Niveles de Vascular Endothelial Growth Factor: ejercicio moderado versus baja intensidad con restricción flujo

Vascular Endhothelial Growth Factor levels in medium-intensity versus low-intensity exercise with blood flow restriction in elderly women

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Abstract

Introduction and Objective: The decrease in muscle mass in the elderly occurs due to molecular changes related to regeneration and degeneration of muscle proteins. Vascular Endothelial Growth Factor has a role in angiogenesis and increasing muscle mass through increasing the number and function of satellite cells. Elderly people have many limitations in strengthening exercises for increasing muscle mass, especially in safety and tolerance. Low-intensity strengthening exercise combined with blood flow restriction can be an alternative to increase muscle strength to the same extent as high-intensity strengthening exercise. This research aims to compare vascular endothelial growth factor levels between medium-intensity strengthening exercise and low-intensity strengthening exercise with blood flow restriction in elderly women.
Methods: Twenty-two participants were trained for six weeks and underwent assessment at baseline, immediate after exercise, and at the end of training period. Participants were randomly divided into two groups: moderate intensity strengthening group (≥40-60% one-repetition maximum) and low intensity strengthening group (20-30% one-repetition maximum) with blood flow restriction using a cuff applied on the upper thigh at a restrictive pressure of 50 millimeters of mercury or 40% arterial occlusion pressure.
Results and Conclusions: The low-intensity group showed significant acute increases in vascular endothelial growth factor levels, but no chronic effects were observed. The findings suggest that low-intensity strengthening exercises with blood flow restriction can effectively promote an acute increase in vascular endothelial growth factor levels in elderly women.

Keywords

BFR; elderly women; muscle mass; strengthening exercise; VEGF.

Resumen

Introducción y Objetivo: Los cambios moleculares afectan la regeneración y degeneración de las proteínas musculares, lo que causa la reducción de la masa muscular en los individuos mayores. El Factor de Crecimiento Endotelial Vascular promueve la angiogénesis y aumenta la masa muscular al mejorar las células satélite. Las personas mayores a menudo tenían preocupaciones sobre la seguridad y la tolerancia al realizar ejercicios de fortalecimiento de alta intensidad debido a limitaciones. Los ejercicios de baja intensidad con restricción del flujo sanguíneo son una alternativa viable para mejorar la fuerza muscular, con resultados similares a los de alta intensidad. Se efectuó una comparación de los niveles de factor de crecimiento endotelial vascular en mujeres de edad avanzada que ejecutaron ejercicios de fortalecimiento de intensidad media y baja, con restricción del flujo de sangre.
Metodología: Veintidós participantes participaron en un programa de entrenamiento de seis semanas, y se realizaron evaluaciones al inicio, inmediatamente después del ejercicio y al término del período de entrenamiento. Un grupo realizó ejercicios de fortalecimiento de intensidad moderada y otro grupo realizó ejercicios de baja intensidad con restricción del flujo sanguíneo.
Resultados y Conclusiones: A pesar de los incrementos notables en los niveles de factor de crecimiento endotelial vascular, el grupo de baja intensidad no registró efectos crónicos. Las actividades de fortalecimiento de intensidad reducida con restricción del flujo sanguíneo pueden fomentar un incremento inmediato en los niveles de factor de crecimiento endotelial vascular en mujeres de edad avanzada.

Palabras clave

BFR; ejercicio de fortalecimiento; masa muscular; mujeres mayores; VEGF.

Introduction

Population ageing represents a significant global trend that is reshaping societies worldwide. Life expectancy at birth now exceeds 75 years in half of the world's countries, marking an increase of 25 years since 1950. By 2030, older adults are projected to outnumber youth globally, with this rise occurring most rapidly in developing countries (WHO, 2024). However, the elderly population especially in developing countries is vulnerable to various physical declines due to a reduction in muscle strength and muscle mass (Kristiana, et al., 2020).

The decline in muscle mass in the elderly is attributed to multiple molecular changes associated with the regeneration and degeneration of muscle proteins (Valenzuela et al., 2019; Rudrappa et al., 2016). Several hypotheses have been proposed, including mitochondrial dysfunction, decreased myogenic capacity (reduced number and function of satellite cells), hormonal changes, and nutritional factors (Valenzuela et al., 2019; Yeung et al., 2021). Vascular Endothelial Growth Factor (VEGF) is known to play a role in angiogenesis and muscle mass enhancement by increasing the number and function of satellite cells through the Insulin Growth Factor-1 (IGF-1) pathway (Li et al., 2022; Maga et al., 2022; Huey, 2018).

In vivo and in vitro evidence supports the hypothesis that VEGF is essential for muscle growth in response to hypertrophic stimuli (Huey, 2018). VEGF helps maintain normal blood flow during increased muscle contractile activity, resulting in the migration of macrophages and growth factors to the muscle. Furthermore, VEGF acts as a signaling molecule between satellite cells and endothelial cells, promoting satellite cell activation and angiogenesis (Huey, 2018). Muscle mass increase in response to hypertrophic stimuli occurs through enhanced activation and differentiation of satellite cells, repair and regeneration of muscle fibers, and accumulation of contractile proteins (Egner et al., 2016; Fry et al., 2014; Fujimaki et al., 2016; McCarthy et al., 2011). Further research is required to elucidate the mechanisms underlying VEGF's role in muscle hypertrophy.

Strength training can increase VEGF levels in human blood and muscle (Zhao et al., 2020). A study found that moderate-intensity knee extensor strength training significantly increased mRNA (messenger ribonucleic acid) and VEGF protein levels in human skeletal muscle (Gavin et al., 2007). Ischemic muscles provide a strong stimulus for the upregulation of hypoxia-inducible factor-1 alpha (HIF-1), which activates VEGF (Huey, 2018). Further investigation is necessary to explore the mechanisms of VEGF's role in muscle hypertrophy.

The recommended strength training exercises range from moderate intensity (40-60% 1RM) to high intensity (> 70% 1RM). However, many elderly individuals are unable to perform high-intensity exercises, particularly due to safety and tolerance concerns. One form of resistance training that has gained popularity is low-load resistance training (LLRT) (intensity 20-30% 1RM) with blood flow restriction (BFR). This method requires lower load intensity while achieving muscle mass gains (Li et al., 2022; Cook et al., 2017), making it suitable for elderly individuals who cannot perform moderate-intensity exercises (Summer et al., 2017). Strengthening training combined with BFR is also potentially used for persons suffering illnesses because it does not require high-load heavy weight liftings (Hening, 2018).

The application of BFR strength training in elderly populations in Indonesia remains limited. No studies have been conducted or published in Indonesia comparing VEGF serum levels following low-intensity training combined with blood flow restriction in the elderly. This study aims to compare VEGF serum levels after 6 weeks of strength training.

The introduction is a presentation of the topic, the most relevant works must be briefly presented and the contributions of other authors to the subject of study must be highlighted, as well as justify the reasons why the research is carried out. In this section, citations must be included (complying with APA 7th edition standards). The section should conclude with a description of the objectives of the research, highlighting the importance and scope of the solution. Use of verb tenses in the present tense.

Method

Participants

The design of this study was true experimental with pre and post-test randomized control group. This study was conducted at the Department of Medical Rehabilitation, Dr. Soetomo General Academic Hospital, Surabaya, Indonesia and has obtained a certificate of ethical eligibility from the Ethics Committee of Dr. Soetomo General Academic Hospital Surabaya with number 0683/KEPK/VI/2023.

The sample in this study includes the following inclusion criteria: 1) Female elderly aged 60 – 80 years. The same gender was selected to minimize biases due to hormonal factors and musculoskeletal differences. The elderly age limit of 80 years was set for patient safety. 2) Good cognitive function and ability to follow instructions, evidenced by a score of ≥ 26 on MoCa-INA (the Montreal Cognitive Assessment, Indonesian version). 3) Willingness to participate, demonstrated by signing an informed consent form. Each participant signed a written informed consent to partake in the study after receiving both verbal and written explanations regarding the purpose, procedures, and potential side effects of research. Medications and protocols for managing adverse effects were prepared at the study site.

The exclusion criteria are primarily focused on factors that could influence the study parameters as well as patient safety. These criteria include: 1) Severe physical disabilities, 2) Visual and hearing impairments, 3) Balance disorders, 4) Blood clotting disorders, confirmed through anamnesis and physical examination, 5) Peripheral artery disease in both legs, diagnosed via anamnesis, physical examination, and ankle-brachial index, 6) Neuropathy of lower extremities, confirmed through anamnesis and the physical examination, 7) Severe cardiorespiratory disorders, confirmed via anamnesis, the physical examination, and/or ECG, 8) Deep vein thrombosis in both legs, confirmed through anamnesis, the physical examination, and Well's score, 9) Uncontrolled hypertension with blood pressure ≥ 140/90 mmHg, 10) Uncontrolled diabetes mellitus, confirmed via anamnesis, the physical examination, and laboratory tests, 11) History of vascular surgery, 12) History of skin graft on the lower extremities, 13) History of lower limb bone surgery within the last 12 weeks, 14) Immobilization within the past 4 weeks, 15) History of compartment syndrome and fasciotomy, 16) History of stroke, 17) Statin use, 18) Sarcopaenia 19) Osteoarthritis of the knee with a VAS score >4 (severe degree) and the limited joint range of motion, 20) Liver dysfunction.

There are also dropout criteria, which include: 1) The subject chooses not to continue. 2) Unable to complete the training as the established research protocol (missing two consecutive sessions). A minimum attendance of 10 strength training sessions is required. 3) Conditions necessitating the termination of training: cardiovascular complications during the training program, such as chest pain, shortness of breath, syncope, and other symptoms like pain, swelling, cramps, redness, or discoloration in the trained legs; nerve injury (persistent paresthesia after cuff release); prolonged muscle soreness (more than 72 hours after training) that does not improve with analgesics and modalities (icing and TENS); or muscle weakness that prevents the continuation of exercise.

Exercise intervention

The subjects are divided into the moderate-intensity strengthening group and the low-intensity strengthening group with BFR. Both groups train twice per week for 6 weeks, with a 3-4 day rest between sessions. The moderate-intensity group performs quadriceps femoris strengthening exercises with ankle weights (≥ 40-60% 1RM), with each session consisting of 3 sets of 8-12 repetitions per set and a 2-minute rest period between sets. The BFR group performs low-intensity quadriceps femoris strengthening exercises with ankle weights (20-30% 1RM), combined with BFR. Each session consists of 4 sets: 30 repetitions in the first set, and 15 repetitions in sets 2-4, with 30-second rest period between sets. The BFR is applied using a cuff on the upper third of the thigh, with a restrictive pressure of 50mmHg or 40% AOP, which is released during the rest period.

All study subjects were assured safety throughout the research. During screening, the selected sample had a minimum OLS > 10 seconds to minimize the risk of falls. During the 6-week exercise program, the following safety protocols were followed:

Monitoring before, during, and after exercise, including complaints, vital signs, BORG scale, and oxygen saturation.

The availability of wheelchair, safety box, and emergency kit in the medical rehabilitation clinic.

If subjects experienced calf muscle pain, exercise was halted.

During the exercise sessions, subjects were accompanied by the research doctor, and they were provided with the researcher's contact information in case of emergencies.

Data collection

The parameter of this study is VEGF, which is evaluated three times: at the baseline before treatment, 30 minutes after the first session, and 24 hours after the final session (week 6). The research material is obtained from blood serum samples. Venous blood (10 cc) is drawn and collected into serum separator tubes (SST). Blood samples are sent to the Clinical Pathology Laboratory at Dr. Soetomo General Academic Hospital for centrifugation. The serum obtained after centrifugation is stored in a freezer at -80°C. Samples that meet exclusion criteria are discarded from the study. Testing is conducted after all samples are collected according to the study timeline. VEGF levels are measured using Human Vascular Endothelial Cell Growth Factor ELISA Kit (Bioenzy R).

Statistical analysis

Data analysis is performed using SPSS version 26.0 (IBM, the USA). Participant characteristics are described descriptively, followed by the Shapiro-Wilk test to assess data normality. If the data are normally distributed, parametric tests are used, while non-parametric tests are applied if the data are not normally distributed. A paired t-test is used to compare pre- and post-treatment results within each group. If the data are not normally distributed, the Wilcoxon Signed Rank test is used. An independent t-test is used to compare differences between groups A and B. If the data are not normally distributed, the Wilcoxon-Mann Whitney test is applied. A p-value is considered significant if $p < 0.05$. The effect size is calculated using Cohen's formula to assess the statistical impact of changes.

Results

A total of 22 research subjects met the inclusion criteria and were not excluded based on exclusion criteria. The subjects were divided into two groups: the moderate group, which received moderate-intensity strengthening exercises, and the BFR group, which received low-intensity strengthening exercises combined with BFR, with 11 subjects in each group. The general characteristics of the research subjects in both groups are presented in Table 1. Subject characteristics such as age, body weight, body height, Body Mass Index, and baseline VEGF levels were tested for homogeneity using the Levene test and for normality using the Monte Carlo test. The statistical tests indicated that the data were homogeneous and normally distributed, allowing for parametric comparisons.

Table 1. Characteristics of the subjects

No	Characteristic	Moderate (n=11)	p normality Moderate	BFR (n=11)	p normality BFR	p homogeneity
1	Age (year)	67.55 ± 7.31	0.532	64.27 ± 3.98	0.820	0.067
2	Body weight (kg)	55.55 ± 9.19	0.646	59.23 ± 8.44	0.454	0.784
3	Body height (cm)	156.0 ± 6.5	0.529	153.77 ± 5.63	0.227	0.719
4	Body mass index (kg/m^2)	23.16 ± 3.53	0.189	25.08 ± 2.94	0.571	0.719
5	Comorbid n (%)					
	a. Hypertension	3 (27.3 %)		8 (72.7%)		
	b. Diabetes	0 (0%)		3 (27.3%)		
	c. Dyslipidemia	4 (36.36%)		5 (45.45%)		
	d. Low back pain	3 (27.3 %)		3 (27.3%)		
6	Daily physical activity n (%)					
	a.High	0 (0 %)		0 (0 %)		
	b.Moderate	11 (100 %)		11 (100%)		
	c.Low	0 (0 %)		0 (0%)		

*the p-value is significant if p< .05.
Nota: Nanda et al. (2025).

In Table 2, the average baseline VEGF level in the moderate group was 1,477.21 ± 1,353.75 ng/L, and in the BFR group, it was 1,799.69 ± 1,446.57 ng/L. The homogeneity test showed that all p-values were greater than 0.05, indicating homogeneity of variance. The normality test also showed all p-values > 0.05, indicating a normal distribution of data, thus enabling parametric analysis.

Table 2. The VEGF Results

No	VEGF	Moderate (n=11)	P normality Moderate	BFR (n=11)	P normality BFR	P homogeneity
1	Baseline	1,477.21 ±1,353.75	0.459	1,799.69 ± 1,446.57	0.300	0.067
2	Acute	1,570.73 ± 1,363.14	0.339	1,829.91 ± 1,486.13	0.318	0.784
3	Chronic	1,530.72 ±1,268.89	0.733	1,752.6 ± 1,352.23	0.414	0.719

Figures for VEGF are mean ± standard deviation. * the p-value is significant if p< .05.
Note: Nanda et al. (2025).

Table 3 shows the comparison of the average baseline, acute, and chronic VEGF values in moderate and BFR groups before and after the intervention. Based on the parametric statistical test (paired samples t-test), it was found that 6 weeks of low-intensity strengthening exercises in the BFR group resulted in a significant increase in baseline-to-acute VEGF values ($p < 0.05$), but not in baseline-to-chronic VEGF values. In the moderate group, there were no significant differences between baseline-to-acute or baseline-to-chronic VEGF values ($p > 0.05$). This implies that VEGF as angiogenesis markers concentrations will back to baseline values after relatively short intervals (less than 1 hour) following aerobic and resistance exercises.

Table 3. Comparison of The Baseline, Acute, dan Chronic VEGF

Group	Baseline VEGF (ng/L)	Acute VEGF (ng/L)	p-value	Cohen's D	Chronic VEGF (ng/L	p-value	Cohen's D
Moderate	1,477.21 ±1,353.75	1,570.73 ± 1,363.14	0.290	-0.173	1,530.72 ±1,268.89	0.308	0.156
BFR	1,799.69 ± 1,446.57	1,829.91 ± 1,486.13	0.023*	-0.688	1,752.6 ± 1,352.23	0.218	-0.245

Figures for VEGF are mean ± standard deviation. *the p-value is significant if p<0.05.
Note: Nanda et al. (2025).

The table 4 compares the changes in VEGF values between baseline-to-acute and baseline-to-chronic in moderate and BFR groups. The mean delta VEGF from baseline-to-acute in the moderate group was 30.22 ± 175.03 ng/L, while in the BFR group, it was 93.52 ± 135.97 ng/L. The mean delta VEGF from baseline-to-chronic in the moderate group was -47.09 ± 302.62 ng/L, whereas in the BFR group, it was 48.34 ± 220.89 ng/L. Based on the independent samples T-test, there were no significant differences in delta VEGF baseline-to-acute and delta VEGF baseline-to-chronic between the moderate and BFR groups ($p = 0.355$ and $p = 0.408$).

Table 4. The comparison of the Differences in Baseline VEGF – Acute and Baseline VEGF – Chronic Between the Two Groups

	Moderate (n = 11)	BFR (n = 11)	p-value
Delta VEGF Baseline – Acute (ng/L)	30.22 ± 175.03	93.52 ± 135.97	0.355
Delta VEGF Baseline – Chronic (ng/L)	-47.09 ± 302.62	48.34 ± 220.89	0.408

Numbers are mean ± standard deviation (SD) *the p-value is significant if p<0.05
Note: Nanda et al. (2025).

Two adverse events were reported in the moderate group: one subject complained of delayed onset muscle soreness (DOMS), and another experienced post-exercise muscle pain. These adverse events were reported in the third week of training after the intensity was increased in the moderate group. The muscle pain resolved within 30 minutes to 1 hour after treatment, and the DOMS symptoms fully disappeared within 3 days of training.

Table 5. Adverse events in research subjects

	Moderate (n = 11)	BFR (n = 11)
DOMS (%)	1 (9.09%)	0 (0%)
Post-exercise muscle pain (%)	1 (9.09%)	0 (0%)

Discussion

The average age of subjects in the moderate group was 67.55 ± 7.31 years, while in the BFR group, it was 64.27 ± 3.98 years. Age is one of the risk factors that have a significant correlation with sarcopenia among elderly patients in Indonesia (Nurdiansyah, 2024). A recent systematic review indicated that age and gender did not significantly affect VEGF responses in elderly individuals (Song et al., 2024). VEGF is essential for blood vessel growth and is a key regulator of physiological and pathological angiogenesis in adult tissues (Ferrara, 2014). VEGF production and VEGF receptor expression levels decrease with age, as evidenced by studies in both animals and humans. Impaired HIF1α activation is likely the primary reason for reduced VEGF expression (Lähteenvuo & Rosenzweig, 2012). Exercise has been shown to enhance recovery after limb ischemia in older mice by increasing HIF1α and VEGF-A expression, resulting in increased capillary density in the ischemic limb (Leosco et al., 2007).

The average height in the moderate group was 156.0 ± 6.5 cm, and in the BFR group, it was 153.77 ± 5.63 cm. The average body weight in the moderate group was 55.55 ± 9.19 kg, while in the BFR group, it was 59.23 ± 8.44 kg. The average BMI in the moderate group was 23.16 ± 3.53 kg/m², while in the BFR group, it was 25.08 ± 2.94 kg/m². Both groups had average BMIs ranging from normal to overweight. Song et al. (2024) stated in their systematic review that the correlation between BMI and VEGF responses to exercise in the elderly remains unclear. However, previous studies have shown that BMI is correlated with VEGF levels (Wieczor et al., 2016; Zaki et al., 2019). A systematic review by Zafar et al. (2018) indicated that individuals with obesity tend to have elevated VEGF levels. Furthermore, Zaki et al. (2019) reported that obese women with insulin resistance had significantly higher serum VEGF levels compared to control groups. This suggests that obesity may influence angiogenesis in humans through endothelial growth factors (Zaki et al., 2019; Zafar et al., 2018).

The baseline VEGF levels in the moderate group were 1,477.21 ± 1,353.75 ng/L, while in the BFR group, they were 1,799.69 ± 1,446.57 ng/L, with no significant differences in homogeneity or normality tests. Research has shown that VEGF concentrations in serum are notably higher than those in plasma (Webb et al., 1998), possibly due to VEGF being stored in platelets (Banks et al., 1998). The activation of platelets can lead to an increase in serum VEGF levels in both healthy individuals and those with medical conditions (Lee et al., 2011). While some studies indicate that changes in serum VEGF might be more valuable for predicting outcomes in cancer patients compared to plasma VEGF (Lee et al., 2011), current research is inconclusive regarding whether plasma or serum is the superior sample type for tracking VEGF alterations in response to exercise among older adults. (Song et al., 2024).

Baseline VEGF levels serve as the basis for evaluating the increases after intervention. Research conducted by Ruggiero et al. (2011) shows that VEGF levels increase with age. Furthermore, there are polymorphism factors that may influence individual blood serum VEGF levels (Ruggiero et al., 2011). Individual analysis becomes essential for evaluating the effects of exercise before and after the intervention.

Research findings indicated that six weeks of low-intensity resistance training with blood flow restriction (BFR) led to a notable rise in acute VEGF levels from baseline ($p < 0.05$), though chronic VEGF levels remained unchanged. A meta-analysis conducted by Li et al. (2021) showed an increase in VEGFR-2 mRNA following BFR exercise, potentially due to enhanced VEGF binding (Ferguson et al., 2018) and a greater number of endothelial cells (Gustafsson et al., 2007) resulting from BFR training. Moreover, when combined with exercise, BFR stimulates the expression of VEGF through the activation of crucial regulatory factors (HIF-1a, PGC-1a, and eNOS), leading to heightened local muscle ischemia or hypoxia, shear stress, and mechanical stress. This process reflects increased hypoxia levels, followed by enhanced VEGF activation, which is part of the HIF-1a pathway (Li et al., 2021).

Multiple systematic reviews suggest that physical activity can influence the concentrations of angiogenic proteins, especially VEGF, in both young and older adults (Gorski & Bock, 2019; Kissane & Egginton, 2019; Kwak et al., 2018; Spirandelli et al., 2020). After aerobic and resistance exercises, the levels of angiogenesis markers, including VEGF, revert to their initial values within a brief period (under 1 hour) (Tsai et al., 2018). The long-term effects of exercise have been linked to alterations in angiogenesis markers, which may enhance the well-being of older populations (Al-Jarrah et al., 2010).

The moderate group showed no notable changes in VEGF levels from baseline to acute or chronic stages ($p > 0.05$), aligning with the findings of Song et al. (2024) for both resistance training and combined resistance-aerobic exercise subgroups. A brief review on exercise and angiogenesis suggested that while both resistance and aerobic exercises promote angiogenesis, the latter has a more pronounced effect (Kwak et al., 2018). It is important to note, however, that studies on resistance training are considerably fewer than those on aerobic exercise. Consequently, the impact may have gone undetected due to insufficient evidence, highlighting the need for further investigation into the differential VEGF responses to aerobic and resistance training (Song et al., 2024). However, these results differ from studies in mice which showed that both moderate-intensity continuous and interval training can increase VEGF levels (Amalia, et al., 2024).

Mechanical resistance and metabolic stress are the primary mechanisms behind muscle hypertrophy induced by resistance training with BFR, both working synergistically to mediate various secondary mechanisms, all of which stimulate autocrine and/or paracrine actions to induce muscle hypertrophy (Pearson & Hussain, 2015). Low-intensity resistance training combined with BFR results in muscle strength gains due to hypertrophy, occurring in the early weeks of training, around week four. In contrast, moderate-intensity resistance training sees muscle strength improvements in the early weeks (< 4 weeks) due to neural adaptations, with hypertrophy occurring after week four. The muscle size increase in the early weeks of training is attributed to edema (Loenneke et al., 2012; Seynnes, et al., 2009; Damas, 2016).

The analysis of VEGF delta values between the moderate and BFR groups showed no significant differences in baseline-to-acute or baseline-to-chronic VEGF ($p > 0.05$). Although subgroup analysis revealed significant differences, the overall VEGF delta analysis between the two groups showed no significant results. This indicates that VEGF responses were not significantly different between acute and chronic responses. VEGF changes were more influenced by ischemic responses specific to the acute response in the BFR group. BFR has advantages in better VEGF expression, consistent with research conducted on the Asian population by Zhao et al. (2020).

A systematic review by Maga et al. (2022) examined alterations in VEGF concentrations during BFR. The majority of studies analyzed in this review supported the notion that BFR promotes VEGF production. The meta-analysis results suggested that BFR training is superior to conventional training in promoting angiogenesis, with confidence intervals nearing "0". Additionally, BFR training led to enhanced VEGF mRNA expression, which consistently surpassed the increases observed with regular exercise in all instances (Maga et al., 2022).

Adverse events occurred in 2 subjects from the moderate group in week three of training, during the increase in exercise intensity. These subjects received treatment, with one reporting post-exercise muscle pain, and one experiencing delayed onset muscle soreness (DOMS). Muscle pain improved within 30 minutes to 1 hour after treatment, and DOMS symptoms resolved entirely within 3 days of exercise.

The results align with other research on muscle training using BFR. A study by Harper et al. (2019) on older adults with grade II osteoarthritis found that moderate-intensity strength training led to more negative outcomes, such as pain during exercise, compared to the BFR group. In contrast, Karabulut et al. (2013) reported no adverse effects from high-intensity BFR strength training, with no rise in inflammatory markers (IL-6) or muscle damage indicators (CK). Similarly, Yasuda et al. (2015) showed that BFR strength training in older adults (aged 61-84 years), following a protocol of twice-weekly sessions for 12 weeks at 20–30% 1RM, did not significantly elevate FDP, D-dimer, or creatine kinase (CK) levels. These findings suggest that combining low-intensity strength training with BFR offers a safer option for elderly individuals, particularly in Asian countries.

A study in China showed that individuals over 60 years of age will experience decreased muscle and bone mass as one of the producers of IGF-1 needed for satellite cell activation in the process of muscle hypertrophy (Ye et al, 2020). The more sedentary / deconditioning, the greater the changes expected to occur. Healthy individuals will respond differently from those with health problems such as hypertension, diabetes, multiple sclerosis, osteoarthritis, and others. Nutritional status also plays an important role, supplements such as protein or low-protein diets or vitamins also affect the variables assessed after undergoing BFR training such as muscle strength and hypertrophy (Freitas et al., 2021).

Conclusions

The addition of low-intensity strengthening exercises with BFR for 6 weeks can increase VEGF in elderly women more than moderate-intensity strengthening exercises, namely the acute effect. The acute elevation in VEGF levels may contribute to enhanced angiogenesis and vascular function in elderly female subjects. The integration of BFR with low-intensity exercise protocols could potentially provide a more suitable and efficacious alternative for older individuals who may experience difficulties with high-intensity training regimens. Additional research is warranted to elucidate the long-term implications of this training methodology on cardiovascular health and overall physical performance in geriatric populations.

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