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The role of blood flow restriction training for applied practitioners: a questionnaire based survey.

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ABSTRACT

The purpose of the study was to investigate the current use of blood flow restriction (BFR) by practitioners during exercise/training. A questionnaire was developed and data were obtained from 250 participants, with 115 stating that they had prescribed BFR as an intervention. The most common exercise intervention used in combination with BFR was resistance exercise (99/115), followed by during passive (30/115) conditions, and during aerobic exercise (22/115). The main outcome measure for using the technique was to increase muscle mass (32.6%) followed by rehabilitation from injury (24.2%). Over half of respondents (57.4%) reported that they did not use the same cuff widths for the lower body and upper body, with varying final restriction pressures also being utilised during each different exercise modality. Most practitioners performed the technique for ~10 min each training session, 1-4 times per week. Eighty percent of practitioners rated the use of BFR as very good-excellent. The incidence rate of side effects was largest for delayed onset muscle soreness (39.2%), numbness (18.5%), fainting/dizziness (14.6%) and bruising (13.1%). These results indicate that the use of BFR training is widespread amongst practitioners; however care should be taken to ensure that practice matches current research to ensure the safety of this technique.

KEYWORDS: KAATSU; Occlusion training; BFR Training; safety; rehabilitation.

INTRODUCTION

Blood flow restriction (BFR) training is a novel exercise method that has gained popularity in the past 15 years, involving exercise whilst blood flow is limited to the muscle, via application of an inflatable cuff or tourniquet, proximal to the muscle being trained (Scott et al. 2015). Low-intensity aerobic (i.e. 3-5 km.h^{-1}) and light-load resistance exercise (i.e. 20-50% one repetition maximum [1-RM]) with BFR results in beneficial adaptations to muscle strength, mass, and endurance (Laurentino et al. 2012, Takarada, Takazawa & Ishii 2000, Kacin, Strazar 2011) and the vasculature (Patterson, Ferguson 2011, Patterson, Ferguson 2010), and has strong evidence for use in clinical and elderly populations (Patterson, Ferguson 2011, Mattar et al. 2014, Yasuda et al. 2015), healthy athletic populations (Takarada, Sato & Ishii 2002, Manimmanakorn et al. 2013, Luebbers et al. 2014) and use for rehabilitation following injury or illness (Loenneke et al. 2013, Ohta et al. 2003).

Anecdotal evidence suggests that both aerobic and resistance exercise is being performed with BFR in the field by practitioners such as strength and conditioning coaches, sport scientists and physical therapists. The increasing use of BFR during aerobic and resistance exercise due to its popularity among researchers and practitioners may be of some concern and interest, considering the different methodologies used in the literature relating to exercise prescription and the application of BFR, which may affect the overall outcomes relating to function/performance (Fahs et al. 2012). For example, applying different cuff widths (wide versus narrow) at the same absolute BFR pressure (e.g. 200 mmHg) for different muscle groups (e.g. upper body versus lower body) will have different acute effects when examining the neuromuscular, haemodynamics, metabolic and perceptual responses, as well as potentially affecting the more longer-term adaptations in muscle strength, mass and endurance (Fahs et al. 2012). While current research continues to attempt to answer these questions regarding the *optimal* BFR and exercise methodologies, it is currently unknown how practitioners in the field are applying these techniques to clinical and athletic populations, and if the manipulation of these variables impacts the safety of this technique.

The largest study in this area demonstrated a low occurrence of any adverse effects of BFR training other than subcutaneous haemorrhage, in various populations in Japan (Nakijima et al. 2006). In more controlled conditions, 4 weeks of BFR had no negative effects on pulse-wave velocity, ankle-brachial index, prothrombin time, nerve conduction, markers of coagulation or fibrinolysis (Clark et al. 2011). Whilst the aforementioned studies have not reported negative side effects of BFR training, more recent case studies have reported rhabdomyolysis (Iversen, Rostad 2010, Tabata et al. 2016) and retinal occlusion (Ozawa et al. 2015). Furthermore, skeletal muscle damage is reported following BFR training (Umbel et al. 2009, Wernbom et al. 2012) however, this has been disputed in the literature (Loenneke, Thiebaud & Abe 2014).

Despite the growing profile of BFR training (both aerobic and resistance) and increasing attention in scientific literature, there is currently little published information available pertaining to practices and strategies employed by practitioners such as strength and conditioning coaches, sport scientists and rehabilitation specialists. The only previous study to investigate the practices and safety of BFR training was performed over a decade ago in Japan, by the inventor and founder of KAATSU equipment and published in their own journal (Nakajima et al. 2006). Therefore, the aim of this study was to investigate the current state of BFR training and how this type of training is managed by practitioners working with healthy, clinical, and athletic populations. A secondary aim was to investigate the risks associated with this technique and to report current side effects to this type of training as assessed in practice.

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METHODS

A cross-sectional observational study was conducted using a self-administered online questionnaire which took 15-20 min to complete. A multiple-choice questionnaire was used for data collection and participants were given the opportunity to expand on their responses. The questionnaire contained six sections, containing 62 questions; personal details, BFR methodology (devices, cuff width, pressures and duration of use) and prescription for (i) resistance training (ii) aerobic training and (iii) passive use and finally questions relating to safety and contraindications to BFR prescription. The questionnaire was developed as per Ebben and Blackard (2001) whereby it was created by the authors and was pilot tested on four experienced practitioners, who regularly prescribe BFR to their patients and athletes. This approach has also been adopted in previous research (Ebben & Blackard, 2001; Read et al. 2016).

The questionnaire was distributed to strength and conditioning coaches, sport scientists, physiotherapists, researchers and doctors via email and advertised through social media including Twitter, Facebook, online blogs, forums and by word of mouth between March and April 2015. A link was provided to the internet-based questionnaire in addition to some brief information about the research.

The participants were informed that by participating in the questionnaire and agreeing to the terms, they had provided informed consent for their information to be used in this study. The inclusion criteria were individuals aged ≥ 18 years and involved in the following professions rehabilitation, physiotherapy, sport science and/or strength and conditioning. This study was approved by the St Mary's University Ethics Committee.

Data Analysis

All data was collected using an online questionnaire (British Online Surveys, Bristol, UK). Data were analysed using descriptive statistics, with frequency counts and percentages calculated.

RESULTS

Participant details

We obtained an answer from 250 responders to the questionnaire from 20 countries. The descriptive characteristics of the responders and description of their current work profession and work setting are displayed in Table 1. Of the 250 participants, 239 (95.6%) stated that they had heard of the BFR technique for exercise and rehabilitation prior to answering the questionnaire, while 115 (46.0%) stated that they have prescribed BFR as an exercise intervention.

BFR methodology

BFR device and cuff width

BFR was applied using handheld inflatable pumps (50.7%), automatic inflatable pumps (18.6%), knee wraps (17.9%), *Kaatsu* training device (9.3%) and elastic tourniquets (3.6%). Of 115 responses, 57.4% reported that they did not use the same cuffs for the lower body and upper body. The distribution of cuff widths used for the lower body and upper body is displayed in Figure 1A.

Final exercise pressure and duration

The duration of the applied BFR pressure is displayed in Figure 1B and the final exercising BFR pressure for the upper body and lower body is displayed in Figure 1C- D, respectively. Participants chose the final exercising BFR pressure based on previous research (40.0%), information from professional colleagues or conference presenters (37.4%), personal experience (20.6%) or information from the internet (1.9%). Other common methods included basing the final exercising

BFR pressure based on pre-assigned pressures from previous literature (43.4%), relative to an individual's limb circumference (19.5%), a percentage of individuals resting blood pressure (19.5%), a percentage of individual's limb occlusion pressure (LOP; 11.5%) or based on subjective measures (6.2%).

Prescription of BFR

The age distribution of persons that practitioners had applied BFR to was $\leq$ 20 years (20.5%), 21-30 years (46.0%), 31-40 years (15.6%), 41-50 years (3.6%), 51-60 (5.8%), 61-70 (5.4%) and 71-80 years (3.1%). Practitioners had applied BFR to various populations including athletes (57.6%), general/healthy (24.3%), clinical (10.4%) and the elderly (7.6%). The use of BFR during exercise was reported to be supervised 82.6% of the time. Participants of the questionnaire answered that the main aim of the inclusion of BFR in to a training programme was to induce muscle hypertrophy (32.6%), followed by use during injury rehabilitation (24.2%), which also consisted of avoiding muscle atrophy following injury (20.3%) and as a stimulus to protect joint structure (9.7%). Other uses included to increase muscle/bone strength (10.1%) and aerobic conditioning (1.8%) and to induce vascular adaptations (1.3%). From 115 responses, 92 (80%) rated the effectiveness of BFR as a training tool for strength and conditioning or rehabilitation as "very good" to "excellent".

The next questions within this subsection were related to the use of BFR as a rehabilitation technique. The distribution of its use were as follows knee joint (32.8%), lower body muscle strain or tear (14.4%), ankle joint (13.2%), during limb immobilisation (11.5%), shoulder joint (6.9%), hip joint (5.2%), elbow and wrist (9.2%), other (4%) and during prolonged bed rest (2.9%). Participants' comments in response to this question regarding other uses for rehabilitation from injury included "early stage rehabilitation where reduced load is required", "following surgery" and back-related injuries such as "lumbar stress fractures". Comments in response to more specific uses for BFR during injury rehabilitation included "anterior cruciate ligament", "medial collateral ligament", "meniscus damage", "osteochondral defect" various tendinopathies including "patella-femoral" and "biceps", and following muscle strains including the hamstring, quadriceps, adductors and gastrocnemius muscle groups. In addition, BFR was stated to be used following surgery for "total hip replacement", "shoulder reconstruction" and bone fractures of the humerus, mid-shaft of the tibialis anterior-fibular were also reported.

Resistance exercise with BFR

Ninety nine of the 115 respondents indicated that they prescribed resistance exercise with BFR. The cuff widths, final restriction pressure, and duration of applied pressure prescribed during resistance exercise are listed in Figures 1A-D. Participants were asked what type of resistance exercises were prescribed (Figure 2) and what exercise variables were prescribed (Table 2). The most commonly prescribed external load was 20-30% 1-RM (55.4% responses). The most commonly employed repetition scheme prescribed was one initial fatiguing set of 30 repetitions, followed by three sets of 15 repetitions (30-15-15-15; 44.8%), while repetitions to failure (31.9%) and other set/repetition schemes were also prescribed (23.3%). The most common objective measures to monitor change were adaptations in muscle mass (35.0%) and strength (30.4%). Other responses included injury specific measures (18.0%) and return to normal daily activities or return to sport participation (16.6%).

Aerobic exercise with BFR

Of 115 responses, 22 individuals reported using BFR combined with aerobic exercise. The cuff widths, final BFR pressure, and duration of applied pressure prescribed during aerobic exercise are listed in Figures 1 (A-D). Participants were asked what types of aerobic exercises were prescribed (Figure 2B) and what exercise variables were prescribed (Table 2). The most common objective measures to monitor change were return to normal daily activities or return to sport participation (45.5%), adaptations in muscle strength (20.5%) and mass (18.2%), with injury specific measures (15.9%) also declared.

Passive BFR

Thirty of the 115 respondents indicated that they prescribed passive BFR (i.e. no exercise). The cuff widths, final BFR pressure, and duration of applied pressure prescribed during passive BFR are listed in Figures 1 (A-D). Participants were asked what variables were prescribed during passive BFR (Table 2). The most common reason given for using this technique was reducing muscle atrophy during inactivity (57.5%), warm-up before exercise (30.0%), muscle strengthening (7.5%), vascular adaptations (2.5%) or recovery from previous injury (2.5%). The most common objective measures to monitor change were muscle mass (32.7%) and strength (21.2%), with return to normal daily activities or return to sport participation (26.9%), injury-specific measures (15.4%) and vascular adaptations (3.8%) also declared.

Safety Precautions

The initial question in this subsection asked participants if there were any specific contraindications that may exclude the use of BFR with their athlete/clients and is displayed in Figure 3. A number of specific comments to this question included the following “the use [of BFR] is doctor dependent on condition”, and its inclusion is “subject to medical staff approval”. However, others stated that there were no contraindications in “healthy/young populations”, “general population” and “healthy athletes”.

When asked if participants had any concerns using BFR with athletes/clients (154 responses), 27.3% reported no concerns, while ratings of pain (24.0%), adverse cardiovascular effects (15.6%), delayed onset muscle soreness (14.3%), adverse neuromuscular effects (9.7%), and bruising (9.1%) were reported. The final question in this section asked participants if their athletes/clients ever reported any side effects as a result of BFR exercise/training (Figure 3).

DISCUSSION

This study investigated the opinions of practitioner's currently using BFR training and its derivatives. This is the first major study to investigate the use of BFR training by practitioners since the national survey of Japanese practitioners 10 years ago (Nakijima et al. 2006). In that time, the research and applied use of BFR training has expanded to many countries, and as such methodologies for this technique have been refined and altered, thus the findings of this study are novel as an update to this technique.

BFR methodology and exercise prescription

The most commonly used BFR method was that of resistance exercise. The final restriction pressure and cuff types used within the literature vary widely (50-300 mmHg and 3-20 cm, respectively; (Scott et al. 2015, Loenneke et al. 2011, Loenneke et al. 2012c)) and this was also reflective of participants responses. Current practice reflects this varied range of cuff widths (3 to ≥15cm; Figure 1A) whilst the most frequently used was 10-12 cm. Only just over half (57.4%) of responders reported that they did not use the same cuff widths for the upper body and lower body. This is an important factor to consider, since it has been shown that wider cuffs provide a more effective transmission of pressure through the soft tissue compared with narrow cuffs (Crenshaw et al. 1988, Graham et al. 1993, Shaw, Murray 1982). Therefore, this may impact the efficacy of neuromuscular, endocrine, haemodynamic and perceptual responses and adaptations to exercise/training. In an early study by Crenshaw et al. (1988), it was observed that wider cuffs (18 cm) likely occluded arterial blood flow at a lower overall pressure in comparison with narrow cuffs (4.5 cm). Similar results for arterial occlusion pressures for the lower body have been confirmed (Graham et al. 1993, Loenneke et al. 2012b) and also arterial occlusion pressures for the upper-body (Moore, Garfin & Hargens 1987), however a recent study has demonstrated their to be no differences in training induced adaptations to different cuff widths (i.e wide versus narrow) when the LOP is matched (Laurentino et al. 2016).

The final restriction pressures used varied also (Figure 1C-D), with no great distinction between those used in the upper- and lower-body, despite the obvious difference in muscle mass and overall size of affected limbs. The interaction of cuff width and pressure plays an important role in determining the reduction of blood flow at rest and during exercise, with the amount of pressure needed to occlude blood flow dependent on limb size (Loenneke et al. 2015, Hunt, Stodart & Ferguson 2016). Despite the large number of BFR training studies, there is a lack of detail on the technical characteristics of the cuffs and pressure systems used, therefore large variations in the degree of BFR between individuals and studies are large. We recommend that all factors relating to BFR should be reported within the literature: BFR device, cuff type (material and width), final exercise pressure used and duration of application (continuous or intermittent).

While generalised procedures were used in the early research (i.e. between 1998 and 2012) for determining cuff pressures during exercise, more recent research suggests that the final exercising cuff pressure should be individualised to each participant/user. Loenneke et al. (2012b) first proposed a standardisation to enable more reliable BFR stimulus. To do so they suggested using an arterial LOP measurement at rest and using a percentage of that measurement for the BFR pressure as first described by Laurentino et al. (2012). More recently, Counts et al. (2016) demonstrated that higher LOPs are not more beneficial for muscle adaptations and suggest pressures as low as 40% of an individual's maximal arterial LOP are effective. In addition, the application of wide cuffs (13 cm) coupled with high restriction pressures (230 mmHg) during knee extension exercise have also been shown to result in reduced quadriceps CSA at the site of muscle origin, possibly due to the high compression and shear stress under the cuff (Kacin, Strazar 2011). Further evidence from a recent meta-analysis indicate that higher restriction pressures (≥ 180 mmHg) are no more effective than lower pressures for inducing training adaptations (Loenneke et al. 2012c).

As it stands, it appears that practitioners are not basing their pressures of a limb occlusion measurement as demonstrated by the low response in the questionnaire (11.5% of respondents). Instead they are basing them largely from values observed in the literature (43.4%), relative to an individual's limb circumference (19.5%) or a percentage of individuals resting blood pressure (19.5%). Basing the final exercise pressure from values in the literature will not control for any of the variation associated with cuff type and widths or intra-individual differences such as limb circumference, strength, resting blood pressure, and the underlying tissue (adipose and muscle). Alongside this, practitioners are restricting blood flow based on brachial systolic blood pressure, yet the resulting pressure may vary as a percentage of LOP due to differences in cuff width and type (Loenneke et al. 2015). This lack of control may place some individuals under complete ischemia and increase the adverse risks associated with this, therefore we recommend that practitioners are more careful in their selection of pressures and use a percentage of each individual's maximal arterial LOP for use during exercise.

Participant responses to the use of BFR as a rehabilitation tool reflect those that have been reported within the current literature. In particular, the use of BFR during rehabilitation of lower body muscle or joint injuries made up 60.4% of responses. Several previous papers have demonstrated the positive effect of BFR following anterior cruciate ligament reconstruction, either in combination with resistance exercise (Ohta et al. 2003, Cook et al. 2010) or use during passive rest to protect against muscle atrophy (Takarada, Takazawa & Ishii 2000, Kubota et al. 2011, Kubota et al. 2008). Additionally, the combination of BFR and light load resistance exercise has been used in return to play/activity protocols following patella tendonitis (Sata 2005) and osteochondral fracture (Loenneke et al. 2013). Perhaps more insightful from the questionnaire were the uses of BFR as a rehabilitation technique from upper body muscle or joint injuries and also the lower back. Whilst there are currently no scientific papers to support the use of BFR during rehabilitation of the upper-body or trunk musculature, both Scott et al. (2015) and Loenneke et al. (2012a) have proposed rehabilitation protocols that may easily be adapted for these purposes. In particular, it would seem that the light loads (20-30% 1-RM) during resistance exercise or low-intensities during aerobic exercise, in combination with BFR, offer participants and their client/athletes the ability to reduce overall training loads whilst still enhancing muscle strength and mass (Scott 2014), as well as sports/athletic performance measures such as increased maximal oxygen uptake (Park et al. 2010), jump height (Cook, Kilduff & Beaven 2014), speed (Cook, Kilduff & Beaven 2014, Abe et al. 2005) and agility (Manimmanakorn et al. 2013).

Safety

One noteworthy finding were the side effects associated with BFR within the questionnaire results (Figure 3). Reported complications in the literature associated with BFR training are rare, however, due to its popularity as a technique, key criteria and contraindications should be considered by practitioners. The data reported by practitioners does not always match up to that reported in the literature. For example, 39% of practitioners reported delayed onset muscle soreness following BFR training in their clients. This is a large response and in contrast to recent evidence (Loenneke, Thiebaud & Abe 2014) however, this is a transient response to unaccustomed exercise and usually subsides within 24 to 72 h (Umbel et al. 2009, Wernbom et al. 2012) or following repeated exercise (Sieljacks et al. 2016). With that said, despite the low response, 3% of practitioners reported rhabdomyolysis in their clients/patients following BFR training which is in line with previous research (Nakijima et al. 2006, Iversen, Rostad 2010, Tabata et al. 2016), but higher than that reported in physically active military recruits (Alpers & Jones, 2010). It should also be noted that we did not determine how rhabdomyolysis was assessed, but do suggest practitioners exercise caution and screen participants prior to BFR training. Other reported side effects not often mentioned in the literature include numbness, bruising and fainting/dizziness following BFR training. Nakijima et al. (2006) reported numbness in only 1% of cases in comparison to a large 18.5% in the current study. It is likely that the BFR may cause compression of the peripheral nerve during the exercise bout, potentially as a result of high pressures leading to acute numbness when the cuff is on and/or removed. Tourniquet compression has been demonstrated to cause numbness as a result of ischemia and nerve conduction in the hand (Lundborg et al. 1982) and leg following BFR training (Kacin, Strazar 2011) however, it does not result in long-term issues as side effects are usually transient (Nakijima et al. 2006). Therefore, the final BFR pressure utilised should be carefully considered to ensure a reduction in the reported cases of acute numbness.

One of the major concerns for practitioners using BFR was adverse cardiovascular effects (15.6%), with previous research in the area by Nakijima et al. (2006) reporting seven cases of thrombosis following Kaatsu training. This is an interesting finding considering the low incidence rate of cardiovascular problems that were actually reported (superficial thrombophlebitis [0.8%] and subcutaneous haemorrhage [0.8%]) in the current study. Moreover, when low-intensity resistance or aerobic exercise is performed with BFR by both young and older adults, the acute cardiovascular response has been shown to be less than high-intensity exercise (Staunton et al. 2015), while blood vessel function may be improved following BFR training (Hunt et al. 2013; Patterson & Ferguson 2010, 2011) rather than negatively affected.

Eighteen percent of practitioners reported the use of knee wraps in application to induce BFR, a technique known as practical BFR training (Loenneke & Pujol 2009). While there are some obvious benefits of using practical BFR (cost and time effective for large groups), one major issue with this type of BFR technique is that it is extremely difficult to be clear on the final restrictive pressure that is being applied (and is based on a subjective scale), and thus future research should focus on the reliability and repeatability of the type of application. Recently, a risk assessment tool has been developed for BFR training (Kacin et al. 2015) and should be used by practitioners to ensure adverse risks of BFR training are reduced.

CONCLUSIONS

This study gives a current overview of BFR training and how it is currently used by researchers and practitioners in the field. The discrepancies for these results are unclear but may be as a result of the wide range of methods used (e.g. BFR methodology and exercise prescription) by practitioners in comparison to the controlled research environment. In the light of current research we suggest that BFR training appears to be a safe mode of exercise, provided practitioners perform screening for key contraindications. We further suggest that the pressures used are individualised (40-80% LOP) which also reduces the need for a consistent cuff width. In summary, all the actions lower the risk of BFR training which has been shown to be safe in healthy, young, old and several different clinical groups.

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Table 1. Description of participants who answered the questionnaire (*n* = 250).

	Absolute responders (n = 250)	**Relative responders (%)**
Age distribution (yrs)		
18-29	105	42.0
30-39	95	38.0
40-49	36	14.4
50-59	13	5.2
≥ 60	1	0.4
Gender		
Male	219	87.6
Female	31	12.4
Geographical location of current residence		
United Kingdom	132	52.8
North America	36	14.0
Australasia	34	13.2
Europe	31	12.0
Other (South America, Middle East, Africa)	17	8.0
Current profession		
Strength and Conditioning	101	40.4
Research	59	23.6
Physiotherapist	47	18.8
Sport Scientist	29	11.6
Rehabilitation Specialist	9	3.6
Medical Doctor	3	1.2
Personal Trainer	2	0.8
Current work setting*		
University	108	36.0
Professional Sports Club	69	23.0
Elite National Team	47	15.7
Private Facility	47	15.7
Amateur Sports Club	16	5.3
Hospital	9	3.0
Military	4	1.3

* Note: participants could select more than one option for current work setting (*n* = 300 responses).

Table 2. Exercise prescription variables (% responses)

Number of sets			
	RES	**AER**	**PAS**
1	2.3	30.8	18.4
2	3.0	11.5	5.3
3	30.1	19.2	31.6
4	45.9	23.1	21.1
5	13.5	11.5	21.1
> 5	5.3	3.8	2.6
External load (% 1-RM)			
10	3.6	-	-
20	23.6	-	-
30	31.8	-	-
40	15.9	-	-
50	11.3	-	-
60	5.6	-	-
70	4.6	-	-
80	3.1	-	-
90	0.5	-	-
Length of work sets			
0 – 1 min	-	13.3	15.6
1 – 2 min	-	20.0	6.3
2 – 3 min	-	23.3	21.9
3 – 4 min	-	10.0	15.6
4 – 5 min	-	13.3	40.6
Other	-	20.0	-
Rest periods between sets			
None-continuous	-	21.7	-
< 15 sec	1.8	4.3	11.1
15.5 – 30 sec	35.1	26.1	14.8
30.5 – 60 sec	45.0	26.1	7.4
> 60 sec	18.0	21.7	44.4
3 min	-	-	11.1
5 min	-	-	11.1
Training frequency			
1-2 days	44.1	40.0	31.0
3-4 days	35.4	36.7	23.8
5-6 days	8.7	10.0	11.9
Daily	7.1	3.3	16.7
Twice daily	4.7	10.0	16.7

Blank cells indicate response was not applicable. RES = resistance exercise (*n* = 99), AER = aerobic exercise (*n* = 22), PAS = passive (*n* = 30).

FIGURES

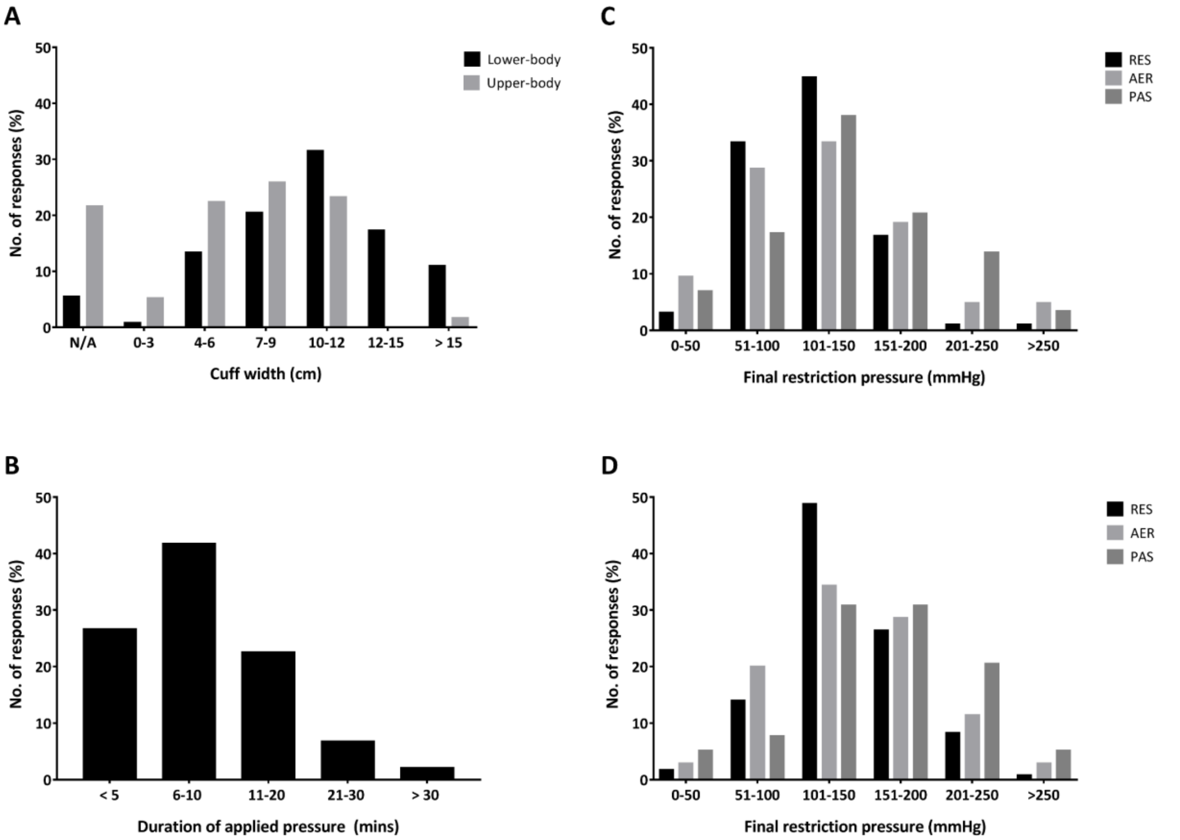

Figure 1. Prescription variables used during blood flow restriction. Cuff widths used for the lower- and upper-body (A); Duration of applied restriction pressure (B), Final restriction pressures used for the upper-body (C) and lower-body (D) during resistance exercise (RES; *n* = 99), aerobic exercise (AER; *n* = 22) or passive (PAS; *n* = 30).

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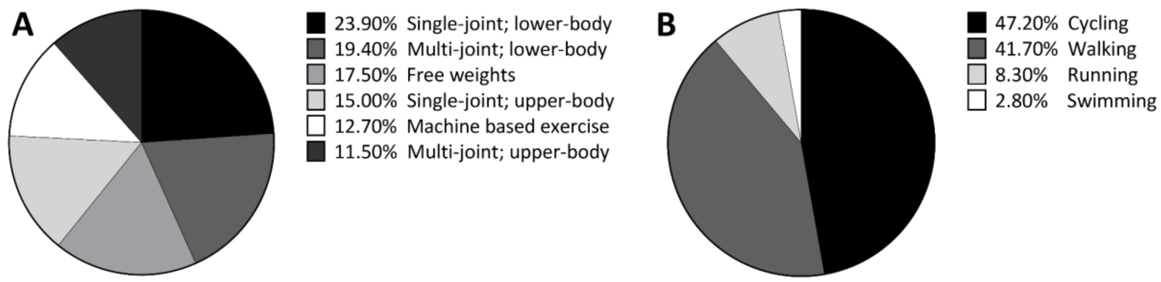

Figure 2. Exercise selection during resistance training (A; *n* = 346) and aerobic training (B; *n* = 33).

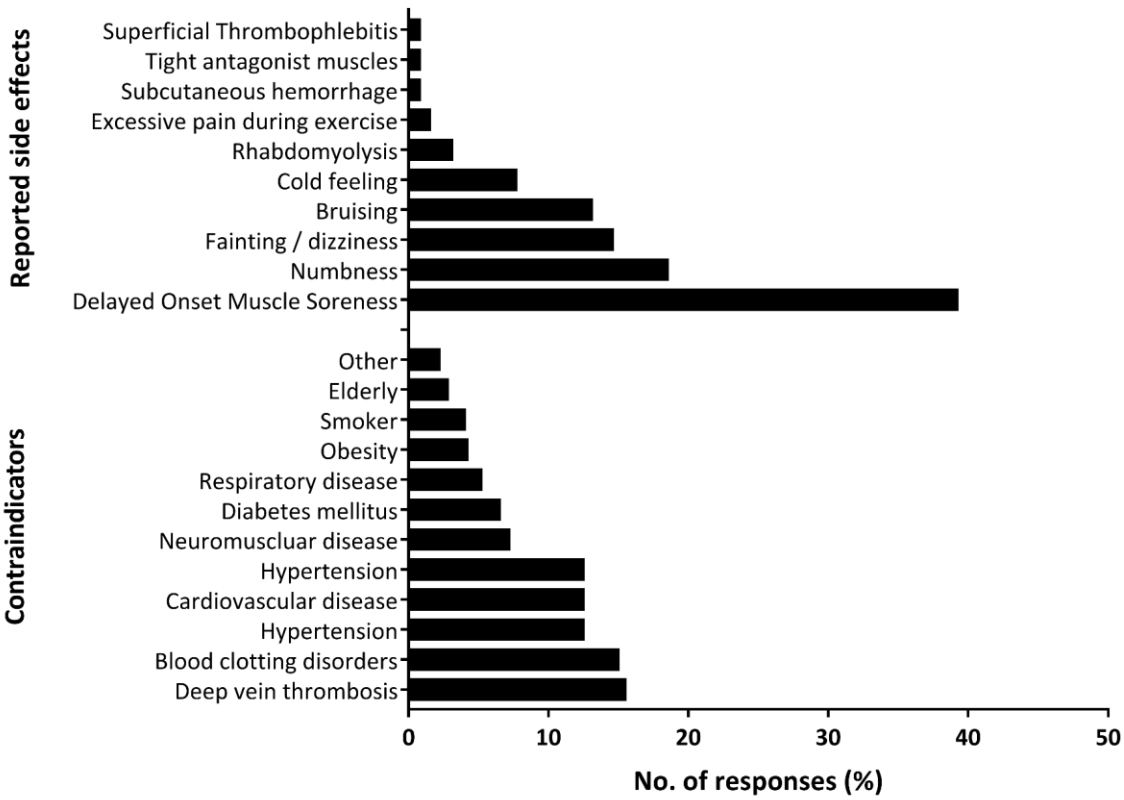

Figure 3. Reported side effects (top) and possible contraindications (bottom) to BFR training (*n* = 154).