Original Paper

Chronic Respiratory Disease

Chronic Respiratory Disease
Volume 18: 1–10

DOI: 10.1177/14799731211056092
journals.sagepub.com/home/crd
SAGE

Title: Blood flow restricted exercise training: Perspectives of people with chronic obstructive pulmonary disease and health professionals

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Abstract

Objective: This descriptive qualitative study explored perspectives of people with chronic obstructive pulmonary disease (COPD) and health professionals concerning blood flow restricted exercise (BFRE) training.

Methods: People living with COPD and health professionals (exercise physiologists, physiotherapists, and hospital-based respiratory nurses and doctors) participated in interviews or focus groups, which included information about BFRE training and a facilitated discussion of positive aspects, barriers and concerns about BFRE training as a possible exercise-based intervention. Sessions were audio-recorded, and transcript data analysed using inductive content analysis.

Results: Thirty-one people participated (people with COPD *n* = 6; health professionals *n* = 25). All participant groups expressed positive perceptions of BFRE as a potential alternative low-intensity exercise mode where health benefits might be achieved. Areas of overlap in perceived barriers and concerns included the need to address the risk of potential adverse events, suitability of training sites and identifying processes to appropriately screen potential candidates.

Discussion: While potential benefits were identified, concerns about determining who is safe and suitable to participate, delivery processes, health professional training and effects on a variety of health-related outcomes need to be addressed before implementation of BFRE training for people with COPD.

Keywords

ischemic training, vascular occlusion, consumer perspectives, chronic obstructive pulmonary disease, exercise training

Date received: 7 June 2021; accepted: 8 September 2021

Introduction

Blood flow restricted exercise (BFRE) training is a novel exercise modality where low-intensity exercise is performed while restricting peripheral blood flow through use of resistive cuffs or straps. Benefits of this form of training have been reported to be similar to high-intensity exercise training for aerobic and muscle capacity in healthy adults and specific clinical populations.[1–3] In principle, peripheral blood flow is reduced, but not occluded, to upper or lower

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limb exercising muscles through the proximal application of an inflatable cuff (such as in sphygmomanometer cuffs where cuff pressure can be monitored and controlled) [4] or adjustable straps.[5] The mechanisms underlying beneficial BFRE training responses are not yet fully confirmed. It is hypothesised, during exercise, restriction of blood flow to exercising muscles results in local muscular hypoxia and increased metabolite load triggering physiological responses leading to increases in aerobic capacity[3] and muscle strength and hypertrophy.[2,6] This novel training modality has been suggested for use in people with chronic obstructive pulmonary disease (COPD),[7] but current evidence consists of a single case-study where BFRE training was experienced as part of a comprehensive pulmonary rehabilitation program.[8] However, exercise training is recommended as a core component of COPD management,[9] symptom burden can limit exercise performance of people with COPD.[10] As a low-intensity approach, BFRE training may be an option for people with COPD who have difficulty performing traditional moderate- to high-intensity exercise required to achieve physiological benefits.[7]

Whilst a potential exercise alternative, the safety of BFRE training in people with chronic conditions is unknown, with concerns regarding BFRE training effects on blood pressure[11] and vascular function.[12] Despite these concerns, the presence or absence of adverse events related to BFRE is rarely reported.[12] Given the small body of evidence on BFRE training in people with chronic conditions, on both potential benefits and risks, further research is needed to progress evaluation of this approach in people with COPD. For novel interventions, especially in this potential target population where there are no or few reports of BFRE training use, a pivotal initial step is seeking perspectives of key stakeholders to provide insight into issues or challenges that would need to be addressed before piloting the intervention.[13] Early engagement with potential end-users has been reported to result in increased acceptance and more effective interventions as their design, delivery and implementation take into consideration perspectives and needs of key stakeholders.[14]

This study aimed to explore BFRE training as a potential exercise training strategy for people with COPD from the perspectives of people with COPD and health professionals involved in the care of people with respiratory conditions. The objectives of this study were to identify and describe the perceived: a) positive aspects of BFRE training, b) barriers to BFRE training and c) concerns and challenges that need to be considered as a basis for planning pilot studies of BFRE training implementation for people with COPD.

Methods

This qualitative descriptive study was approved by the University of South Australia Human Research Ethics Committee (Protocol number 202325) and reported according to the Consolidated Criteria for Reporting Qualitative Research (COREQ) guidelines.[15]

The research team had no existing clinical or close professional relationships with the study participants. The research team comprised a) a registered physiotherapist with previous BFRE training research experience (EPN, PhD candidate); b) registered physiotherapists (SK, KJ and MTW) and an epidemiologist (TB), all with PhD qualifications and experienced in research but with minimal previous experience with BFRE training; and c) an accredited exercise physiologist (HL, PhD qualification) and a respiratory doctor (AF), each with no previous experience with BFRE training. Previous experience with qualitative research processes within the research team included education and training in interview/focus group design and delivery (MTW, KNJ and SK), data transcription and coding (MTW, KNJ, SK, HL and EPN) and descriptive, content and thematic analysis (MTW, KNJ, SK and HL).

A – theoretical framework

Constructivist learning theory proposes that people actively learn and build personal knowledge from past experiences within social contexts.[16] This personal knowledge contributes to beliefs and perceptions and influences ongoing learning.[17] We intentionally sought a variety of perspectives about BFRE training from people experienced at living with COPD or being involved in the care of people with chronic respiratory conditions. Both groups were likely to be have personal knowledge and direct experience of the importance of exercise in the management of chronic respiratory conditions but little direct experience with BFRE training.

A – participant recruitment

In this descriptive study, we planned to purposely recruit individuals with specific experience of exercise from the perspective of people living with COPD and with variable degrees of knowledge of BFRE training from professionals likely to be involved in COPD management.[16] Within our metropolitan area, BFRE training is more likely to be used in younger athletic populations and unlikely or common within the care of people living with chronic respiratory conditions. This sampling approach was used to facilitate a broad range of perspectives and experiences from both potential recipients and prescribers of BFRE training. People living with COPD were recruited from a pulmonary rehabilitation program at a local physiotherapy practice in Adelaide and were eligible for inclusion in this study if they were diagnosed with COPD and currently under the care of a medical practitioner. A study information sheet was provided to eligible participants by the physiotherapist

leading the pulmonary rehabilitation group. Written informed consent was obtained from participants prior to study commencement. Age and gender of participants was provided by the physiotherapy practice.

Health professionals were eligible for inclusion if they were registered with the national regulation bodies for each profession. Physiotherapists and exercise physiologists were invited via email based on a publicly available list of speakers within the Cardiorespiratory program of the 2019 Australian Physiotherapy Association Conference and by contact with the manager of a local exercise physiology practice, respectively. Respiratory nurses and doctors were invited via email communication through the respiratory trainees' journal club of a public metropolitan tertiary hospital. All health professionals were provided with a study information sheet. Health professionals indicating interest in participating in the study were provided a link to an electronic site which included a consent form, a 3-min video summarising key BFRE training aspects (Supplemental Material 1), a narrative review about potential of BFRE in COPD,[7] a survey to obtain demographic data and previous knowledge regarding BFRE training (Supplemental Material 2), and the proposed date for the focus group/interview.

A – data collection process

Face-to-face focus groups using semi-structured discussion guides were planned to collect data in each of the participant target groups. If participants were unable to attend a group, individual interviews (face-to-face or via videoconference) were used to overcome scheduling and geographical barriers.

Focus groups (minimum of four participants) were planned to have a duration of 60 min. One-on-one interviews were planned for 30 min. Sessions were structured in four sections, with minor differences in content and method of information delivery between sessions for people living with COPD and health professionals (Supplemental Material 3). The first three sections focused on information about BFRE training (Content of the information section is presented on Supplemental Materials 4 and 5) and were facilitated by EPN. The focus group discussion was facilitated by SK, KJ or MTW, and by EPN in the one-on-one sessions. Face-to-face sessions were conducted in a location convenient for participants (physiotherapy or exercise physiology practice, hospital journal club meeting). The research team and participants were the only individuals present during sessions.

The semi-structured guide (Supplemental Material 6) was developed based on the study objectives concerning positive aspects and barriers to BFRE, and concerns and challenges that would need to be addressed to plan a pilot study of BFRE training for people living with COPD. The guide was piloted with a physiotherapist (excluded from the final sample). Although no major changes were required for the main questions, further prompts for each question were added to the guide. For the interview and focus groups, the facilitator encouraged broad discussion and ensured participants had opportunities to discuss all topics. Specific questions and prompts were provided in the guide to encourage participants to openly express their opinions. Focus groups and interviews were audio-recorded.

A – data analysis process

Proportion of invitations and participants in the final sample was calculated for each participant target group. Demographic information for each of the participant groups was summarised descriptively. Data from focus groups and interviews were analysed using qualitative content analysis. The analytic framework comprised three a priori main categories for organising data regarding the perceived: a) positive aspects of BFRE training; b) barriers to BFRE training; and c) concerns and challenges that would need to be addressed to plan a pilot study of BFRE training for people with COPD. An inductive coding approach was used to categorise data, from verbatim transcripts, related to each of the three questions of interest[18] (Supplemental Material 7). We aimed to minimise interpretation and abstraction of the data and focus upon describing content specifically related to the three a priori categories of interest.[19] Transcription and initial coding for content of transcripts were undertaken by the lead researcher (EPN). For trustworthiness purposes,[20] a research team member (HL) who had no role in the conduct of focus groups or interviews participated in the coding process. Order of transcript coding was based on the timeline for conduct of focus groups and interviews: exercise physiologists, physiotherapists, respiratory nurses and doctors, and people with COPD.

Data analysis was conducted while data collection was ongoing. Participant quotes were used to illustrate the findings. Key findings were summarised and provided to participants (3 months after data collection). This summary report ensured that all participants were provided with the work product resulting from their participation and provided an opportunity for participants to provide feedback or commentary on perceptions of the validity of the key findings.

Results

Thirty-one people participated in this study from the 86 participants who were invited (36% overall response rate). Table 1 presents demographic data, participation rate and information regarding previous knowledge and use of BFRE training across all participant groups. Participation was higher in people with COPD (6 of 8 participants invited, 75%) and exercise physiologists (8/8, 100%), but lower in physiotherapists (8/44, 18%) and hospital-based respiratory

Table 1. Demographic information and prior knowledge and use of BFRE training.

		People with COPD *n* = 6	Exercise physiologists *n* = 8	Physiotherapists *n* = 8	Respiratory nurses and doctors *n* = 9	All participants *n* = 31
Age in years mean (SD.)		66 (4)	28 (3)	39 (3)	33 (3)	43 (3)
Gender n (%)	Male	2 (33)	7 (87)	3 (37)	6 (66)	18 (58)
	Female	4 (67)	1 (13)	5 (3)	3 (34)	13 (42)
Geographic region n (%)	SA	6 (100)	8 (100)	3 (37)	9 (100)	26 (84)
	NSW	0	0	2 (25)	0	2 (6)
	QLD	0	0	1 (13)	0	1 (3)
	VIC	0	0	2 (25)	0	2 (7)
Indicated prior knowledge of BFRE n (%)		0	7 (88)	5 (63)	0	12 (39)
Prior use of BFRE in clinical practice and/or research n (%)		N/A	0	0	0	0

N/A, Participants were not asked for this information.

nurses and doctors (9/27, 33%). Four focus groups and nine individual interviews were completed between October 2019 and February 2020. Timing of the sessions proceeded as planned, with group/interview discussions averaging 32 (focus groups) and 8 minutes (individual interviews). Three participants living with COPD stated that they would be willing to enrol in a potential pilot study or clinical trial involving BFRE training. Of the eight participants providing feedback or commentary on the summary report of key findings, all stated that the summary was consistent with their views and that no further amendment was required.

A – positive aspects of BFRE training

Four analytic categories were created for positive aspects of BFRE training (Table 2) – BFRE training was perceived (1) as a new, alternative exercise strategy, (2) to be effective at low intensities, (3) as simple and (4) to have existing protocols. Health professionals mentioned clarity, rigour and feasibility of the exercise protocols presented in the information sharing section of focus groups/interviews as positive aspects for the execution of BFRE training.

A – barriers of BFRE training

The possibility of adverse events and practical implementation were the two primary perceived barriers to BFRE training (Table 3).

Potential for BFRE training triggering severe adverse events related to underlying cardiovascular disease or comorbidities was a key concern raised by both people living with COPD and health professionals. Health professionals also expressed concern that less serious side-effects (e.g. delayed onset muscle soreness and discomfort) could negatively influence participants' willingness to perform BFRE training.

Barriers related to the practical implementation of BFRE training included resource requirements (personnel for supervision, time and monetary), lack of knowledge in health professionals and difficulty screening for comorbidities inherent to vascular conditions, which could pose a safety concern.

A – Concerns and challenges in planning a pilot study for BFRE training implementation for people living with COPD

Factors identified as important considerations when planning a pilot study for implementation of BFRE training in people with COPD related to four analytic categories (Table 4).

Amongst people with COPD, diverse perspectives were expressed on two issues; the need for support/clearance by their general practitioner and location of BFRE training. Perspectives of the need for medical review, and clearance prior to participating in BRE training, included (1) the need for a health check and discussing with their general practitioner prior to considering BFRE training, (2) individuals expressing sufficient confidence in understanding their condition to undertake BFRE training and (3) choosing a trustworthy clinician to deliver BFRE training, minimising the need for a general practitioner clearance. In terms of suitable settings to perform BFRE training, people living with COPD expressed preferences to either undertake BFRE training in a clinical setting as this environment would promote a feeling of safety or undertake a home-based program.

Health professionals identified the need for further training and knowledge on specific BFRE training aspects (i.e. using a handheld doppler), and the importance of experiencing BFRE training themselves before recommending it. In addition, health professionals considered that unresolved questions existed relating to the effects of BFRE training on health-related outcomes. Issues were raised regarding limited robust information on physiological effects of BFRE training and determining who BFRE training

Table 2. Positive aspects of blood flow restricted exercise training.

Analytic category	Sub-category	People with COPD	Health professionals			Illustrative verbatim quote
			EP	PT	RNP	
Effective exercise at low intensity enables…	..Similar or greater benefits as high intensity	✗	✗	✗	✗	***EP2:*** We can exercise a person at low load and get a great benefit
	..Quicker benefits than high intensity		✗	✗		***EP1:*** We can actually start to build some capacity quicker, earlier on
New alternative exercise strategy good for…	..Those who cannot perform traditional training or increase intensity		✗	✗	✗	***PT7:*** I see it as being a modality that may have application for the people who either we might somehow identify as being slow to respond or difficult to conduct a lot of training
	..Less joint stress		✗			***PT5:*** Yeah...and lighter loads on the beginning like you saying [sic], so there's less aggravation potentially of joint symptoms
	..For people with COPD	✗	✗	✗	✗	***C3:*** Well it's good because it's different than I would've expected
Simple technique…	To apply	✗				***C4:*** I guess that because it is quite non-invasive, it's a simple thing and if it has benefits I would do it I can say there's more upsides than downsides
	No extra clinician training needed		✗			***EP1:*** Yeah I don't think any extra training is needed...
Existing proposed protocols[17] ...	Are positively rigorous		✗	✗		***EP2:*** ..it's quite a technical thing…proficiency with equipment…I think that the rigour is an advantage
	Are clear		✗			***EP1:*** And there's no problem with the protocol. That's clear as day
	Are feasible on the time aspect		✗		✗	***RNP3:*** I guess time won't be a problem for a person with COPD go through this protocol

Cells with '✗' mean that the sub-category was identified in this group; EP, Exercise physiologist; PT, Physiotherapist; C, Person living with COPD; RNP, Respiratory nurse or doctor.

would be suitable for. Health professionals perceived that this could have implications for clinician willingness to provide clearance for individuals under their care to undertake BFRE training.

Discussion

This study explored perspectives of people living with COPD and health professionals about BFRE training as a potential exercise training strategy. Findings indicated that people with COPD and health professionals perceived BFRE training as an alternative exercise strategy with potential health benefits despite being performed at a low intensity. However, participants raised concerns and identified potential barriers to be addressed before planning future studies exploring BFRE in people with COPD.

Whilst the benefits of exercise training for people with COPD are well established,[9,21] the intensity required to achieve positive physiological adaptations may reduce adherence, particularly for those with a high symptom burden. Hellem et al. reported that people with COPD feel 'pushed too hard' (p 214) when exercise intensity was perceived as too high, reducing their self-confidence in their ability to perform exercise.[22] Blood flow restricted exercise offers an alternative low-intensity exercise strategy, which participants in the current study perceived to be a positive aspect that may help facilitate exercise adherence in people with COPD. Although it is unclear whether BFRE training offers further benefits or is appropriate for people with chronic conditions able to exercise at moderate or high intensity, this strategy might be useful for individuals who are too deconditioned to perform moderate-to-high traditional training or as a bridge to pulmonary rehabilitation. The use of BFRE training for people with respiratory conditions, at present, remains a theoretical possibility compared to other alternative low-intensity activity interventions such as neuromuscular electrical stimulation, singing, dancing and whole-body vibration, which are further along the evidence and clinical implementation pathway.[23,24]With our growing understanding of the importance of tailoring interventions to participant needs and preferences[23,24], broadening the options for people living with COPD may increase their exercise uptake and, in the case of BFRE training, may enhance the exercise stimulus to skeletal muscle and potentially overcome limitations to performing exercise.[23,24] However, with the growing understanding about the importance of tailoring

Table 3. Barriers to blood flow restricted exercise training.

Analytic category	Sub-category	People with COPD	Health professionals			Illustrative verbatim quote
			EP	PT	RNP	
Possible adverse events include…	…Increased risk of delayed onset muscle soreness		✗	✗		***EP1:*** …That we're creating a lot of DOMS [sic] after, which is often something that people are afraid about
	…Increased risk of fatigue			✗		***PT4:*** I would wonder whether the fatigue levels may be higher
	..Uncomfortable for the participant		✗	✗	✗	***RNP2:*** So, most of those [people with COPD] are elderly, as well. So, whether they can deal with that discomfort as well if...they're happy with that
	…Risk for people with cardiovascular disease and other comorbidities	✗		✗		***C2:*** The only thing is my aorta. I'm on the brink of a surgery because of my enlarged aorta. So, if you're putting pressure on my blood, not letting it flow then it could…that's my only concern
Implementation issues include the …	Need to be supervised by a clinician			✗		***PT3:*** … has to be closely supervised, it's not something people can do at home or anything
	Elevated time and financial burden		✗	✗	✗	***EP5:*** …Time to set up as well […] that could impact the amount of work actually done in the session
	Lack of knowledge by clinicians		✗	✗		***EP4:*** Applying the technique wrong..... I feel like you know, when you wrap the rubber band around your finger, like, I have my legs are feeling like that all the moment, you know […]
	Difficulties of screening comorbidities	✗		✗		***C1:*** The only downside …is if someone's got diagnosis of heart conditions or something of that nature, but they might not know about it so if they could hurt themselves or worsen their heart condition or…
	Elevated dropout rates			✗	✗	***PT6:*** We are also dealing with a group that their condition can deteriorate, so they might dropout because of this...

Cells with '✗' mean that the sub-category was identified in this group; DOMS, Delayed onset muscular soreness; EP, Exercise physiologist; PT, Physiotherapist; C, Person living with COPD; RNP, Respiratory nurse or doctor.

interventions to participants needs and preferences[23,24], broadening the options for people living with COPD may increase exercise uptake.

A systematic review of qualitative studies concluded that physical well-being issues experienced by people with COPD impacted on their sustained participation in an exercise program.[25] Although the low-intensity aspect of BFRE training might be an attraction for this form of training, discomfort and pain associated with BFRE training is reportedly up to two times higher than traditional exercise training.[26] Delayed onset muscle soreness is the most common adverse event reported by clinicians after BFRE training.[27] Health professionals participating in the current study identified that the risk of delayed onset muscle soreness and discomfort could discourage people with COPD from engaging in BFRE. It is possible that these factors may pose barriers to uptake and adherence to BFRE training in people with COPD.

Safety of BFRE training was a primary concern raised by participants, particularly related to risk associated with underlying cardiovascular disease, which is 2.4 times more prevalent in people with COPD than people without COPD.[28] It has been hypothesised that the metabolite accumulation caused by BFRE training may lead to increased sympathetic activity, vasoconstriction and clotting issues.[29] To minimise the risk of adverse events during or after BFRE training, participants should be effectively screened using established approaches prior to commencing a program.[4] This is in line with current guidelines for the management of COPD, which similarly recommend people with COPD undergo a thorough assessment including presence of comorbid conditions and specific health care needs, prior to commencing a structured exercise program.[7] In the absence of established screening protocols for BFRE or primary studies of BFRE training in people with COPD, screening assessments could potentially include tools to assess specific BFRE training risk factors, with greater focus on vascular function and cardiovascular comorbidities.

In our study, participants with COPD expressed a range of perspectives regarding the preferred location (i.e. clinic

Table 4. Concerns and challenges to plan a pilot study of BFRE training in people with COPD.

Analytic category	Sub-category	People with COPD	Health professionals			Illustrative verbatim quote
			EP	PT	RNP	
Actions before starting a BFRE program include…	Education and information	✗	✗			***C5:*** I want to... know how it works first
	Clinician training		✗	✗		***PT4:*** I think it would require a lot of education on behalf of health professionals
	Direct personal experience of BFRE	✗	✗			***EP1:*** You need to go through it yourself to know actually what that person is going to be experiencing
Unresolved clearance issues include…	Confidence in the clinician who will deliver the service	✗				***C5:*** It is important to have trust in the person who conducts it
	Need (or not) for clearance from general practitioner	✗				***C6:*** I wouldn't go to my doctor
						C1: I would listen to... doctors or physios …to say this is good or this is not good..take their advice
	Best location to undertake BFRE programs					***C4:*** I'd prefer doing that at home
						C5: A place where we could have medical support if anything happens
	Funding		✗			***EP7:*** Could it be a category …someone's got a cardiovascular risk factor they can get some rebate for
	Feasibility		✗			***PT5:*** I want to cover off on some of the simple feasibility things
	Dropout rates			✗	✗	***RNP5***: If these patients are doing your exercises, they remain in the programs, are there data that supports that?
Further clarity is required on…	Existing proposed protocols		✗	✗		***EP5:*** The guidelines they're quite broad
	General effectiveness		✗	✗		***EP1:*** It's good for someone to have bigger muscles, but does that enable them to perform their daily duties easier?
	Benefits to healthy individuals		✗	✗		***PT3:*** Healthy people do actually find it to be beneficial, or do they actually have concerns about it?
	Physiological mechanisms/ responses			✗	✗	***RNP2:*** How much of this is a systemic effect? And the mechanisms?
	Shortness of breath		✗	✗		***EP4:*** It might've been done .. how shortness of breath comes into that
Unresolved safety issues include…	Risk in participants with comorbidities		✗	✗		***PT5:*** Particularly for those who have peripheral vascular disease
	Criteria for patient screening			✗	✗	***RNP4:*** What needs to be screened, what are any clinical tests that are needed to be done
	Adverse events		✗	✗		***PT6:*** I think there'll be a lot of clinicians who will be wanting reassurance on safety

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or home-based environment) to perform BFRE training. There is currently no guidance around remote BFRE training delivery or the required supervision level in healthy or other clinical populations, possibly due to the small number of studies reporting home-based BFRE training.[30,31] Home-based exercise programs with low or no direct supervision have been demonstrated to be feasible in people with COPD, with benefits similar to traditional centre-based programs.[32] Interest in home-based programs is growing as result of the COVID-19 pandemic[33,34] and platforms such as Zoom and Microsoft Teams may allow clinicians to supervise clients remotely. Having a support person, instructions to cease exercise and seek help in case of breathlessness or fatigue beyond normal levels, chest pain or dizziness[34] and an adverse event plan in case of emergency during sessions, may reduce risk associated with remote exercise delivery.[33] Whilst these suggestions are useful, BFRE training presents a significantly different set

of issues and technical skills not covered by any guideline for remote exercise delivery and needs to be further explored for applicability in this setting.

Despite BFRE training being used since the 1970s,[4] we have been unable to identify studies or recommendations concerning specific education and training requirements for health professionals to be able to safely and efficiently prescribe BFRE training. Health professionals who prescribe BFRE training are commonly trained to prescribe and deliver exercise-based interventions (e.g. exercise physiologists and physiotherapists).[27] However, some aspects of BFRE training, such as using a handheld doppler for artery pulse assessment, may not be commonly covered by the standard training of these professions. Artery pulse assessment is used to determine cuff inflation pressure, essential for safe and effective BFRE training prescription and implementation.[4] The recommended approach to determining BFRE training cuff pressure is between 50 and 80% of limb occlusion pressure (LOP, the pressure of complete arterial occlusion and absence of arterial pulse). Excessive cuff pressures may trigger adverse events and discomfort,[11] while insufficient pressure may not elicit the desired physiological responses to promote benefits.[4] In a systematic review reporting approaches used to determining restriction pressure, 56% of studies used arbitrary non-individualised pressures while only 25% used the recommended LOP.[4,35] Lack of training of those delivering BFRE training may be one reason for this discrepancy. Further training for clinicians on artery pulse assessment will be pivotal for the correct prescription and implementation of this exercise mode.

B – implications for future BFRE training studies in people with COPD

Based on the findings of the study, the authors have formulated a series of 'start -up' questions (Table 5), which could be prioritised in studies of BFRE training as a potential exercise training approach for people COPD. For questions where minimal primary data are available (e.g. potential for home-based BFRE training and clinician training), a consensus-type approach (i.e. Delphi method) may be suitable to seek perspectives of experts in BFRE training and provide guidance for future trials in people with COPD.

B – strengths and limitations

We gained the perspectives of people with COPD and health professionals from diverse disciplinary groups, and to our knowledge, this is the first qualitative research involving stakeholder views about BFRE training in any population. No analytic category was shared completely across the four groups of participants, which highlights the importance of having a broad range of stakeholders providing different perspectives. However, physiotherapists were recruited nationally, other groups were recruited only from selected clinical facilities in Adelaide, South Australia. Thus, views may reflect local clinical practice and experiences and may not be generalisable to other countries. Data collected in interviews (with physiotherapists) may have the limitation of being more investigator-led, compared with peer-discussion facilitated in focus groups (all other participants). Due to scheduling and time commitments of participants, the majority of the focus groups were conducted with participants from a single targeted population (e.g. only exercise physiologists). This negated the possibility of inter-professional discussions and may have limited potential key information that could arise from the debate among health professionals from different groups. When deciding the content and depth of information provided to participants in the 'information sharing' section of interviews and focus groups, we worked on the principles of succinctness and clarity to present the definition of BFRE training, practical aspects and potential benefits and risks. As the majority of participants were unfamiliar with BFRE

Table 5. Suggested priorities for future blood flow restricted exercise training studies.

Recognised issues	Questions
Potential discomfort caused by BFRE	What is the level of discomfort and delayed onset muscle soreness caused by BFRE compared to traditional exercise training?
	Do discomfort and delayed onset muscle soreness caused by BFRE have an impact on adherence rates?
	Do the potential health-related benefits of BFRE outweigh the discomfort?
Screening of participants	What are the risks for people with cardiovascular disease?
	How can we safely screen for comorbidities and determine who is suitable to undertake BFRE?
	Which outcomes for cardiovascular risk should be assessed?
Home/Remote delivery of BFRE training	What level of supervision is required for home-based BFRE?
	What is required to safely and effectively deliver home-based BFRE?
Prescription of BFRE	How much extra training is required for clinicians to safely and effectively prescribe BFRE?
	Which is the best approach to determine restriction pressure for BFRE training?

BFRE, Blood flow restricted exercise; COPD, Chronic obstructive pulmonary disease.

training, it is likely that their views were impacted by the information presented. Although participants were provided with an opportunity to experience placement of partially inflated cuffs during information sessions, they did not undertake exercise with cuff inflated.

Conclusion

From the perspectives of stakeholders who participated in this study, BFRE training has potential as a novel, low intensity yet effective exercise training modality for people with COPD. Existing guidelines on remote exercise testing and training for people with COPD may provide guidance to minimise BFRE training risks, however, before implementing a BFRE training program for people with COPD, several concerns and barriers need to be addressed including how to safely screen patients, identifying risk of adverse events, level of supervision required, potential for home-based delivery and level of additional clinician training needed.

Acknowledgements

The authors would like to acknowledge the assistance provided by Associate Professor Saravana Kumar (SK) from the University of South Australia in conducting the discussion section of two of the focus groups performed during this study. The authors would also like to acknowledge the assistance from clinical and administrative staff at facilities where recruitment and data collection were conducted: Respiratory PhysiO_2, InForm and The Queen Elizabeth Hospital – all located in Adelaide, South Australia.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: EPN was supported by a University of South Australia and Australian Technology Network PhD scholarship funding. HL was supported by a Le Fonds de Recherche du Québec Santé Postdoctoral Training Fellowship.

Supplemental material

Supplemental material for this article is available online.

References

1. Centner C, Wiegel P, Gollhofer A, et al. Effects of blood flow restriction training on muscular strength and hypertrophy in older individuals: A systematic review and meta-analysis. *Sport Med* 2019; 49: 95–108.
2. Hughes L, Paton B, Rosenblatt B, et al. Blood flow restriction training in clinical musculoskeletal rehabilitation: a systematic review and meta-analysis. *Br J Sports Med* 2017; 51: 1003–1011.
3. Silva JCG, Pereira-Neto EA, Pfeiffer PAS, et al. Acute and chronic responses of aerobic exercise with blood flow restriction: A systematic review. *Front Physiol* 2019; 10: 1–16.
4. Patterson SD, Hughes L, Warmington S, et al. Blood flow restriction exercise: Considerations of methodology, application, and safety. *Front Physiol* 2019; 10: 1–15.
5. Abe T, Mouser JG, Dankel SJ, et al. A method to standardize the blood flow restriction pressure by an elastic cuff. *Scand J Med Sci Sport* 2019; 29: 329–335.
6. Lixandrão ME, Ugrinowitsch C, Berton R, et al. Magnitude of muscle strength and mass adaptations between high-load resistance training versus low-load resistance training associated with blood-flow restriction: A systematic review and meta-analysis. *Sport Med* 2018; 48: 361–378.
7. Thiebaud RS, Loenneke JP and Abe T. COPD and muscle loss: Is blood flow restriction a potential treatment? *J Trainology* 2014; 3: 1–5.
8. Kohlbrenner D, Aregger C, Osswald M, et al. Blood-flow restricted strength training combined with high-load strength and endurance training in pulmonary rehabilitation for COPD: a case report. *Phys Ther* 2021.
9. Global strategy for the diagnosis, management, and prevention of Chronic Obstructive Pulmonary Disease (GOLD) 2021 report. 2020.
10. Keating A, Lee A and Holland AE. What prevents people with chronic obstructive pulmonary disease from attending pulmonary rehabilitation? A systematic review. *Chron Respir Dis* 2011; 8: 89–99.
11. Domingos E and Polito MD. Blood pressure response between resistance exercise with and without blood flow restriction: A systematic review and meta-analysis. *Life Sci* 2018; 209: 122–131.
12. Pereira-Neto E, Lewthwaite H, Boyle T, et al. Effects of exercise training with blood flow restriction on vascular function in adults: A systematic review and meta-analysis. *Peer J* 2021; 9: 1–21.
13. Moore GF, Audrey S, Barker M, et al. Process evaluation of complex interventions: Medical research council guidance. *BMJ* 2015; 350: h1258.
14. Craig P, Dieppe P, Macintyre S, et al. Developing and evaluating complex interventions: Following considerable development in the field since 2006, MRC and NIHR have jointly commisioned and update of this guidance to be published in 2019. *Med Res Counc* 2019; 1–39.
15. Tong A, Sainsbury P and Craig J. Consolidated criteria for reporting qualitative research (COREQ): A 32-item checklist for interviews and focus groups. *Int J Qual Heal Care* 2007; 19: 349–357.

16. Rillo AG, Martínez-Carrillo BE, Castillo-Cardiel JA, et al. Constructivism: An interpretation from medical education. *IOSR J Res Method Educ* 2020; 10: 1–12.
17. Dennick R. Constructivism: Reflections on twenty five years teaching the constructivist approach in medical education. *Int J Med Educ* 2016; 7: 200–205.
18. Elo S and Kyngäs H. The qualitative content analysis process. *J Adv Nurs* 2008; 62: 107–115.
19. Su N. *Positivist Qualitative Methods*. SAGE Handb Qual Bus Manag Res Methods Hist Tradit, 2018, pp. 17–31.
20. Elo S, Kääriäinen M, Kanste O, et al. Qualitative content analysis: A focus on trustworthines. *SAGE Open* 2014; 4: 215824401452263.
21. Mccarthy B, Casey D, Devane D, et al. Pulmonary rehabilitation for chronic obstructive pulmonary disease. *Cochrane Database Syst Rev* 2015; 2015: 1–155.
22. Hellem E, Bruusgaard KA and Bergland A. Exercise maintenance: COPD patients' perception and perspectives on elements of success in sustaining long-term exercise. *Physiother Theor Pract* 2012; 28: 206–220.
23. Gloeckl R and Osadnik C. Alternative training strategies for patients with chronic respiratory disease. *Pulm Rehabil* 2021: 67–82.
24. McNamara RJ, Spencer L, Dale M, et al. Alternative exercise and breathing interventions in chronic obstructive pulmonary disease: A critical review. *EMJ Respir* 2018; 6: 117–127.
25. Robinson H, Williams V, Curtis F, et al. Facilitators and barriers to physical activity following pulmonary rehabilitation in COPD: A systematic review of qualitative studies. *Npj Prim Care Respir Med* 2018; 28: 1–12.
26. Hughes L, Paton B, Haddad F, et al. Comparison of the acute perceptual and blood pressure response to heavy load and light load blood flow restriction resistance exercise in anterior cruciate ligament reconstruction patients and non-injured populations. *Phys Ther Sport* 2018; 33: 54–61.
27. Patterson SD and Brandner CR. The role of blood flow restriction training for applied practitioners: A questionnaire-based survey. *J Sports Sci* 2017; 36: 123–130.
28. Chen W, Thomas J, Sadatsafavi M, et al. Risk of cardiovascular comorbidity in patients with chronic obstructive pulmonary disease: A systematic review and meta-analysis. *Lancet Respir Med* 2015; 3: 631–639.
29. Cristina-Oliveira M, Meireles K, Spranger MD, et al. Clinical safety of blood flow-restricted training?: A comprehensive review of altered muscle metaboreflex in cardiovascular disease during ischemic exercise. *Am J Physiol - Hear Circ Physiol* 2020; 318: H90–H109.
30. Kilgas MA, Lytle LLM, Drum SN, et al. Exercise with blood flow restriction to improve quadriceps function long after ACL reconstruction. *Int J Sports Med* 2019; 40: 650–656.
31. Kilgas MA, DenHerder AE, Lytle LLM, et al. Home-based exercise with blood flow restriction to improve quadriceps muscle and physical function after total knee arthroplasty: A case report. intergovernmental panel on climate change. *Phys Ther* 2019; 99: 1495–1500.
32. Mendes De Oliveira JC, Studart Leitão Filho FS, Malosa Sampaio LM, et al. Outpatient vs. home-based pulmonary rehabilitation in COPD: A randomized controlled trial. *Multidiscip Respir Med* 2010; 5: 401–408.
33. Dechman G, Aceron R, Beauchamp M, et al. Delivering pulmonary rehabilitation during the COVID-19 pandemic: A Canadian thoracic society position statement. *Can J Respir Crit Care Sleep Med* 2020; 4: 232–235.
34. Garvey C, Holland A and Corn J. ATS Statement: Pulmonary Rehabilitation Resources in a Complex and Rapidly Changing World, 2020.
35. Murray J, Bennett H, Boyle T, et al. Approaches to determining occlusion pressure for blood flow restricted exercise training: Systematic review. *J Sports Sci* 2020; 00: 1–10.