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## ORIGINAL ARTICLE

### How does blood flow restriction training have been applied in Brazil?

#### Como o treinamento com oclusão vascular tem sido utilizado no Brasil?

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## Abstract

**Objective:** The aim of the present study was to analyze how the blood flow restriction (BFR) training has been used by professionals in Brazil, focusing on the user's profile, control of training variables and the rate of occurrence of adverse effects. **Methods:** Eighty-six health professionals with experience in BFR training were interviewed through a digital questionnaire prepared by the authors containing 17 questions about the characteristics of using the method. **Results:** BFR training has been used in Brazil for the past 5 years, mainly by Physical Education professionals who attend healthy adults, athletes and elderly people with several objectives. Most of the professionals seem to follow specific scientific recommendations for the BFR training prescription, except for a small portion of participants, especially regarding pressure control to BFR. Low-severity immediate adverse effects associated with the method were observed at reasonable rates and no serious effects were reported. **Conclusion:** Since a small number of professionals reported inattention to scientific recommendations for controlling this variable, these adverse effects may be associated with inadequate control of vascular occlusion pressure.

**Keywords:** hypoxia; physical training; rehabilitation; therapeutic occlusion; vascular occlusion devices.

## Resumo

**Objetivo:** O objetivo do presente estudo foi analisar como o treinamento de restrição de fluxo sanguíneo (RFS) tem sido utilizado por profissionais no Brasil, com foco no perfil do usuário, controle de variáveis de treinamento e taxa de ocorrência de efeitos adversos. **Métodos:** Oitenta e seis profissionais de saúde com experiência em treinamento de RFS foram entrevistados por meio de um questionário digital elaborado pelos autores, contendo 17 perguntas sobre as características do uso do método. **Resultados:** O treinamento em RFS tem sido utilizado no Brasil nos últimos 5 anos, principalmente por profissionais de Educação Física que atendem principalmente adultos, atletas e idosos saudáveis, com diversos objetivos. A maioria dos profissionais parece seguir recomendações científicas específicas para a prescrição do treinamento de RFS, com exceção de uma pequena parcela dos participantes, principalmente no que se refere ao controle da pressão no RFS. Efeitos adversos imediatos de baixa gravidade associados ao método foram observados a taxas razoáveis e nenhum efeito sério foi relatado. **Conclusão:** Como um pequeno número de profissionais relatou desatenção às recomendações científicas para o controle dessa variável, esses efeitos adversos podem estar associados ao controle inadequado da pressão de oclusão vascular.

**Palavras-chave:** hipóxia; treinamento físico; reabilitação; oclusão terapêutica; dispositivos de oclusão vascular.

## Introduction

The blood flow restriction (BFR) training is a technique created by the Japanese researcher Yoshiaki Sato in the late 1960s, which consists of performing physical exercises under the condition of restricted blood flow to the mobilized segment (arms or legs) and has the primary aim of maximizing adaptations related to strength and hypertrophy under conditions where the application of high intensities is not possible or desirable [1]. It has become popular worldwide in the last decade. The main justification for this fact is based on the large number of scientific publications demonstrating the benefits of this technique for heterogeneous populations, especially on muscle strength and mass [2-4], besides relative safety [5-7].

Studies have shown that the isolated use of partial BFR can attenuate the loss of strength and muscle mass in immobilization situations [8]. If associated with aerobic exercise, such as walking and cycling, it can promote increased muscle strength and hypertrophy and these increases are more significant when associated with strength training using low external loads [9]. Thus, the method has become a training alternative for both musculoskeletal rehabilitation and performance. In addition, while there is much speculation about possible risks associated with BFR, several studies show that if the specific recommendations for its application are observed, the risks are low.

Following this worldwide trend of popularization of BFR training, in Brazil the technique has become better known and interest in its use has grown in the last decade, especially associated with physical training. Much of this fact is due to the greater availability of information on the topic in Portuguese, such as scientific articles [10,11], books [12,13], lectures and classes.

However, although popularity is increasing and the body of technical and scientific information is large, little is known about how BFR training is used in Brazil. Thus, considering the need to know the characteristics of its use to confront the specific scientific evidence, the aim of this study was to analyze how the BFR training has been used by professionals in Brazil, focusing on the user's profile, control of training variables and the rate of occurrence of adverse effects.

## Methods

### *Participants*

Ninety-five health professionals with experience in BFR training operating in different regions of Brazil participated in the study, of these, 9 were excluded from the analysis because they did not completely answer the questionnaire. All participants were invited through digital means (e-mail and social medias) and the participation in the study was voluntary, by digital signature of informed consent term. The project complied with all ethical criteria contained in the Declaration of Helsinki and was approved by the Research Ethics Committee of Nove de Julho University (#1.861.919 of Dec 12, 2016).

### *Instruments and procedures*

To accomplish the aim of the research and considering that we did not find previous studies with similar research model on BFR training, a digital questionnaire was elaborated through the Google Forms platform, containing 17 closed questions about to the professional's profile (3 questions) and the form to use the BFR training (14 questions). After disclosure of the link through invitations sent by digital means such as emails and social medias of health professionals from all over Brazil, the questionnaire was available for completion for a period of 15 days. After this period, the data were tabulated, and the completed questionnaires were considered for analysis.

1. How old are you?
2. What is your gender?
3. What is the area of your academic background?
4. How long have you known (or used) BFR training?
5. For what purpose do you use BFR training? You can tick more than one option.
6. What is the public profile to which you apply BFR training? You can tick more than one option.
7. What type of exercise do you use for BFR training? You can tick more than one option.
8. What is the weekly training frequency which you apply BFR training?
9. How many exercises in a training session do you usually use BFR training?
10. In a training session, what is the maximum time limit for BFR?
11. What sets and repetitions protocol do you usually apply to BFR training?
12. Which external load zone do you use in BFR training?
13. How long rest interval do you apply between sets of the same exercise performed with BFR?
14. How long rest interval do you adopt between different exercises performed with BFR?
15. What occlusion pressure value do you use in BFR training?
16. What type of equipment do you use to restrict blood flow?
17. Did you observe or experience any adverse effects from BFR training? You can tick more than one option.

### Statistical analysis

The results are presented considering the respective absolute and relative (percentage) distributions for each question applied. For analysis, we used Microsoft Excel and SPSS v.20software.

## Results

Of the 86 volunteers who participated in the study (11 women, 75 men,  $30.8 \pm 7.6$  years), 81 (94.2%) were academics or professionals of Physical Education, 2 (2.3%) of Physical Therapy and 3 (3.5%) from other health areas. Regarding the use of the method, the vast majority of professionals (89.5%) reported knowing or using it for less than 5 years and the main purpose reported for use was musculoskeletal rehabilitation (57.0%), with balanced distribution for other purposes. Healthy adults comprise the public most frequently assisted with BFR training (Table I).

**Table I - Absolute (N) and relative (%) distribution related to time and purpose of use, as well as the profile of the public assisted with BFR training**

<b>Time of knowledge and/or use of the BFR training</b>		
<b>Answers</b>	<b>N</b>	<b>%</b>
Less than 1 year	24	27,9
1 to 3 years	35	40,7
3 to 5 years	18	20,9
More than 5 years	9	10,5
<b>Purpose of use of the BRF training*</b>		
<b>Answers</b>	<b>N</b>	<b>%</b>
Improved sports performance	39	45,3
Improved body aesthetics	45	52,3
Health promotion and quality of life	32	37,2
Musculoskeletal rehabilitation	49	57,0
<b>Audience profile served with the method*</b>		
<b>Answers</b>	<b>N</b>	<b>%</b>
Healthy adults	76	88,4
Elderly	28	32,6
Children and adolescents	7	8,1
Athletes	42	48,8
Disabled people	9	10,5
Special populations (hypertensive, diabetic, obese etc.)	16	18,6

\*questions in which more than one answer was allowed, so the sum of the relative distribution is greater than 100%

**Table II - Absolute (N) and relative (%) distribution related to control of variables in BFR training**

<b>Type of exercise used in association with the method*</b>		
<b>Answers</b>	<b>N</b>	<b>%</b>
Resistance exercise	86	100,0
Aerobic exercise	18	20,9
Without exercise (at rest)	12	14,0
<b>Weekly frequency of method use</b>		
<b>Answers</b>	<b>N</b>	<b>%</b>
1 to 2 times	71	82,6
3 to 4 times	14	16,2
5 to 6 times	1	1,2
<b>Amount of exercises associated with the method in a training session</b>		
<b>Answers</b>	<b>N</b>	<b>%</b>
Only in 1	21	24,4
Between 1 and 3	56	65,1
More than 3	9	10,5
<b>Maximum time limit for using the method in a training session</b>		
<b>Answers</b>	<b>N</b>	<b>%</b>
Less than 5 minutes	25	29,0
Between 5 and 10 minutes	35	40,7
Between 10 and 15 minutes	9	10,5
Between 15 and 20 minutes	6	7,0
More than 20 minutes	0	0,0
Without time control	11	12,8
<b>Protocol of sets and repetitions applied to resistance exercises associated with the method</b>		
<b>Answers</b>	<b>N</b>	<b>%</b>
1 set of 30 plus 3 sets of 15 repetitions	15	17,4
2 to 4 sets until concentric failure or voluntary fatigue	50	58,1
2 to 4 sets with predetermined number of repetitions	19	22,1
Other	2	2,4
<b>Intensity applied to resistance exercises associated with the method</b>		
<b>Answers</b>	<b>N</b>	<b>%</b>
Low (less or equal to 50% 1RM)	61	70,9
Moderate (between 50 and 70% 1RM)	22	25,6
High (more than 70% 1RM)	3	3,5
<b>Rest interval between sets of same resistance exercise associated with the method</b>		
<b>Answers</b>	<b>N</b>	<b>%</b>
Less than 30 seconds	65	75,6
Between 30 and 60 seconds	9	10,5
More than 60 seconds	12	13,9
<b>Rest interval between different resistance exercises associated with the method</b>		
<b>Answers</b>	<b>N</b>	<b>%</b>
1 minute	16	18,6
Between 1 and 3 minutes	45	52,3
Between 3 and 5 minutes	14	16,3
Use in 1 exercise only	11	12,8
<b>Occlusion pressure used in the method</b>		
<b>Answers</b>	<b>N</b>	<b>%</b>
Determined percentage of total occlusion pressure	28	32,6
Determined percentage of systolic blood pressure	21	24,4
Value corresponding to total occlusion pressure	5	5,8
Value corresponding to systolic blood pressure	11	12,8
Fixed pressure value determined at random	8	9,3
Other	13	15,1
<b>Type of equipment/accessory used to generate blood flow restriction</b>		
<b>Answers</b>	<b>N</b>	<b>%</b>
Conventional sphygmomanometer to measure blood pressure	14	16,3
Specific inflatable cuff with analog manometer	35	40,7
Specific inflatable cuff with digital manometer	12	14,0
Orthopedic surgery inflatable cuff with analog or digital manometer	2	2,3
Elastic tourniquets without pressure gauge	23	26,7

\*questions in which more than one answer was allowed, so the sum of the relative distribution is greater than 100%

Regarding the control of training variables, in most cases, the method is applied preferentially to resistance exercises, in a single exercise per session, with low weekly frequency (1 to 2 times), respecting a maximum use time of 10 minutes per session. Most professionals also reported using a low intensity protocol from 2 to 4 sets performed until voluntary fatigue with short intervals between sets (less than 30 seconds).

When the method is applied to more than one exercise, most professionals reported adopting a time less than 3 minutes between exercises. To generate blood flow restriction, specific inflatable cuffs and elastic tourniquets were adopted. Regarding occlusion pressure for training, most reported the use of a certain percentage of total occlusion pressure and systolic blood pressure (Table II).

Regarding the observation of adverse effects resulting from the method, most professionals reported never having observed problems, but paresthesia and red pigmentation in the limb under BFR were reported by 1/3 of the volunteers, while severe acute pain by 1/4 of the professionals (Table III).

**Table III - Absolute (N) and relative (%) distribution related to observation of adverse effects observed in BFR training**

<b>Adverse effects observed as a result of the method *</b>	<b>N</b>	<b>%</b>
No symptoms/adverse effects	29	33,7
Limb paraesthesia (numbness, tingling)	28	32,6
Red pigmentation in the limb	28	32,6
Intense acute pain	21	24,4
Delayed onset muscle soreness	14	16,3
Dizziness or nausea	12	14,0
Itching	10	11,6
Subcutaneous hematoma	9	10,5
Acute decrease or loss of limb sensitivity	5	5,8
Others	1	1,2

\*questions in which more than one answer was allowed, so the sum of the relative distribution is greater than 100%

## Discussion

Considering the increasing popularity of BFR training in Brazil and the lack of information on how the method has been used by professionals working in this country, this paper sought to understand how this type of training has been used by professionals in Brazil, focusing on user's profile, control of training variables and the rate of adverse effects occurrence. The main finding of the present study was that most of the interviewed professionals seem to adopt practices consistent with the current recommendations for prescribing, supervising and controlling the variables involved in BFR training, revealing attention to scientific evidence. Additionally, the occurrence of high severity adverse effects has not been reported.

The vast majority of professionals who participated in this research and reported the use of the method were from the Physical Education area, which was to be expected since many studies involving BFR training observed significant increases in strength and muscle mass [2,3]. These are results that achieve the aims of majority of the public seeking the services of the Physical Education professional for aesthetic purposes, health promotion or improvement of physical performance, confirmed in the purposes reported by the volunteers.

However, what attracted attention was the small participation of professionals from physical therapy and other health areas, which indicates a probable underutilization of the method in these areas, since the current scientific literature has supported the use of this technique for therapeutic purposes [14,15]. Importantly, despite the small participation of physiotherapists and health professionals from other areas in this research, musculoskeletal rehabilitation was the most reported purpose given the use of BFR training, highlighting the significant performance of Physical Education professionals in this area, following trend pointed by Thompson [16].

Although international scientific literature has been exploring the BFR training for over a decade, especially after the first publication by Kaatsu Training creator Yoshiaki Sato [1], most professionals interviewed have known the method for less than 5 years. However, this data is justified by the recent availability of information on BFR training in Portuguese.

Regarding the public to which the technique has been applied, a higher utilization rate was observed in healthy adults and athletes, publics for whom the scientific literature presents great availability of information to support its safe use [9,17,18]. In special populations, such as



the elderly, children, adolescents, people with disabilities and people with certain diseases, the rates of BFR training application were lower revealing caution among the professionals, because, although emerging, there is still a small amount of scientific publications involving this population [4,19,20].

About training variables, resistance exercises were the most used, corroborating the literature that shows the effects of this type of exercise associated with BFR on strength and hypertrophy may be more expressive than aerobic exercises and BFR without exercise [9]. Most professionals use up to 3 resistance exercises associated with BFR per training session, in accordance with Pope *et al.* [17].

Although the literature does not present a limit number of exercises that can be associated with blood flow restriction in a training session, Nakajima *et al.* [21] recommend a maximum time limit for using the technique in a single session, which would be 15 and 20 minutes per sessions involving upper and lower limbs, respectively. In this sense, except for 12% of respondents who do not control the use time, the others do not exceed 15 minutes, revealing attention to the recommendations in the literature.

Regarding the external loads used in resistance exercises associated with BFR, although ~70% of the professionals reported using low external loads (<50% 1RM), ~1/3 of the sample reported the use of high intensities (>50% 1RM), a fact that caught our attention, as some studies show that use of high external loads in the method does not provide additional benefits [10,22]. Corroborating the idea, studies have shown that one of the main advantages of strength training associated with BFR over traditional training models is that it does not need to use heavy loads and may be a viable alternative for conditions in which high loads are not possible and/or desirable [2,9].

The most used sets and repetitions protocols include performing 2 to 4 sets per exercise, performing repetitions to concentric failure (~58%) or with a predetermined number of repetitions (~22%). Although some studies use similar protocols [23,24], the literature reports as the most common performing 1 set of 30 repetitions, followed by 3 sets of 15 repetitions [25]. In the present study, a minority reported the use of this protocol, a fact that also draws our attention because it is considered a standard protocol, as it has been widely investigated [26].

Most participants (~86%) reported adopting short rest intervals between sets ( $\geq 60$  seconds), in accordance with specific scientific recommendations [9]. However, when the method is applied to more than one exercise in the training session, 71% of respondents said to apply rest intervals of less than 3 minutes between exercises, a shorter time than suggested by Pope *et al.* [17] to allow reperfusion, which is 5 minutes without BFR. Almost all participants (~99%) reported applying the method with weekly frequency less than or equal to 4 times, also in accordance with what has been recommended [9].

To generate BFR, about 73% of professionals use some type of inflatable cuff with objective pressure control (manometer), however, the use of elastic tourniquets with no objective pressure control was expressive (~27%). Although previous studies have shown the use of elastics tourniquets may be a practical and cost-effective [27] and safe [28] alternative, the number of publications is limited [29]. Moreover, when using elastic tourniquets, pressure control becomes subjective [28] and it depends on the user's sensitivity which increases the risk of intervention failure, as noted by Loenneke *et al.* [30].

Regarding occlusion pressure, although many professionals use values related to total occlusion pressure or systolic blood pressure, which meets the scientific safety recommendations [9,17,25], the use of total or randomly determined-occlusion pressure values have been reported (~6 and ~9%, respectively), which may substantially increase the risk of adverse effects.

About the occurrence of adverse effects resulting from the method, according to the best of our knowledge, this is the first study that analyzed the observation rate among professionals working in Brazil. One third of the sample reported never having observed any adverse effects; in contrast the observation of paresthesia and red pigmentation in the limb was also reported by approximately 1/3 of respondents.

In the present study, although the occurrence rates were higher than those reported by Nakajima *et al.* [31], in research conducted in Japan, reported effects are immediate and appear to be alleviated or disappear after the end of the training session. However, these effects may decrease training adherence and this hypothesis needs to be further investigated. It is important to highlight that, even observing that most of the professionals follow scientific recommendations for the prescription of BFR training, part of the interviewees does not seem to pay attention to these details, especially regarding the pressure control during the training session. This may partly explain the adverse effect rates observed in the present study.

The main limitation of this study is related to the limited number of professionals interviewed considering the geographic and population dimensions of Brazil. Thus, it is necessary to enlarge the sample to confirm the results found here.

## Conclusion

BFR training has been used in Brazil for the past 5 years, mainly by Physical Education professionals who mainly attend healthy adults, athletes, and elderly people with several objectives. Regarding the manipulation of training variables, most of the reports seem to follow specific scientific recommendations for the BFR training prescription, except for a small portion that did not seem to pay attention to these recommendations, especially regarding pressure control to BFR, which may increase the risk of adverse effects.

Low-severity immediate adverse effects associated with the method were observed at reasonable rates and no serious effects were reported. However, these effects may be associated with inadequate control of vascular occlusion pressure, since a small number of professionals reported inattention to scientific recommendations for controlling this variable.

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