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NARRATIVE REVIEW

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Obesity management with blood flow restriction training: a scoping review

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Abstract
One of the biggest threats to global health that affects both individual health and global health is obesity. People have used traditional exercise programmes to deal with body fat for a long time but often have problems and limits. In the field of exercise science, blood flow restriction (BFR) training has gained popularity in the past few years. It could be a new way to deal with obesity. This review aims to examine previous research on the effectiveness of BFR training in treating obesity and provide an overview of the available data. Using particular search phrases associated with obesity, blood flow restriction training, and exercise interventions, several databases, including PubMed, ScienceDirect, and MEDLINE, were examined. Understanding these processes could lead to the creation of more effective treatments for people who are overweight. In the end, this review gives a full look at the current data about the role of BFR training in managing obesity. While initial findings are promising, more investigation is needed to prove the effectiveness, safety, and long-term effects of BFR training as a treatment to control obesity. The information learned from this review could help shape future research and help healthcare professionals plan exercise programmes for people who are overweight.

Keywords Anthropometric parameters, Blood flow restriction training, Body composition, Obesity and overweight

Introduction
Obesity is a complicated, multidimensional, and generally preventable illness [1]. The World Health Organization defines obesity as an abnormal or excessive fat accumulation that may be detrimental to an individual's health. Several anthropometric parameters are used to categorize individuals as normal, overweight, or obese. Individuals are considered obese if their body mass index (BMI) is greater than 30 kg/m^2 (Fig. 1) [2]. Moreover, type II diabetes mellitus, hypertension, dyslipidaemia, cancer, obstructive pulmonary disease, and mental health issues are among the many conditions that increase the risk of obesity [3, 4].

Currently, around one-third of people worldwide suffer from obesity and overweight [5, 6]. Obesity and overweight have been considered a global epidemic because they are spreading in many nations [7–13]. With a twofold increase since 1975, 39% of the world's population was considered overweight (BMI 25.9–29.9 kg/m^2) or obese (BMI > 29.9 kg/m^2) in 2014 [14]. Current projections indicate that by 2030, 57.8% of the world's population is expected to be overweight or obese [15]. Rising rates of overweight and obesity have been correlated with changes in the population and epidemiology in developing nations such as India, where there has been a decrease in mortality and fertility and an increase in the incidence of lifestyle-related illnesses [16–18].

Overall and central obesity have prevalence rates ranging from 16.9 to 36.3% and 11.8 to 31.3%, respectively, according to the 2015 ICMR-INDIAB research [19]. BMI is a common tool for assessing overall adiposity. Numerous studies have demonstrated that those with normal BMIs are less likely to die than those who are obese.

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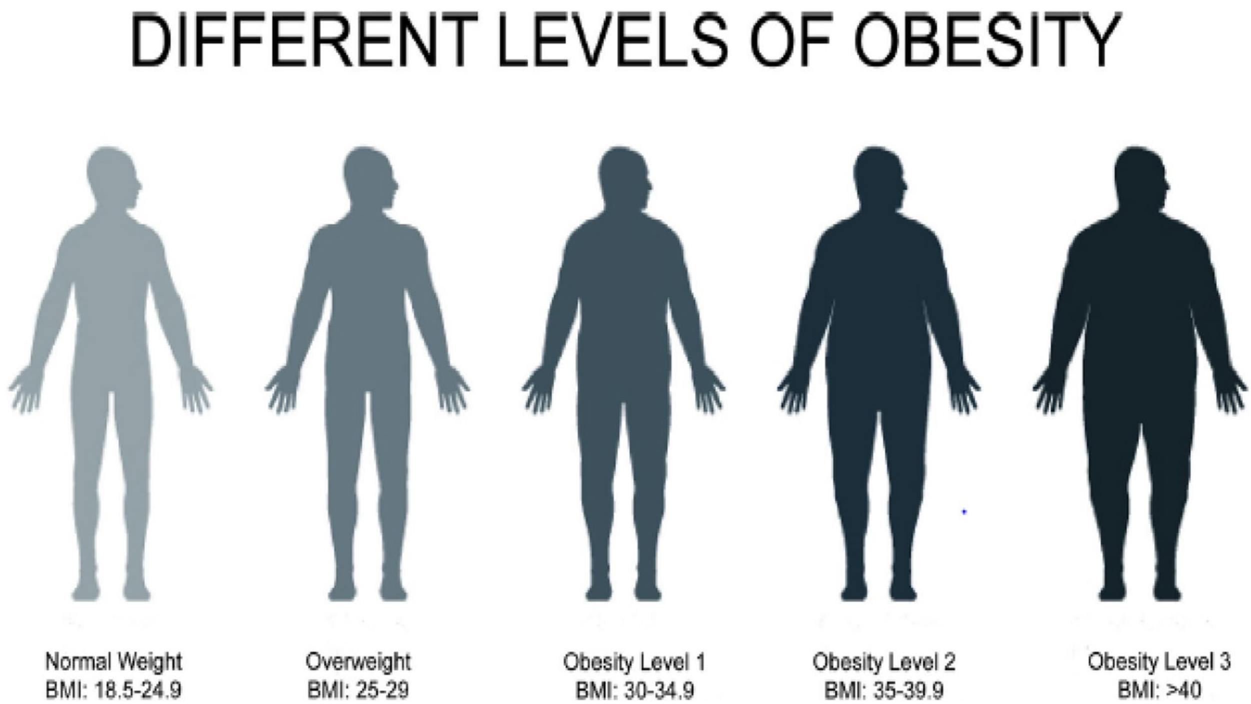

Fig. 1 Body mass index classification of patients as normal, overweight, or obese. Based on established diagnostic protocols, the patient meets the criteria for obesity [2]

However, particularly for those with a BMI < 30, BMI is unable to distinguish between lean mass and body fat or to accurately depict the distribution of body fat. A different condition known as normal-weight central obesity (NWCO) is used to describe the co-occurrence of having both a normal BMI and excessive visceral fat associated with this BMI constraint [20]. Waist circumference (WC) and waist-to-hip ratio (WHR) are the most widely used inexpensive anthropometric measures to determine central obesity. The World Health Organization (WHO), the International Diabetes Federation (IDF), and the Adult Treatment Panel III guidelines (ATP III) have distinct definitions; hence, their cutoff thresholds vary as well. The definitions of the cutoff values also differ based on gender. For instance, there are two commonly used cutoff definitions for CO in women (≥ 80 or ≥ 88 cm), while there are three cutoff definitions for men (≥ 90, ≥ 94, or ≥ 102 cm). Waist-to-height ratio (WHtR) is another CO anthropometric assessment. A cutoff value of ≥ 0·5 has been shown to be a straightforward and efficient noninvasive screening tool for cardiovascular risk factors and mortality [21].

According to estimates, across the world in 2010, obesity and overweight caused 34 million deaths, 4% of years lost to premature death, and 4% of disability-adjusted life years (DALYs) [5]. According to data from research conducted in the USA, the rise in obesity could eventually cause life expectancy to decline [22]. WHO member nations voluntarily decided to stop the obesity epidemic's rise by 2025 in response to widespread requests for continual monitoring of alterations in the prevalence of overweight and obesity across all demographic groups [23, 24]. Previous research on obesity trends show that, irrespective of geography, ethnicity, or socioeconomic status, the condition has become increasingly prevalent in adults and children of all ages [25]. All ages and genders are affected by obesity in high-income countries, although disadvantaged communities are disproportionately more likely to suffer from it. In low-income countries, middle-aged people from affluent urban backgrounds especially women are more likely to be obese [26].

Various treatment methods, including pharmacological, non-pharmacological, exercise, surgeries and behavioural therapies, have been opted in the past for obesity management. The purpose of this review is to give a summary of the literature on the use of blood flow restriction training (BFRT) as a potential weight-management technique. The study looked at how BFRT affected measurements of body composition, including waist circumference, body weight, body mass index (BMI), and lean and fat mass. It covered the possible advantages and drawbacks of BFRT in altering body composition in individuals with obesity.

Methodology and data synthesis

A scoping review was carried out, which involved formulating the research question, selecting and identifying pertinent studies, charting the data, and ultimately compiling, analysing, and reporting the results. Selecting papers by looking at their titles and abstracts was the primary search strategy. This review adhered to the Preferred Reporting Items of Systematic Reviews and Meta-Analyses (PRISMA).

Data sources and search strategy

Using PubMed, MEDLINE, ScienceDirect, and Google Scholar, three investigators separately searched the literature for a variety of research pertaining to keywords (("Blood Flow Restriction Therapy OR Kaatsu training OR Blood flow occlusion therapy" OR blood flow restriction OR restricted blood flow [Mesh]) AND "Obesity"[Mesh]) AND "Obesity Management"[Mesh]. The data used in these searches was from the years 2004 to 2024. The Boolean operator AND was used to join concepts, and OR was used to combine the search phrases inside each idea. When necessary, phrase and truncated symbols were used in the keyword search to provide accurate and thorough results. We also looked through the corresponding author's own libraries and sources of grey literature, such as conference proceedings.

Study selection and screening

Each study title and abstract was reviewed for eligibility by all authors following the initial literature searches. The entire texts of all possibly pertinent research and other than English-language papers were later collected and subjected to additional scrutiny. As limited literature is available on blood flow restriction training, hence attempt to include and translate papers of other languages was done. Duplicate papers were removed by corresponding author, and studies that were irrelevant were ignored. Figure 2 displays the PRISMA flow diagram for the search strategy results of this review.

Inclusion and exclusion criteria

Studies including individuals (18 years and older) with a diagnosis of obesity (BMI $\geq$ 25 kg/m^2), regardless of gender or ethnicity, including those with central or visceral obesity, were included in this scoping review. The studies must had evaluate the benefits of using blood flow restriction (BFR) training either alone or in conjunction with other types of exercise, such as resistance or aerobic training, as a primary or supplemental intervention for managing obesity. Research included contrasting conventional obesity management instruction with and without blood flow restriction. Studies published in peer-reviewed journals during the 20 years that are randomized controlled trials (RCTs), cohort studies, case–control studies, cross-sectional studies, reviews, and meta-analyses were all eligible. The review had concentrate on outcomes including changes in body composition, weight loss, and fat reduction. Articles relating to blood flow restriction training, obesity, physical therapy, rehabilitation, occlusion therapy, and KAATSU had meet the full-read inclusion criteria.

Research with underweight or normal-weight participants and research concentrating on children and systemic review were among the exclusion criteria. Animal studies and studies that solely evaluate non-BFR therapies were excluded. Studies that do not provide quantitative data or that do not provide direct outcomes related to managing obesity were disqualified, as will those that were published prior to 2004.

Findings

A total of 550 papers were identified before 281 duplicates were discarded. In screening, 269 articles were remained. In total, a further 76 papers were included after screening of full text, and 36 papers were further excluded after screening for methodology. Further papers were identified by hand searching; therefore, in total, 12 papers were included in this scoping review.

Overview of exercise and its impact on obesity

Increased prevalence of obesity in all ages, ethnicity, gender, and socioeconomic status poses many risks for comorbid diseases. Obesity increases the individual likelihood for cancer, heart attack, metabolic illness, and additional cardiovascular disorders. Therefore, it is important to lower the prevalence of obesity and its incidence [27–29]. One such way to deal with it is to maintain a healthy weight through modulation of energy expenditure, such as physical activity. Anaerobic and aerobic exercise are recommended in the most recent guidelines published by the American College of Sports Medicine (ACSM). Exercises that involve high oxygen consumption, such as running, cycling, rowing, and other aerobic activities, allow muscles to meet their energy needs without the need for extra energy sources. Anaerobic exercise, on the other hand, uses less oxygen to meet the energy demands made on the muscles. This is why it is often referred to as resistance training or weightlifting. The muscles must therefore break down extra energy sources, including carbohydrates, in order to produce lactic acid and energy [30].

The Obesity Medical Association (OMA), The Obesity Society (TOS), and the American College of Sports Medicine (ACSM) are among the organizations that provide exercise guidelines that are medically approved and can be used to prescribe exercise for obese individuals.

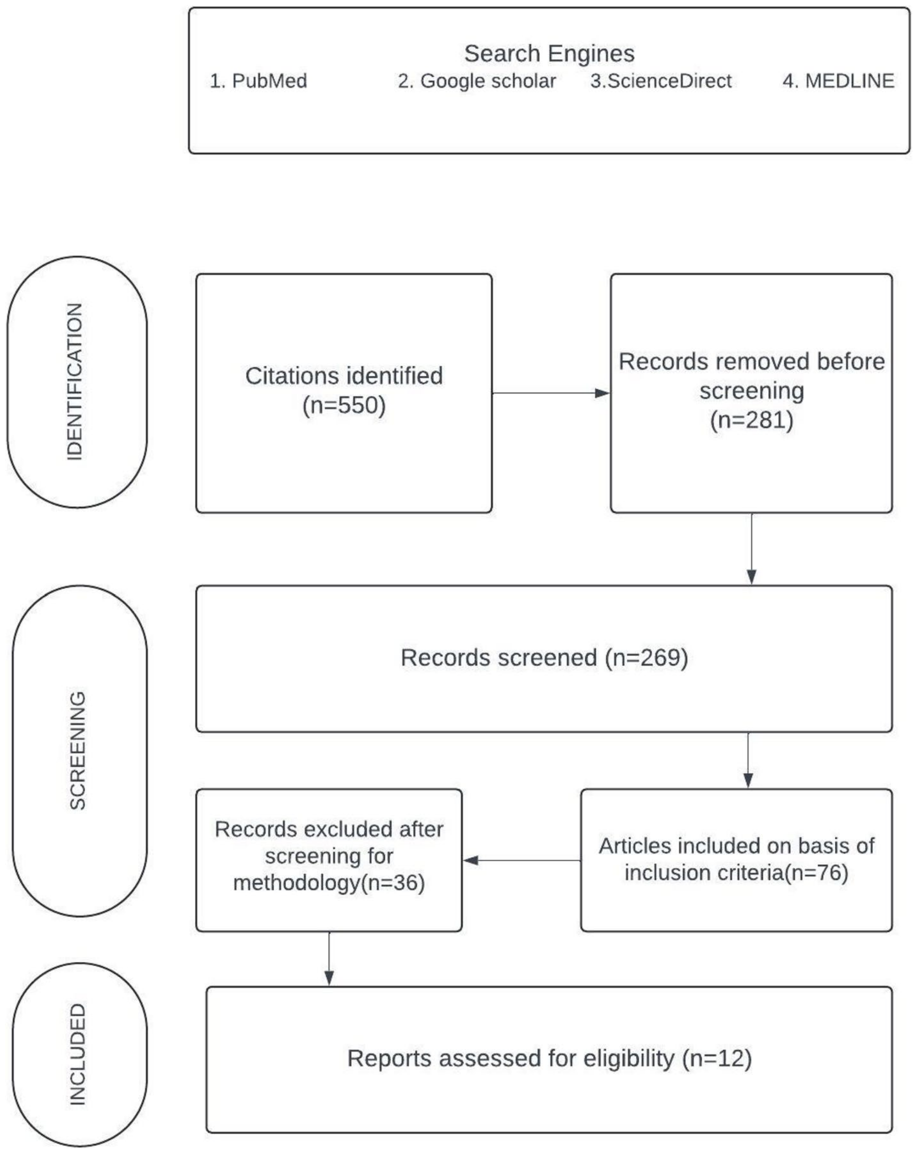

Fig. 2 PRISMA flow chart

This section contains the general recommendations for overweight individuals. To optimize patient safety, medical history and physical examination of patient are used to determine whether they have any concomitant illnesses [13]. The Health/Fitness Facility Preparticipation Screening Questionnaire and the Physical Activity Readiness Questionnaire (PAR-Q+) are two such applications [31]. A weekly 150–300 min of moderate exercise or 75–150 min of vigorous physical activity are needed to maintain weight loss, accelerate calorie loss, and enhance wellbeing [14]. Moderate-to-intense physical exercise for 200–300 min a week is advised for those who wish to lose weight in order to support long-term weight loss [32].

It is possible to alter our energy balance via exercising, which is the most significant daily energy expenditure that one can choose to perform. Several long-term studies have demonstrated this to be accurate. For instance, it has been discovered that regularly engaging in high levels of physical exercise greatly lowers the risk of weight gain, especially for women. In that study, those who engaged in physical activity for the majority of the time acquired less weight than those who did not [33]. During a 6-week structured physical exercise programme in obese African Americans, exercise not only causes changes in weight reduction but also boosts significantly male body esteem, self-efficacy, and motivation when comparing post-intervention scores to pre-intervention scores [34]. The hypoxic Pilates exercise training group enhances the hemorheological and vascular functions of 32 obese Korean ladies as compared to the normoxic Pilates training group. The normoxic and control groups were compared to the hypoxic Pilates training group. Significant enhancements were also noted in the hypoxic Pilates training groups in outcome measures of diastolic blood pressure, total cholesterol and triglyceride levels, flow-mediated dilation, and erythrocyte deformability and aggregation (all $p < 0.05$) [35]. When exercise is employed as a technique to manage obesity, it offers benefits beyond only reducing fat mass (Fig. 3). Numerous studies have linked increased fitness to better clinical outcomes, such as a lower risk of inflammation, metabolic disease, cardiovascular disease, Alzheimer's disease, and many other disease states [36].

Traditional obesity management techniques

Dietary intervention, lifestyle intervention, pharmacological treatment, and surgery are among the treatments options for obesity, according to the American Obesity Society's management guidelines. There is an urgent need for a healthier, more straightforward, and more lasting treatment due to various unfavourable circumstances, such as low patient compliance, numerous adverse effects, and easy rebound [39–41].

Comprehending the biology underpinning food intake and weight management is crucial for creating effective weight loss regimens (Fig. 4). Changing food intake to influence obesity outcomes has been an essential component of obesity management for thousands of years. Reducing energy consumption is an essential element of weight loss and obesity prevention therapies. As suggested by dietary guidelines and the majority of scientific organizations, dietitians and other healthcare practitioners should treat obesity using energy-restricted diets as a primary measure. The golden rule, according to which a 500 cal daily energy reduction corresponds to a weekly weight loss of roughly 0.5 kg and a monthly weight loss of roughly 2 kg, is commonly followed by these diets [42]. This can be accomplished in several ways, such as managing portion sizes, cutting back on carbs, total fat, and saturated fat, and consuming more fruits and vegetables to provide protein and fibre. All of these approaches lead to an increase in dietary satiation and a decrease in total dietary energy density [43].

Time-restricted eating (TRE), a different dietary strategy, assisted overweight older men and women in losing weight and belly fat in just 6 weeks. Following 6 weeks of TRE, significant weight loss was experienced by both the gender (1.8 kg for men and 1.3 kg for women; $p = 0.03$). Men's visceral fat mass (0.54 l; p 0.001) and waist measures (2.9 cm; $p < 0.015$) both showed substantial declines. A total of 99% of women and 98% of men were able to adhere to the time-restricted eating (16/8) diet as it is popular, secure, and easy for older adults. This shows that eating this way may help older, overweight women in losing weight and may even improve the body composition of older, overweight men [45].

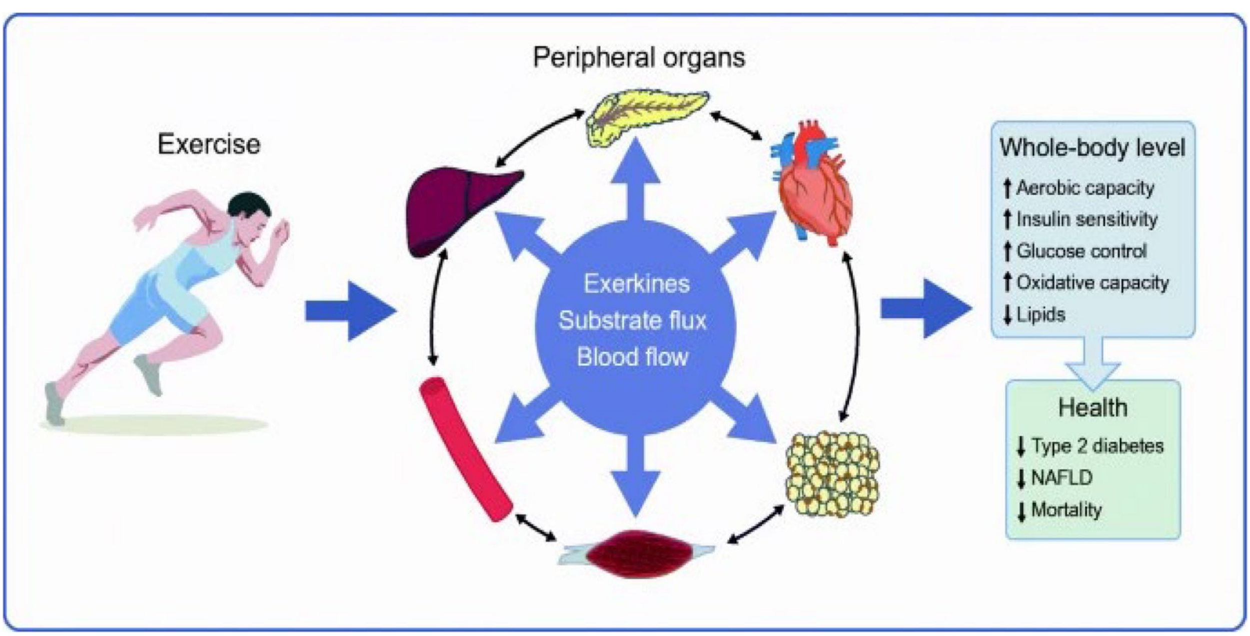

Fig. 3 Effect of exercise of obesity [37, 38]

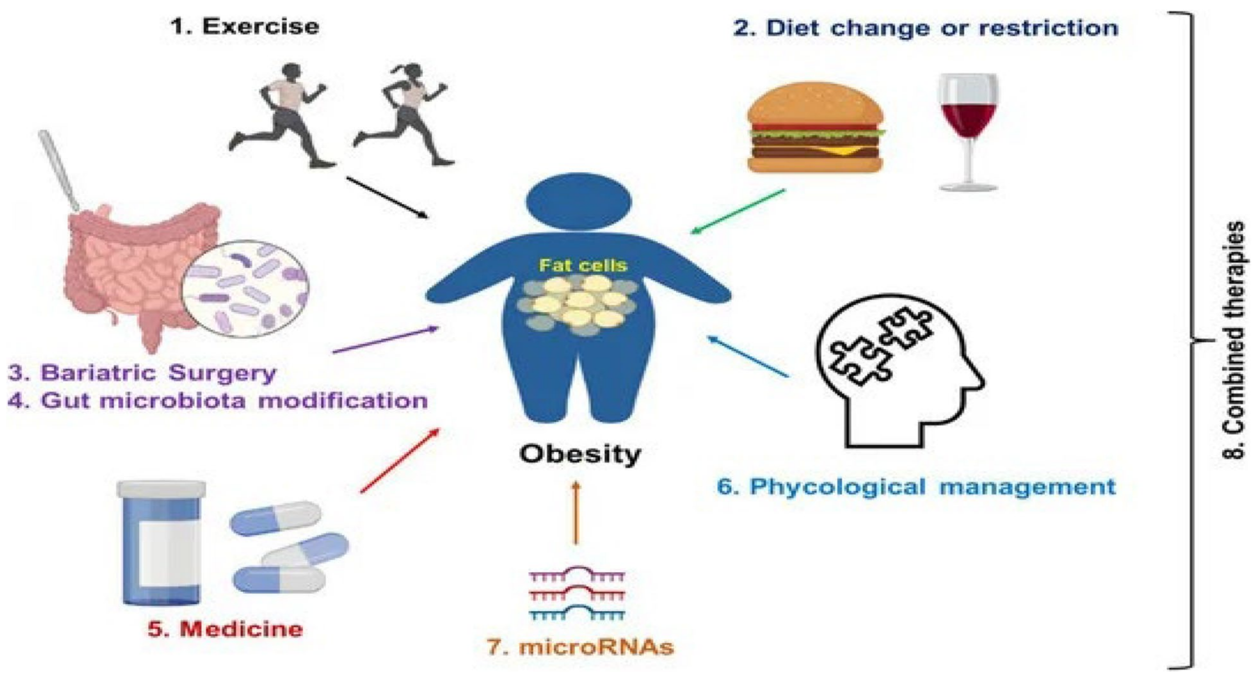

Fig. 4 Strategies for obesity treatment [44]

Apart from dietary managements, yoga is also among top trends in obese population according to latest regional [46] and global researches [47]. Furthermore, an increasing amount of evidence indicates that yoga may help with chronic pain, cardiovascular risk factors, physical fitness, body composition, and mental wellbeing benefiting a number of populations, including the obese. Enhancing muscle power appears to be possible [48], and this is crucial for enhancing a variety of anthropometric and body composition metrics in overweight and obese inactive people. Yoga-based practice primarily integrates exercises with body's weight into a full-body, resistance-based floor workout [49]. According to reports, yoga can fulfil or exceed the guidelines for moderate-intense exercise (3.0–5.9 metabolic equivalents (METs)) at a variety of tempos, providing an alternate, low-impact exercise option for those who are obese and overweight people who have never exercised before and have low levels of fitness for their musculoskeletal system and cardiorespiratory system [50]. In contrast to previously reported levels, healthy young people who had been practising yoga for at least a year, a 56-min hatha yoga session, decreased reactivity to exercise stress (49.4% MHR, rating of perceived exertion 12–13) and energy expenditure (3.2 kcal/min, 2.5 METs) [51]. The metabolic demands of yoga are generally comparable to those of adult leisure aerobic exercise, like walking quickly at a self-determined pace [52]. It is also clear that each yoga style may be characterized by distinct requirements for metabolism based on its emphasis on the aforementioned activities, given that the normal yoga practice incorporates three basic categories of activities: stasis physical posture, breathing exercises, and meditation. As a result of regular exercise sessions and increased metabolic efficiency, yoga practice may have a positive impact on some anthropometric measures and body composition indices in obese people. Although there is little evidence exists to back up the claim that yoga interventions alone can reduce energy expenditure, yoga practice may assist lower energy consumption and enhance eating behaviours [53].

Several medications have been created expressly to help people lose weight; some of these have been approved for sale in the recent 5 years, while others are still in the research and development stage [54]. A few well-known examples are topiramate, an antiepileptic drug also used to prevent migraines, roflumilast, bupropion, and fluoxetine, drugs used to treat depression. Of course, not every obese patient requires medication to help them lose weight. The pillars of any antiobesity programme should always be behaviour change, food, and exercise [55]. With that strategy, however, many affected people fail to lose weight or fail to keep it off. There is consensus that individuals with BMI more than 27 kg/m^2 and weight-related conditions are tend to be suitable for antiobesity treatment if lifestyle changes do not improve after 6 months of therapy [55].

Bariatric surgery and nonsurgical therapies are available as treatment options for extremely obese population.

The conservative techniques typically consist of a multifaceted approach that frequently fails, including behavioural counseling, dietary advice, increased physical activity, and pharmaceutical treatments. Compared to conservative techniques, bariatric surgery has greater rates of remission for type II diabetes mellitus and metabolic syndrome and provides a permanent, secure, and efficient means of weight loss [56]. Bariatric surgery has demonstrated preventive effects against disorders linked to obesity due to significant weight loss and physiological changes, when compared to non-surgical and drug therapy [57]. According to a recent meta-analysis, there was a correlation between the development of dyslipidaemia, hypertension, and type II diabetes mellitus and relative risk reductions of 61%, 64%, and 77%, respectively. However, the study sample size was insufficient, and all of the studies that were included in the meta-analysis were conducted in advanced nations [58].

The most important thing in managing obesity is to produce an imbalance in energy and maintaining it to achieve an appropriate weight. Maintaining a lower weight is essential for individuals, especially if they live in an environment where high-calorie foods are readily available [59]. It has been hypothesized that these people have particular cognitive processes operating in them that aid in their long-term adherence to lifestyle adjustment [60]. Initially, behavioural therapy for obesity was founded on learning theory, or behaviourism, and the notion that patients could alter their exercise and eating routines in order to attain and maintain a normal weight by learning about and recognizing environmental cues and the consequences of their food consumption. Following this, the therapy was supplemented by applying the theory of social cognition (such as goal setting, role-playing, and self-efficacy), fundamental cognitive methods (such as problem-solving and cognitive restructuring), and particular dietary and exercise recommendations [61]. The average rate of dropping out is approximately 20%. Following behaviour therapy after a year, about 25% of patients were able to successfully reduce and keep off 5–10% of their body weight [62].

Lifestyle changes are the most important part of the first line of defence against fat [63]. Many treatment methods recommend that people who are overweight or obese should change their lifestyle as the main part of their treatment [64]. Similar recommendations regarding how to assist people in changing their lifestyles have been made by a number of expert panels, including Centers for Medicare and Medicaid Services (2011), the Guidelines (2013) for Managing Overweight and Obesity in Adults, and the USPSTF (2018), which will henceforth be referred to as the Obesity Guidelines [65]. The Obesity Guidelines say that people who want to change their lifestyles should have at least 14 one-on-one or group lessons during the first 6 months. A randomized controlled study (RCT) showed that frequent contact is important for weight loss that is clinically significant [66]. Programmes aimed at changing one's lifestyle include 150–180 min a week of aerobic activity that is moderately strenuous, such as brisk walking or cycling. Regular aerobic exercise has been linked by researchers to numerous health benefits, such as better physical and mental health (including lowered blood pressure, anxiety, and depressive symptoms) [67]. Physical activity is also linked to improved well-being, and this may mitigate the risk of death that comes with being overweight. People who feel lack the time to work out are told to do short bursts of activities for instance, 10 min during the day and to be more active in other ways, like taking the stairs instead of the lift. Recently, standing desks with treadmills have become more popular, which could be a handy way to burn more calories every day. Another important thing to think about if you want to be more active (and lose weight) is to spend less time in front of the TV and doing other idle things.

More recently, there have been initiatives to enhance weight loss via digital distribution, and improvements have been made to make users more interested. One way this has been done is by making the digital programme more participatory. Researchers looked at how well a 12-week online programme that used engaging lessons instead of the usual static materials worked. Videos, quizzes, and hands-on tasks were added to the lessons to make them better [68]. The programme also gave the participants tools for autonomous weekly feedback and self-monitoring based on the data they entered. Even though they had also heard about the advantages of reducing weight, after 6 months, the control group's participants had lost only 1.3 kg, whereas the intervention group had lost 5.4 kg. Other ways to make people connect more include putting lifestyle programmes on social media sites, using virtual reality, and making online games. The BMI of overweight or obese children was found to be significantly impacted by the proactive intervention of using video games, according to a randomized controlled experiment carried out in Australia [69]. Parental encouragement of gaming rather than discussion of their children may prove more successful because the intervention under evaluation in this study was a single-component strategy that was inexpensive (active video games are priced similarly to conventional video games) and easy to implement.

As part of a new approach to treating obesity, endoscopic and radiological bariatric devices and methods have been created. These are less invasive, easier to use, and possibly reversible. Aspiration therapy (AT) is done with the AspireAssist device, which has a large-bore percutaneous gastrostomy tube, a skin port, and a drainage system that can be attached and controlled by remote. Under anaesthesia, the gastrostomy tube is inserted endoscopically, just like a percutaneous endoscopic gastrostomy, but it works in the opposite way. After a meal, around 30% of the stomach's contents can be evacuated when the drainage system is connected to the gastrostomy tube via a skin port. Twenty minutes after eating, aspiration is performed by flushing water into the stomach and depending on the positive pressure inside to push liquid filled with food out through the gastrostomy tube. Two-hundred seven participants participated in the experimental study of this device. Out of those, 137 received lifestyle counseling in addition to AspireAssist, whereas 70 individuals in the control group alone received lifestyle counseling. A modified intention-to-treat research conducted after 1-year follow-up revealed that the AspireAssist group experienced a 12% reduction in body weight, while the control group only saw a 3.5% reduction [70].

Overview of BFRT and its impact on obesity

Despite the proliferation of programmes and regulations aimed at preventing obesity and reversing this prevalent condition, many people still struggle with weight loss and weight control. Training with blood flow restriction is one such method to combat an increase in fat (Fig. 5). It has been demonstrated that blood flow restriction (BFR) training increases cardiorespiratory fitness at slower velocities (2–4 mph) and shorter session durations (15–20 min) in comparison to the suggested duration of regular exercise [71].

Adults who are obese can reduce their body weight with moderate-intensity aerobic exercise. Resistance training at a moderate level can help adults lose weight while maintaining their lean body mass [73]. But for people who have high body weight or are obese, are older, or do not have much training experience, they may get a injured while doing high-intensity aerobic or strength training. This is because their joints won't be able to handle the high mechanical pressure that comes with high-resistance training. For instance, the symptoms of muscular injury during vigorous exercise can be greatly impacted by a high BMI and percentage of body fat [74]. Additionally, vigorous cycling, swimming, and running can cause damage to an athlete's muscles [75]. Knee injuries which have a high prevalence among sportsperson can be healed, and the musculoskeletal system can be repair with blood flow restriction training [76].

Blood flow restriction training (BFRT) is an intervention that involves cuffing a muscle to stop blood flow, along with strength or aerobic training. Only the upper and lower limbs can be treated with BFRT [77]. In this, the arterial blood flow into working muscles is partly limited, and the venous blood flow out of working muscles is completely limited [78]. By obstructing the blood vessels around the muscle, Dr. Sato of Japan was the first to exercise with less blood supply to the muscle. This was referred to as "training with added pressure" or "KAATSU training." KAATSU training is now practised worldwide. It is more commonly known as "BFR training," and it is done with pneumatic tourniquet system.

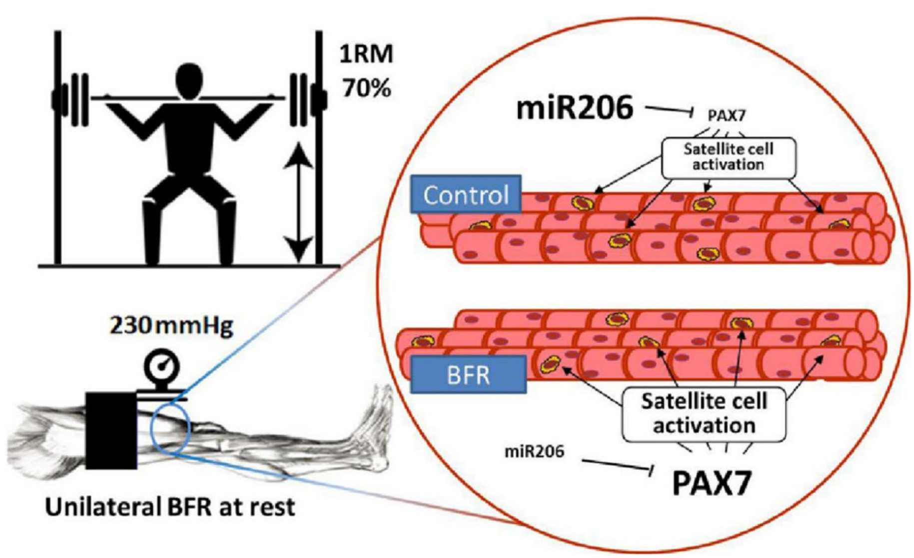

Fig. 5 Overview of blood flow restriction training [72]

Using a tourniquet cuff, with pressure applied to the proximal region of the upper and/or lower extremities to establish required BFR for the muscle. The vasculature beneath the cuff gradually compresses when the cuff is inflated mechanically. This partly restricts arterial blood flow to regions far from the cuff, but it also has greater impact on venous outflow from beneath the cuff, which also diminish venous return. There is insufficient oxygen in the muscle tissue when the blood vessels close to the skeletal muscle are compressed [79]. Also, because the veins are not getting enough blood, blood pools in the vessels of the limbs that are blocked. Also, when muscle movements are done under BFR conditions, the intramuscular pressure under the cuff level up further [80], which further disrupts blood flow.

Although there are many theories on the mechanism of action of BFRT, the current consensus is that muscle growth and strength are enhanced by the interaction of physiological stress from vascular obstruction and mechanical tension from resistance exercise [81]. Cellular processes include metabolites, hormone changes, cell-to-cell communication, cell enlargement, and intracellular signaling pathways [82]. The comparatively low oxygen levels and blood flow in BFR promote metabolites such as lactic acid, which build up during exercise and are known to promote muscle growth. BFR with low loads recruits the same number of motor units as resistance training with high loads [83]. Additionally, under BFR conditions, type II muscle fibres which are only active at higher intensities are activated at lower intensity. This explains why low-load BFR leads to more muscle growth than low-load exercise alone [84].

However, increased motor unit activation occurs in muscles closer to the site of occlusion as well. More proximal muscle groups (rotator cuff, pectoralis major, and gluteus maximus) have been demonstrated to recruit more than controls in both upper- and lower-limb BFR [85]. This is believed to occur as a result of the rapid exhaustion of synchronous muscle groups far from the site of occlusion. This has a major impact on the use of BFR after surgery or accident where a tourniquet cannot be administered proximally.

Even though injuries from this type of exercise are rare, there is a chance that it could cause problems like subcutaneous bleeding and numbness [86]. It has been suggested that optimum BFR pressure may be linked with hormesis [87]. If the amount of restrictive pressure is too low, it is possible that muscle reactions won't change much. Furthermore, it is possible that moderate pressures will not aid in muscle growth, and that really high pressures—those that obstruct blood flow to the arteries during rest and/or activity in between sets—might possibly be harmful, especially for those with impaired vascular function. In general, BFRT trainers and instructors are certified as KAATSU practitioners.

It is important to have a good screening process that includes a healthcare professional to protect against certain bad effects that might come from this exercise. The goal of a screening is to get rid of potential people who may be more likely to get hurt because of their risk factors. Another goal is to find the things that will make it less likely that structures that might be overloaded will break.

Numerous investigations have been carried out to assess the effectiveness of BFRT on various obesity-related indicators. Tables 1 and 2 show the summary of all the studies included in the review. The literature was arranged and displayed according to the author ID, study duration, study design, sample size, methods used, outcome measurements, results, and year of publication.

BFRT is often done along with other exercises because it has a number of benefits that cannot be found in other ways of exercise training. Muscle growth is improved with BFRT as it promotes muscle development (muscle growth) with less weight. Cutting off blood flow to the muscles creates a low-oxygen situation that causes metabolic stress and encourages the recruitment of hypertrophy muscle fibres. This means that combining BFRT with exercises like resistance training, muscle mass can be gained even with lighter weights. When combined with exercises like weightlifting, BFRT also helps in improving muscle power. Fast-twitch muscle fibres are more activated when blood flow is interrupted, which increases the amount of effort required by the muscles. BFRT offers same benefits as high-intensity training with less weight and shorter workout sessions. This can be especially helpful for people who have limited time for training or who are healing from an illness. By blending BFRT with other exercises, one can get the most out of their workouts in less time while getting the most out of them.

BFRT has been shown to work well in rehabilitation settings, especially for people who have been injured or are recovering from surgery. Using lighter weights during workouts, BFRT puts less stress on joints and tendons while helping muscles grow and strengthen. Because of this, it is a useful tool for getting better in short span and avoiding more injuries. It is crucial to keep in mind that BFRT should only be carried out under the guidance of a qualified expert due to a number of regulations and safety considerations.

Discussion

To the best of our knowledge, this is the first review that evaluated the effects of established obesity management techniques with those of blood flow restriction training (BFRT) on obesity. Blood flow restriction training

Table 1 Summary of the included studies

Author's ID	Study duration	Study design	Sample size	Methods used	Dependent variable	Results
Yong Chen (2021) [39] Prospective experiment Mean ± SD, 95% CI	12 weeks	Randomized controlled trial	Thirty-seven obese male college students	For a period of 12 weeks, the exp. Grp and control Grp each performed 40% VO2max cycling while combining BFRT exercises. The CG performed 40% VO2max cycling without BFRT twice a week	Waist circumference (WC), cm Body mass index (BMI), kg/m^2 % body fat (BF), % Total cholesterol (TC), mmol/L	Combining BFRT with cycling at 40% VO2max enhances blood lipid profile and body composition
Xianyou Cui (2024) [88]	1 week	Experiment design	Fourteen obese college students	Blood analysis for lipolytic agents and metabolomics	Lipolytic hormones: GH and IL-6 levels Untargeted metabolomics results after exercise	BFRT showed superior lipid-lowering effects compared to control group
Yanhong Su (2024) [89]	12 weeks	Randomized controlled trial	Twenty-six male obese college students	Blood flow restriction combined with low-intensity resistance training Random	Body composition index, muscle mass, neuromuscular activation, muscle strength, endurance, glucolipid metabolism, cardiac autonomic regulation	Improved body composition, muscle mass, strength, endurance, and cardiac regulation Reduced body fat percentage, waist-to-hip ratio, blood pressure, and low-density lipoprotein
Soontaraporn Huntula (2023) [90]	6 weeks	Randomized trial	Thirty overweight participants	Individuals engaged in resistance training at 40% of their one-repetition maximum (1RM) while maintaining 60% of arterial occlusion pressure (AOP). In contrast, a group engaged in typical resistance exercise at 70% of their 1RM	Muscle mass Muscle strength	Significant increase in muscle mass after 6 weeks Arm and leg circumference also increased notably
Vernon Bond (2017) [91]	3 weeks	Pilot study	Nine normotensive, overweight, young adult African-Americans participated	Unilateral training of quadriceps' femoris muscles with partially restricted blood flow Training at 30% of one-repetition maximum load for 3 weeks	One-repetition maximum (1RM) load increase Post-occlusion blood flow measurements	Increased muscle strength with restricted blood flow exercise Decreased vascular autoregulation and endothelial function with training

Table 2 Summary of the included studies

Author's ID	Study design	Sample size	Methods used	Dependent variable	Results
Murat Karabulut and Sonio D. Garcia (2017) [92]	Within-subject study design	34	Cycling sessions with blood flow restriction cuffs applied	Heart rate (HR) Systolic blood pressure (SBP) Diastolic blood pressure (DBP) Rating of perceived exertion (RPE) Respiratory exchange ratio (RER) Energy expenditure (EE)	Significant interactions for HR, SBP, RPE, and RER observed BFR increased exercise intensity, while perceived effort remained light
Murat Karabulut (2014) [93]	Randomized within-subjects study design	Twenty young males	Isotonic knee extension exercises with varying initial restrictive pressures Biodex System 4 Pro for strength assessment pre and postexercise	Tissue oxygenation and blood lactate levels Leg strength pre- and postexercise	Higher initial restrictive pressure decreases tissue oxygenation significantly Increased fatigue response observed with higher restrictive pressure
Takashi Abe (2010) [94]	Randomized controlled trial	Nineteen active older adults	KAATSU-walk group performed 20-min treadmill walking, 5 days/week	Muscle size and strength measurements Functional ability and aerobic capacity assessments	KAATSU-walk training increased muscle strength and size No improvement in aerobic capacity observed
Thitiwat Noikhammueang (2023) [95]	Crossover design	Ten obese male adolescents	Assessing vascular function parameters before and after exercising at multiple time points	Brachial-ankle pulse wave velocity, body composition, and heart rate	HIIE-BFR at 40% arterial occlusion pressure (AOP) showed similar outcomes to HIIE-SUPRA in terms of heart rate and vascular function
Igor Martins da Silva (2020) [96]	Randomized trial	Thirty overweight men	High-intensity strength training (ST) Low-intensity strength training with blood flow restriction (ST-BFR)	Whole blood TNF-α production in different conditions Expression of monocyte subsets and markers	Blood flow restriction impairs the anti-inflammatory effects of exercise in overweight individuals
Zachary R. Salyers (2017) [97]	Randomized controlled trial	Nine subjects	The 4-week training regimen, which included upper and lower body training, was completed by both groups. There were four sets in the BFR programme: one set with 30 repetitions and three sets with 15 repetitions	Girth measurements of arms, legs, chest, and shoulders 1RM on bench press and back squat	No significant differences in body composition measurements BFR group improved bench press performance significantly
Omid Razi (2021) [98]	Randomized controlled trial	BFR group ($n=9$), no-BFR group ($n=9$)	Overweight middle-aged males underwent 8-week treadmill walk training	Lipid profiles Inflammatory factors Haematological indices	BFR group showed significant changes in TG and fibrinogen levels RBC levels increased in the BFR group

(BFRT) offers several unique advantages over traditional methods for obesity management. Combining BFRT with moderately strenuous strengthening or endurance exercise can help in gaining muscular mass and strength. Furthermore, it has been shown that combining endurance exercise with blood flow restriction may improve cardiopulmonary health [99].

In terms of metabolic improvements, BFRT's capacity to enhance insulin sensitivity and metabolic markers with less strenuous exercises can be advantageous, especially for those with obesity-related metabolic disorders. Additionally, the potential for muscle growth through BFRT, even with lighter loads, appeals to individuals seeking to build muscle while minimizing joint stress. Human studies have demonstrated that BFRT-induced cell swelling enhances lipolysis while both inhibiting protein catabolism and enhancing protein synthesis by protein sparing [100].

Safety is another notable advantage of BFRT. With proper application, BFRT can be gentler on joints compared to traditional exercises that involve higher loads. This makes BFRT a suitable option for obese individuals who are concerned about joint stress and injury.

While conventional techniques such as hypertrophy-focused resistance training and high-intensity interval training (HIIT) have advantages of their own, BFRT offers an exclusive and possibly more approachable strategy for individuals who are obese. Its ability to achieve positive outcomes with lower loads and reduced impact on joints underscores its potential to complement and enhance traditional methods in the multifaceted landscape of obesity management [101].

Strengths and limitations as well as an outlook for the future

The potential customization of BFR protocols for different population groups, such as adolescents, elderly individuals, and individuals with varying levels of obesity, warrants exploration. Future studies can offer a more comprehensive picture of the total effect of BFR training on obesity control by incorporating psychosocial and behavioural components.

However, several limitations must be acknowledged. Firstly, the review primarily relied on existing studies, which might have varied in terms of methodological rigour and sample size. This variation could introduce biases and impact the overall reliability of the findings.

Conclusion

In conclusion, the review highlights the possibility of using blood flow restriction training as an innovative approach to support obesity treatment. To sum up, the review of obesity management with blood flow restriction (BFR) training emphasizes the promise of this innovative approach in tackling the multifaceted problem of obesity. The review synthesized existing research, revealing promising outcomes in terms of muscle strength improvement, cardiovascular health, and potential weight loss. BFR training has emerged as a unique strategy that can enhance traditional obesity management interventions, offering an innovative avenue for individuals struggling with obesity to achieve better outcomes in their weight loss journey.

Abbreviations

BFRT Blood flow restriction training
BMI Body mass index

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Data availability

Not applicable. All articles included in the systematic review are cited and referenced appropriately in the manuscript. Data from this study were pooled from online electronic databases of PubMed, MEDLINE, ScienceDirect, and Google Scholar.

Declarations

Ethics approval and consent to participate

Being a scoping review, this research was exempt from human subjects IRB review.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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