Research Paper

Effect of Aerobic Exercise With Blood Flow Restriction on Mitochondrial Dynamics Proteins of Human Skeletal Muscles

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ABSTRACT

Background Aerobic exercise with Blood Flow Restriction (BFR) plays an important role in skeletal muscle adaptation; however, the effects of this type of exercise on mitochondrial dynamics proteins are unclear.
Objective The purpose of this study was to investigate the effect of aerobic exercise with and without BFR on mitochondrial dynamics proteins of human skeletal muscles.
Methods Participants were 5 young men (mean age, 33.4±2.30 years; mean weight, 79.64±10.49 kg; BMI, 26.24±2.27 kg/m^2). They performed aerobic exercise with BFR (AE+BFR) and without BFR (AE) in two separate days at five 2-min sessions and 1 min rest between the sessions. Western Blot method was used to measure the protein levels of Mitofusin 2 (MFN2) and Dynamin-Related Protein 1 (DRP1) in skeletal muscles.
Findings AE+BFR (1.02±0.05 vs. 0.77±0.03) and AE (0.65±0.08 vs 0.57±0.03) significantly increased the mean MFN2 protein level compared to the pre-test mean values (P<0.05). AE+BFR (3.54±0.46 and 5.01±0.66) and AE (3.38±0.38 vs. 2.82±0.59) also significantly reduced the mean DRP1 level (P<0.05). Moreover, AE+BFR had greater significant effect on the mean levels of MFN2 (0.24±0.01 vs. 0.08±0.04) and DRP1 (-1.46±0.22 vs. -0.33±0.12) compared to AE (P<0.05).
Conclusion It seems that aerobic exercise with BFR is a strong stimulant for the improvement of skeletal muscle mitochondrial dynamics.

Extended Abstract

1. Introduction

Blood Flow Restriction (BFR) as a new training method has been increasingly used to apply more physiological stress with low-intensity exercise. Exercise with BFR reduces oxygen delivery to skeletal muscle as well as the clearance of produced metabolites. It creates a stressful muscular environment that may be a strong stimulus for physiological adaptations [1]. However, the effect of BFR training with aerobic exercise on aerobic performance-related parameters has been received less attention. Changes and adaptations caused by exercise on muscle mitochondria can occur as a result of mitochondrial biogenesis, mitochondrial dynamics (including fusion and fission), and the process of mitophagy which can be an important mechanism for improving muscle oxygen consumption and, consequently, athletic performance [8].

Mitochondrial fusion plays an important role in maintaining mitochondrial integrity and is dependent on mitofusin (MFN) 1 and 2 [9], while during mitochondrial fission,

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mitochondrial fragmentation expands and is dependent on Dynamin-Related Protein 1 (DRP1) [11]. Despite the effective role of exercise with BFR, there is no study of the potential role of this type of activity on mitochondrial fusion and fission proteins. Therefore, due to this limitation, the aim of this study was to investigate the effect of aerobic exercise with and without BFR on mitochondrial dynamic proteins (MFN2 and DRP1) of human skeletal muscle.

2. Materials and Methods

This is a quasi-experimental cross-sectional study with pre-test/post-test design. Participants were 5 male students at University of Guilan (Mean±SD age, 33.40±2.30 years; Mean±SD weight, 79.64±10.49 kg; BMI, 26.24±2.27 kg/m^2) who were selected using a convenience sampling method. They performed aerobic exercise with BFR (AE+BFR) and aerobic exercise (AE) without BFR in 2 days. In AE+BFR intervention, BFR was applied by the pressure cuff on the proximal thigh area, and then, after warming up (including walking, running, and stretching), the subjects began to walk (with a speed of 51 meters per minute) on the treadmill.

The walking program included five 2-minute sessions and 1 minute rest between each session, according to Takashi et al. [20]. BFR in the leg muscles was maintained throughout the training session and 1-min rest interval (for 14 minutes which reached 17 minutes with 3-min warming up). The BFR was lifted immediately after the fifth session of walking, and then a period of return to initial state, including

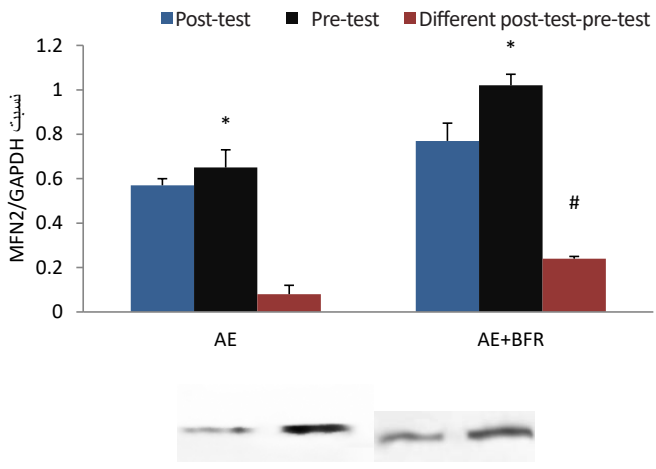

Figure 1. Effect of AE+BFR and AE on the MFN2 protein content (MFN2/GAPDH ratio), and western blot analysis of the expressions of MFN2 and GAPDH.* Significant compared to the pre-test phase (P<0.05), # significant compared to AE(P<0.05)

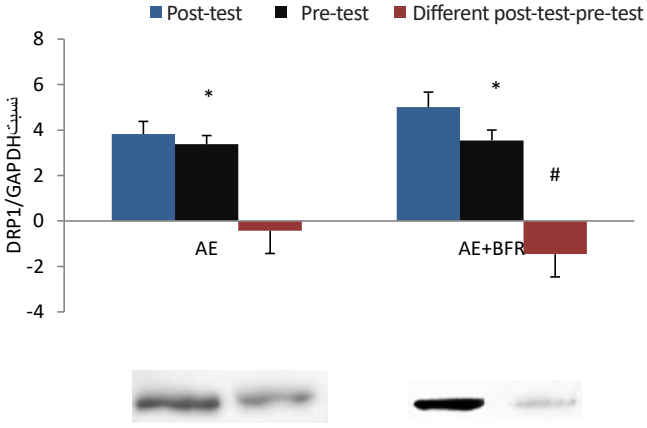

Figure 2. Effect of AE+BFR and AE on the DRP1 protein content (DRP1/GAPDH ratio), and western blot analysis of the expressions of MFN2 and GAPDH.* Significant compared to the pre-test phase (P<0.05); # significant compared to AE (P<0.05)

walking, was performed by subjects for 5-11 minutes. AE intervention was similar to BFR+BFR, but was performed without applying BFR. In order to evaluate the changes in MFN2 and DRP1, a biopsy of the lateral extensor muscle was performed in two stages: 5 minutes before the start of both exercise interventions and 3 hours after their completion. Western blotting was used to measure the protein values of MFN2 and DRP1. In order to determine the difference between pre-test and post-test scores and also the difference between scores of two interventions, the paired t-test was used at the significance level of 0.05.

3. Results

The results showed that both aerobic exercise with BFR (P=0.001) and without BFR (P=0.04) led to a significant increase in MFN2 protein value compared to the pre-test values. A comparison between the two interventions showed that AE+BFR led to a significant increase in MFN2 protein value compared to AE (P=0.01) (Figure 1). The results also showed that both AE+BFR (P=0.001) and AE (P=0.02) led to a significant increase in DRP1 protein value compared to the pre-test values. A comparison between the two interventions showed that AE+BFR also could significantly increase the DRP1 protein value compared to AE (P=0.003) (Figure 2).

4. Discussion

Although there is very limited information on the acute effects of aerobic exercise on mitochondrial dynamics proteins, the findings of the present study showed that aerobic exercise can increase mitochondrial dynamics by reducing fission and increasing fusion, regardless of the role of BFR. Due to the role of PGC-1α in the regulation of proteins involved in mitochondrial fusion and fission, and the up-regulation of PGC-1α activity, both aerobic exercise with and without BFR could increase MFN2 level and decrease DRP1 level by up-regulation of PGC-1α activity [25].

Although there is no direct evidence to compare the effect of exercise with and without BFR on PGC-1α signaling and its regulators in the present study, higher induction and stimulation of PGC-1α following exercise with BFR seems to have resulted in further stimulation of mitochondrial dynamics proteins. Moreover, it is possible that aerobic exercise with BFR leads to an optimal increase in Reactive Oxygen Species (ROS) and PGC-1α stimulation, followed by improved mitochondrial dynamics three hours before exercise [30, 31]. Overall, it was concluded that aerobic exercise with BFR can facilitate mitochondrial dynamics by increasing both mitochondrial fusion and fission processes.

Ethical Considerations

Compliance with ethical guidelines

This study obtained its ethical approval from the Research Ethics Committee of Guilan University of Medical Sciences (Code: IR.GUMS.REC.1397.061).

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This study was extracted from the PhD. thesis of the first author in Department of Exercise Physiology, Faculty of Physical Education and Sport Sciences, University of Guilan, Rasht.

Authors' contributions

Conceptualization and validation: Ali Aryashakib and Bahman Mirzaei; Methodology, draft preparation, data analysis: All authors; Resources and funding acquisition: Ali Aryashakib; Editing and review: Bahman Mirzaei and Payam Saidie; Supervision and project administration: Bahman Mirzaei.

Conflicts of interest

The authors declared no conflict of interest

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