocol:*

The proximal part of each participant's leg was fitted with a pneumatic nylon cuff. Cuffs were inflated on each leg while both legs exercised simultaneously. The participant extended his knee to 90 degrees with resistance 30% of the maximum one repetition.

• *Participants in the (BIL-RE) protocol:*

The subject will extend his knee up to 90 degree with resistance 40% of one repetition maximum.

Statistical analysis:

- The Shapiro-Wilk test was used to determine data normality.
- Descriptive statistics and kruskal wallis-test were conducted to compare all variables of pre and post treatment between the three groups (between group comparison).
- Wilcoxon test was conducted to compare all variables between pre-treatment and post-treatment measurements within each group.
- For subsequent multiple comparisons, post-hoc tests using the Bonferroni test were applied.
- The arithmetic mean as an average description of the data' central tendency.
- The standard deviation provides a measure of the results' dispersion.
- For all statistical tests, the level of significance was set at *p*-value 0.05. All statistical The statistical package for social studies (SPSS) version 27 for Windows was used to perform the measurements.

Results

Participant characteristics: As presented in Table (1), there was no statistical difference of the Demographic Data age, weight and height between the three groups (A, B and C).

Table (1): Demographic Data age, weight and height between the three groups (A, B and C).

	Group A	Group B	Group C	*p*-value
Age (year)	21.60±1.52	21.75±0.11	21.95±1.93	0.21(NS)
Weight (kg)	71.45±7.93	74.25±0.11	72.05±9.84	0.291(NS)
Height (cm)	177.05±6.92	179.29±0.11	177.65±6.24	0.437(NS)
BMI (kg/m^2)	22.75±2.26	23.17±0.72	22.76±1.75	0.105 (NS)

Pre treatment and post treatment mean values of Systolic blood pressure of group (A):

The mean ± SD Systolic blood pressure of group A (UNI-BFR) pre treatment was 115.25 ±6.96, while at post treatment was 121.20 ±7.4. The mean difference was –5.95 and the percent of change was 5.16%. There was a significant increase in Systolic blood pressure at post treatment compared with pretreatment (*p*-value <0.001).

Pretreatment and post treatment mean values of Systolic blood pressure of group (B):

The mean ± SD Systolic blood pressure of group B pre treatment was 116.64 ±0.11, while at post treatment was 112.86±0.11. The mean difference was 3.79 and the percent of change was 3.25%. There was a significant decrease in Systolic blood pressure at post treatment compared with pre treatment (*p*-value <0.001).

Pre treatment and post treatment mean values of Systolic blood pressure of group (C):

The mean ± SD Systolic blood pressure of group C pre treatment was 116 ±5.39, while at post treatment was 114.2 ±4.25. The mean difference was 1.80 and the percent of change was 1.55%. There was no significant decrease in Systolic blood pressure at post treatment compared with pre treatment (*p*-value=0.097).

Table (2): Comparison between pre exercise and post exercise mean values of Systolic blood pressure of group (A),(B) and (C).

Systolic blood pressure	Group A	Group B	Group C
Pre treatment	115.25±6.96	116.64±0.11	116.64±0.11
Post treatment	121.2±7.4	112.86±0.11	112.86±0.11
p-value	<0.001	<0.001	0.097
Sig.	S	S	NS

X : Mean.
SD : Standard deviation.
MD: Mean difference.
Z-value: Wilcoxon value.
p-value: Probability value.
S: Significant.

Table (3): Comparison of post treatment mean values of Systolic blood pressure between the studied groups.

Systolic blood pressure			Test Statistic	*p*-value	Sig.
X ± SD					
Group A	Group B	Group C			
121.20±7.4	112.86±0.11	114.2±4.25	31.837	<0.001	S
Multiple comparison (Bonferroni test)					
	MD	Test Statistic	*p*-value	Sig.	
Group A Vs Group B	8.34	34.85	<0.001	S	
Group A Vs Group C	7	29.55	<0.001	S	
Group B Vs Group C	-1.34	–5.300	0.504	NS	

X : Mean. SD : Standard deviation.
S : Significant. NS : Non significant.
p-value: Probability value.

Discussion

The aim of this study was to assess the acute cardiovascular response of healthy young individuals to lower body resistance exercise with blood flow restriction training (BFR).

The results of the study suggested that training with bilateral contraction pattern has a hypotensive effect as there was a significant decrease in the systolic blood pressure. This effect may had occurred due to a stress-mediated upsurge in nitric oxide synthase which is an enzyme that Its role is to convert L-arginine into nitric oxide which is a tiny electrically neutral molecule that improves vasodilation and smooth muscle relaxation; that lead to decrease in peripheral vascular resistance **[9]**. Furthermore, Some chemicals, such as prostaglandins, potassium, and adenosine, may trigger vascular vasodilation and cause hypotension. Also the restriction of blood flow in both lower limbs at the same time in case of (BIL-BFR) may decrease the cardiac preload as it decrease the venous return to the heart **[10]**.

A study that implemented the training in bilateral pattern on 14 subjects with average age 45 ±9,9 years have shown results comparable to those mentioned in this paper, confirming post-exercise hypotension. They reported that low-intensity strength exercise with blood flow restriction caused hypotensive effect up to 60 minutes after exercise **[11]**.

Maior et al., correspondingly conducted additional research on 15 healthy adults with an average age: 23.4±3.4 years, the outcomes of this study confirmed the prevalence of post-exercise hypotension as it was found that SBP dropped significantly ($p \leq 0.05$) after 30 minutes (125.86 ±9.33 mmHg) and significant decreases in DBP **[12]**.

The findings of this study are also consistent with the study of Neto et al., in which The systolic and diastolic blood pressures (SBP and DBP) were recorded for Twenty-four normotensive males after low-intensity resistance exercise combined with BFR (LI + BFR) this protocol resulted in hypotensive SBP (–5.5%) responses it also stimulated hypotensive responses in DBP (–11.5%) **[13]**.

In the case of unilateral BFR, there was a considerable increase in systolic blood pressure. The rationale behind this result might be that in unilateral group the time of exercise is longer as the patient starts the training in the other leg after completing the sets of the first one this time gives a chance of metabolites accumulation and this will progressively activate the mechano- and metaboreflexes throughout the repetitions which in turn will increase blood pressure.

Moreira et al., conducted a research on the cardiovascular response to knee extension exercise without BFR showed contrast results to our findings as they revealed that unilateral training has a lower cardiovascular response than bilateral training **[14]**, the reason behind that may be that They complemented the entire period of UNI training to BIL training in their study by making subjects exercise only one leg and the cardiovascular response was assessed at that time. The higher muscle mass in bilateral training would definitely result in more pronounced cardiovascular responses when compared to exercises with smaller muscle mass, such as unilateral resistance training with one leg. In the instance of Moreira et al., this favorable cardiovascular response in unilateral training Because the blood flow demand during bilateral exercise is larger in order to supply both legs with oxygenated blood and that will increase the load on cardiovascular system in the current study, the participants exercise both legs for the UNI pattern.

Conclusion According to current study findings it can be interpreted that training with (BIL-BFR) is more recommended to decrease the chance of blood pressure elevation and cardiovascular events.

References

1- BUCKNER S.L., JESSEE M.B., MOUSER J.G., DANKEL S.J., MATTOCKS K.T., BELL Z.W., et al.: The Basics of Training for Muscle Size and Strength. Medicine & Science in Sports & Exercise, 52 (3): 645-53, 2020.

2- HANSEN D., ABREU A., DOHERTY P. and VÖLLER H.: Dynamic strength training intensity in cardiovascular rehabilitation: Is it time to reconsider clinical practice?

A systematic review. European Journal of Preventive Cardiology, 26 (14): 1483-92, 2019.

3- POST D.R., STACKHOUSE W.A., OSTROWSKI J.L., BETTLEYON J.D. and PAYNE E.K.: The Effect of Blood Flow Restriction on Muscle Hypertrophy and Tendon Thickness in Healthy Adults' Distal Lower-Extremity: A Critically Appraised Topic. Journal of Sport Rehabilitation, 1-5, 2022.

4- PETERSON M.D. and SERRA J.A.: Exercise interventions to prevent and improve sarcopenia. Sarcopenia, 305-333, 2021.

5- BARBALHO M., ROCHA A.C., SEUS T.L., RAIOL R., DEL VECCHIO F.B. and COSWIG V.S.: Addition of blood flow restriction to passive mobilization reduces the rate of muscle wasting in elderly patients in the intensive care unit: A within-patient randomized trial. Clinical Rehabilitation, 33 (2): 233-40, 2018.

6- HELD S., BEHRINGER M. and DONATH L.: Low intensity rowing with blood flow restriction over 5 weeks increases VO2max in elite rowers: A randomized controlled trial. Journal of Science and Medicine in Sport, 23 (3): 304-8, 2020.

7- PATTERSON S.D., HUGHES L., WARMINGTON S., BURR J., SCOTT B.R., OWENS J., et al.: Blood flow restriction exercise: Considerations of methodology, application, and safety. Front Physiol., 10: 533, 2019.

8- STANFORD D.M., PARK J., JONES R., CREDEUR D.P., MCCOY S. and JESSEE M.B.: Acute cardiovascular response to unilateral, bilateral, and alternating resistance exercise with blood flow restriction. European Journal of Applied Physiology, 120 (8): 1921-30, 2020.

9- PEARSON S.J. and HUSSAIN S.R.: A Review on the Mechanisms of Blood-Flow Restriction Resistance Training-Induced Muscle Hypertrophy. Sports Medicine, 45 (2): 187-200, 2014.

10- KOLIND M.I., GAM S., PHILLIP J.G., PAREJA-BLANCO F., OLSEN H.B., GAO Y. and NIELSEN J.L.: Effects of low load exercise with and without blood-flow restriction on microvascular oxygenation, muscle excitability and perceived pain. European Journal of Sport Science, 23 (4): 542-551, 2023.

11- ARAÚJO J.P., SILVA E.D., SILVA J.C., SOUZA T.S., LIMA E.O., GUERRA I. and SOUSA M.S.: The acute effect of resistance exercise with blood flow restriction with hemodynamic variables on hypertensive subjects. Journal of human kinetics, 43 (1): 79-85, 2014.

12- MAIOR A.S., SIMÃO R., MARTINS M.S., DE SALLES B.F. and WILLARDSON J.M.: Influence of blood flow restriction during low-intensity resistance exercise on the postexercise hypotensive response. The Journal of Strength & Conditioning Research, 29 (10): 2894-2899, 2015.

13- NETO G.R., SOUSA M.S., COSTA P.B., SALLES B.F., NOVAES G.S. and NOVAES J.S.: Hypotensive effects of resistance exercises with blood flow restriction. The Journal of Strength & Conditioning Research, 29 (4): 1064-1070, 2015.

14- MOREIRA O.C., FARACI L.L., DE MATOS D.G., MAZINI FILHO M. L., DA SILVA S.F., AIDAR F.J. and DE OLIVEIRA C.E.: Cardiovascular responses to unilateral, bilateral, and alternating limb resistance exercise performed using different body segments. Journal of strength and conditioning research, 31 (3): 644-652, 2017.

هل يمكن أن تؤدى ممارسة تمارين المصحوبة بتقييد تدفق الدم إلى حدوث تغييرات فى ضغط الدم عند البالغين الأصحاء

تدريب تقييد تدفق الدم هو أسلوب جديد يمكن أن يثير تكيفات فسيولوجية مماثلة لتلك التى تحدث استجابة لتمارين المقاومة عالية الشدة، ولكن مع شدة تمرين أقل (٢٠٪ إلى ٥٠٪ من التكرار الأقصى لمرة واحدة) وفى فترة أقل (٤–٦ أسابيع) يمكن أن توفر تدريب تقييد تدفق الدم فوائد تمارين المقاومة عالية الشدة دون التعرض لخطر ممارسة ضغط كبير على المفاصل والأنسجة الرخوة حيث أن استخدام مقاومة منخفضة مصحوبة بتقييد تدفق الدم يمكن أن يزيد من محيط العضلات وقوتها بشكل مشابه لممارسة التمارين ذات الأحمال العالية.

أجريت الدراسة الحالية لتقييم الاستجابة الحادة للقلب والأوعية الدموية لدى الشباب الأصحاء لتمارين المقاومة المصحوبة بتقييد تدفق الدم فى محاولة لمعرفة أكثر الانماط أماناً من حيث التأثير على ضغط الدم. تم تطبيق هذه الدراسة على مائة شاب متطوع تتراوح أعمارهم بين ١٨ و ٢٥ عام أجريت الدراسة على مدى ٦ أشهر خلال الفترة من سبتمبر ٢٠٢٢ إلى مارس ٢٠٢٣، تم تقسيم الأفراد الذين استوفوا معايير الاختيار بشكل عشوائى إلى ٣ مجموعات المجموعة أ : ٤٠ مشاركاً أجروا تجربة لنمط أحادى من تمرين المقاومة مع تقييد تدفق الدم مع ٤٠٪ من ضغط انسداد الشرايين مع من الحد الأقصى لتكرار واحد المجموعة ب : ٤٠ مشاركاً أجروا تجربة واحدة لنمط ثنائى من تمرين المقاومة مع ٤٠٪ تقييد تدفق الدم و ٣٠٪ من أقصى تكرار لمرة واحدة. المجموعة ج: أجرى ٢٠ مشاركاً تجربة واحدة من تمرين المقاومة بنسبة ٣٠٪ من التكرار الأ قصى مرة واحدة.

وقد أشارت النتائج : لحدوث ارتفاع ذو دلالة إحصائية فى ضغط الدم الانقباضى بعد التمرين فى مجموعة (أ).

تشير هذه النتائج إلى أن أولئك الذين يرغبون فى تقليل مخاطر الإصابة بأمراض القلب والأوعية الدموية قد يختارون لنمط أحادى من تمرين المقاومة مع تقييد تدفق الدم بدلاً من لنمط ثنائى من تمرين المقاومة مع تقييد تدفق الدم.