applied sciences

MDPI

Systematic Review

Effectiveness of Therapeutic Exercise in Physiotherapy with Blood Flow Restriction in Patients with Knee Pathologies: A Systematic Review

Joel del Cristo López-Santana [1], Raquel Medina-Ramírez [2], María Sandra Marrero-Morales [3], Daniel David Álamo-Arce [2] and Marlene García-Quintana [2,*]

[1] Medical and Surgical Sciences Department, Faculty of Health Sciences, University of Las Palmas de Gran Canaria, 35016 Las Palmas de Gran Canaria, Spain; joel.lopez105@alu.ulpgc.es
[2] Research Group Soc-Dig., Medical and Surgical Sciences Department, Faculty of Health Sciences, University of Las Palmas de Gran Canaria, 35016 Las Palmas de Gran Canaria, Spain; raquel.medina@ulpgc.es (R.M.-R.); danieldavid.alamo@ulpgc.es (D.D.Á.-A.)
[3] Department of Modern Languages, Translation & Interpreting, Faculty of Health Sciences, University of Las Palmas de Gran Canaria, 35017 Las Palmas de Gran Canaria, Spain; sandra.marrero@ulpgc.es
* Correspondence: marlenedelcarmen.garcia@ulpgc.es

Abstract

Background: Blood flow restriction is proposed as an effective treatment method due to strength gain, muscle mass and pain reduction. This review aimed to evaluate and determine the effects of blood flow restriction training versus conventional training to optimize the functional recovery process in patients with knee pathologies such as rheumatoid arthritis, anterior cruciate ligament rupture and osteoarthritis. Methods: This is a systematic review study. A literature search of studies published from 2015 to 2025 in English and Spanish was conducted in the Medline (PubMed), Web of Science, Cochrane Library, Scopus and Science Direct databases according to the Priority Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. In order to determine the methodological quality and scientific evidence of the studies, the Critical Review Form and Oxford scales were applied. Results: Nine articles with a total sample of 540 subjects were selected. The methodological quality scores ranged from 7 to 12 points, and the studies had a level of evidence of 1b with a grade of recommendation of A. Conclusions: Blood flow restriction training may be an effective alternative to conventional physiotherapy treatment. Funding: This research did not receive any specific grant from funding agencies in the public, commercial or non-profit sectors. Registration: This review was registered on the OSF.

Keywords: blood flow restriction training; osteoarthritis; anterior cruciate ligament; rheumatoid arthritis; physiotherapy

check for updates

Academic Editors: María Jesús Casuso-Holgado and Cristina García-Muñoz

Received: 19 September 2025
Revised: 19 October 2025
Accepted: 28 October 2025
Published: 4 November 2025

Citation: López-Santana, J.d.C.; Medina-Ramírez, R.; Marrero-Morales, M.S.; Álamo-Arce, D.D.; García-Quintana, M. Effectiveness of Therapeutic Exercise in Physiotherapy with Blood Flow Restriction in Patients with Knee Pathologies: A Systematic Review. *Appl. Sci.* **2025**, *15*, 11739. https://doi.org/10.3390/app152111739

Copyright: © 2025 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

1. Introduction

Blood flow restriction training, also known as occlusive training (OCT) or Kaatsu training, was patented and developed by the Japanese researcher Yoshiaki Sato during the 1970s and 1980s [1]. It consists of performing a series of exercises with very light loads (around 20–40% of the 1 RM, which is the maximum load at the specific resistance that allows for only one repetition in that series and in a specific exercise) or light aerobic exercise such as walking, with a decrease in blood supply to the muscle by applying a pressure between 100 and 240 mmHg on the proximal musculature of the limb [2]. This

pressure is applied by means of a cuff, which is inflated enough to occlude venous return but low enough to maintain arterial inflow. This method provides benefits in terms of strength and muscle mass, such as those produced by high-load training [3].

Numerous factors must be considered for its effective and risk-free use [4], such as the type of exercise, the material chosen or factors which are specific to the individual, such as the size of the limb or the pressure exerted. Although this method has proven to be safe and effective, contraindications may occur. Contraindications could be hematomas (13%), localized paranesthesia (1%), dizziness (0.3%), deep vein thrombosis (0.06%), pulmonary embolism (0.008%), rhabdomyolysis (0.008%) and worsening of ischemic heart disease (0.02%), among others [5].

However, a review carried out by Scott BR. et al. [3] attempts to reach a consensus considering the variables and contraindications mentioned above to find the most effective and safe methodology for performing BFR.

Several key aspects for its application must be considered [6]:

- The stimulus must be individualized, considering the pressure applied according to the characteristics of the subject, the circumference of the limb and the cuff.
- The BFR produces its greatest benefits in terms of muscle development when combined with light loads. Improvements are also observed using only flow restriction during immobilizations or combined with low-intensity aerobic exercise.
- In healthy individuals, the effects of training are maximized if BFR is combined with traditional training with high loads.

1.1. Physiological Effects of Blood Flow Restriction Training

1.1.1. Physiological Mechanisms of Flow Restriction Training

Blood flow restriction training, also known as occlusive training, triggers a variety of physiological responses that make it a useful tool for both injury prevention and rehabilitation [7]. One of the key effects is the increased recruitment of muscle fibers and a rise in electromyographic activity, suggesting that muscles are working harder even under low loads. This technique also heightens the stimulation of type III and IV afferent nerve fibers, enhancing neuromuscular feedback. On a cellular level, it causes muscle cells to swell and leads to greater metabolite buildup, particularly lactate—which suggests a more intense metabolic environment. These conditions are typically accompanied by lower sarcoplasmic pH and reductions in phosphocreatine and ATP levels, reflecting increased energy demand. At the same time, it supports greater muscle glycogen storage, improves arterial flexibility, and positively influences the autonomic nervous system. Furthermore, these adaptations contribute to better muscle performance and recovery, making occlusion training a promising strategy in sports and rehabilitation settings.

1.1.2. Neuromuscular Responses to Flow Restriction Training

According to the size principle, under normal conditions, slow or type I muscle fibers are the first to act during low-intensity training, with high intensities necessary for the recruitment of fast or type II fibers. However, in flow-restricted training, both an increase in the recruitment of these fibers and greater electromyographic muscle activity are observed. This recruitment is a result of training with high loads, and is much greater than that produced with light loads without occlusion. The increase in fiber recruitment is due to the stimulation of afferent fibers in groups III and IV. This leads to corticomotor hyperexcitability, which produces neural adaptations such as those seen in high-intensity training if performed in a planned and time-regulated manner [8].

1.1.3. Metabolic Responses to Blood Flow Restriction Training

BFR produces "cellular swelling" leading to an accumulation of metabolites, which creates a pressure gradient favoring cell perfusion, leading to an increase in cell volume. This chronically induced increase in intracellular space threatens the membrane structure, initiating the cell's anabolic adaptive responses to reinforce the structure. With BFR, there is an increase in blood, plasma and muscle cell lactate levels. In turn, acidification is achieved, as well as a reduction in phosphocreatine and ATP levels. However, muscle glycogen increases [9].

1.1.4. Hemodynamic Responses to Blood Flow Restriction Training

In terms of hemodynamic responses, the inability of some venous blood to return causes systolic volume to decrease and heart rate and blood pressure to increase in an attempt to normalize cardiac output, leading to an increase in myocardial oxygen demand. Chronically, BFR produces adaptations at the vascular level, with positive effects on carotid artery compliance and endothelial function in brachial arteries, as well as angiogenesis stimulation. BFR increases both sympathetic and parasympathetic nervous activity at the cardiac level [10].

1.1.5. Endocrine Responses to Blood Flow Restriction Training

The main hormonal response to BFR is an increase in growth hormone (GH), reaching values equal or higher than those obtained in high-load training. Values of approximately 290 times higher than the initial values have even been observed. Another important response is an increase in mammalian target of rapamycin (mTOR) and S6K1 phosphorylation, the latter being up to three times higher immediately after EO. There is also an elevation in heat shock protein (HSP-72) activation, as well as norepinephrine (NE). Regarding reactive oxygen species, increases in nitric oxide (NO) have been observed by indirect markers such as maximal arterial dilation, which is dependent on its activation, or increased NOS-1 values. This has been observed indirectly due to the short lifespan of NO. With regard to growth factors, increases in insulin-like growth factor-1 (IGF-1) and endothelial growth factor (VEGF) levels are observed. However, this training method has been found to be ineffective in terms of modifying testosterone levels. Furthermore, in relation to negative responses, there is a decrease with respect to high-intensity training in cortisol and myostatin response, as well as decreases in markers such as Atrogin-1 or MuRF-1 [11].

1.2. Use of BFR in Knee Pathologies

Occlusive training techniques are being increasingly adopted as a possible treatment for several conditions related to the musculoskeletal system [12]. Among them, more studies have been conducted on anterior cruciate ligament (ACL) rupture [13]. Although it is generally a sports injury, it is also prevalent among physically active people. Poorly vascularized and with a limited capacity for healing, the ACL is highly vulnerable. Most of the injuries (about 70%) [14,15] occur through indirect mechanisms and they arise during sudden deceleration or change in direction, or even when someone is coming down from a jump and the knee is almost extended [16,17]. Effective rehabilitation approaches should be based on a clear understanding of its structural and biomechanical properties [18].

Osteoarthritis (OA) is the degenerative disease that affects the joints [19]. It is a condition in which there is damage to the cartilage and bone remodeling, most commonly at the hip, knee, cervical spine and hand joints [20]. It is the most prevalent rheumatic disease in the world. About 28% of people over 60 suffer from this condition, with 80%

suffering movement limitations. In Spain, this disease affects about 7 million people and leads to disability, especially among women [21,22].

Finally, rheumatoid arthritis (RA) is an autoimmune, chronic condition causing sustained synovitis pain and swelling in the joints, along with cartilage destruction [23]. In other instances, it may manifest as a systemic inflammatory disease that affects not only the joints but also the skin, blood vessels and internal organs. Atrophic changes and structural deformities are common in later stages of the disease process [24]. The diagnosis of this disease is made according to criteria defined by EULAR and ACR, which include evidence of synovitis at least in one or more joints detected by serological markers (RF and ACPA) and symptoms which persist at least for six weeks [25].

It is necessary to establish the relevant information in this area. Therefore, this systematic review aimed to evaluate and determine the effects of blood flow restriction training versus conventional training to optimize the functional recovery process in patients with knee pathologies such as rheumatoid arthritis, anterior cruciate ligament rupture and osteoarthritis.

In recent years, scientific evidence has reinforced the clinical relevance of BFR training in the field of rehabilitation, especially in patients who cannot tolerate high mechanical loads. The most recent studies confirm that low-load exercise combined with BFR can significantly improve muscle strength and functional outcomes in rehabilitation processes for knee osteoarthritis, anterior cruciate ligament reconstruction and rheumatoid arthritis, without increasing the incidence of adverse events [26–29]. These findings reinforce the usefulness of BFR as a safe and effective complement to traditional resistance training, especially in populations with limited load tolerance. However, methodological differences between studies and the scarcity of comparative analyses between different knee pathologies justify the need for a systematic review that integrates the most recent available evidence and assesses its current clinical applicability.

According to the literature analyzed, the guiding question of the systematic review is as follows: How effective is blood flow restriction in patients with knee pathology compared to conventional training? The overall objective is to evaluate and determine the effects of blood flow restriction training compared to conventional training in optimizing the functional recovery process in patients with knee conditions such as rheumatoid arthritis, anterior cruciate ligament rupture and osteoarthritis.

2. Materials and Methods

2.1. Search Criteria

The PICO (patient, intervention, comparison, outcomes; detailed in Table 1) strategy was used for the literature search. This mnemonic code makes it easier to remember the components of the structure: (P) patient or patient characteristics; (I) intervention: main intervention to consider (therapeutic, preventive, diagnostic and risk exposure, among others), (C) comparison intervention: alternative with which to compare the main intervention (it should be taken into account that sometimes there is no intervention to compare) and (O) outcomes: results to assess, i.e., effects of the intervention in terms of improvement, side effects [30]. This study was conducted according to the recommendations of the Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) [31] the supplementary document (Table S1: PRISMA) and was previously registered in the OSF Registries with number hg4p7 and DOI https://doi.org/10.17605/OSF.IO/4TA5Y. Therefore, the PICO question is as follows: What is the effectiveness of blood flow restriction in patients with knee pathology versus conventional training? (Table 1).

Table 1. PICO question.

Patient	Patients with Knee Pathologies
Intervention	Blood flow restriction training
Comparison	Blood flow restriction training vs. conventional physiotherapy
Outcomes, results	How effective blood flow restriction is in knee patients

Table created by author.

2.2. Criteria for Selection

Inclusion criteria were as follows: articles which included patients with knee pathologies and used the blood flow restriction (BFR) technique published in English and Spanish between 2015 and 2025. The studies excluded were those which did not use the flow restriction technique or those which applied this technique in another joint group. The use of the technique and the evaluation of its effectiveness in the current literature and in scientific evidence have demonstrated benefits in ACL injuries in OA and RA. Therefore, all the articles which were included in this review focus on the use of this technique in these pathologies.

2.3. Search Strategy

The literature search was conducted in January 2025. Articles written in both English and Spanish from the following databases were included: Medline (PubMed), Scopus, Web of Science, Cochrane Library and Science Direct. Duplicate articles were excluded using the Zotero bibliographic manager. Search strategies were based on the eligibility criteria described above. Medical Subject Headings (MESH), keywords and Boolean operators were used to refine the search: "blood flow—restricted", "knee," "physical therapy", "physiotherapy," "rehabilitation", grouped in the following search equation: (Blood Flow—restricted) AND ((Physical therapy) OR (physiotherapy) OR (Rehabilitation)) AND (Knee).

2.4. Evaluation of the Methodological Quality

The Critical Review Form—Quantitative Studies scale [32] was used to assess the methodological quality of the selected articles. This scale uses 15 questions to evaluate the following aspects: the purpose of the study, the literature, the design of the study, the sample, the outcomes, the intervention, the results from a statistical point of view, the conclusions and the consequences. The questions are answered with "yes" or "no" depending on whether what is indicated in the criteria is fulfilled. However, in order to obtain a numerical score, "yes" will correspond to a score of one and "no" to a score of zero.

To complement this quantitative rating, risk of bias in the randomized trials was examined with the revised Cochrane risk-of-bias tool RoB 2. This instrument covers five domains: randomization, deviations from intended interventions, missing outcome data, outcome measurement and selection of reported results, and classifies each domain as low risk, some concerns or high risk, thereby providing a structured judgement of methodological reliability [33].

The Oxford Centre for Evidence-Based Medicine (CEBM) scale was used to assess the level of evidence and recommendation. This scale allows for the assessment of evidence depending on the subject area or clinical situation, as well as the type of research involved in the relevant clinical questions. In addition, it guarantees the most outstanding knowledge due to the high degree of specialization and provides an explanation of how the lack of methodological rigor is related to the type of study, leading to reduced evidence and strength of recommendations [34].

3. Results

The search strategy identified a total of 69 records, from which duplicate articles were excluded using the Zotero bibliographic manager (Figure 1). The eligibility criteria outlined in the methodology section were applied, and nine studies were finally selected for the final analysis (see Table 2).

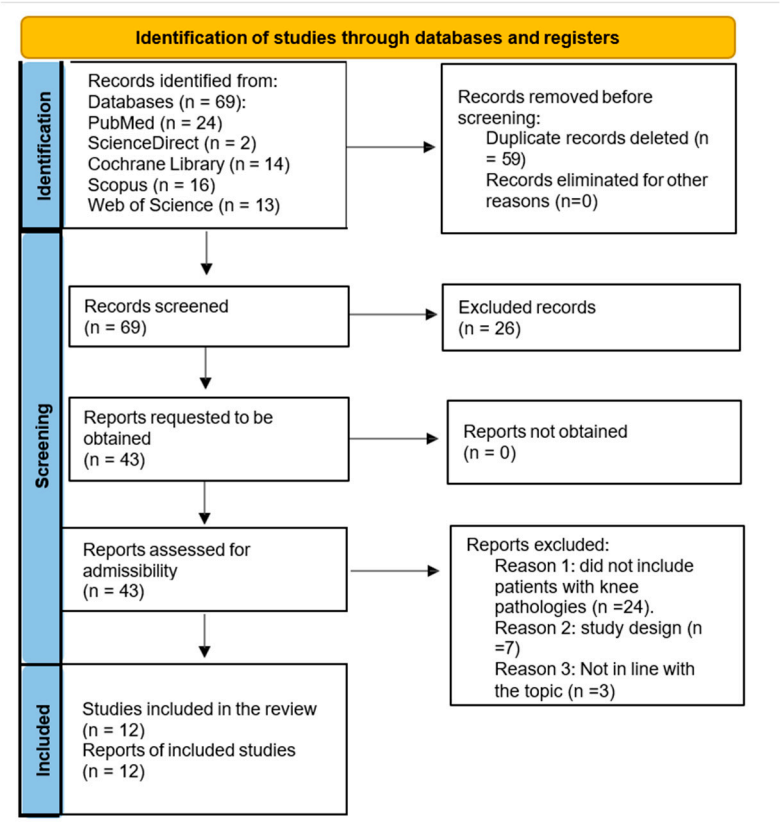

Figure 1. PRISMA flow chart.

Table 2. Summary table of articles selected for the review.

Title	Author(s)	Year	Type of Study
"Efficacy of Blood Flow Restricted Low-Load Resistance Training in Women with Risk Factors for Symptomatic Knee Osteoarthritis".	Segall et al. [35]	2015	Double-blind, randomized, controlled clinical trial.
"Feasibility and estimated efficacy of blood flow restricted training in female patients with rheumatoid arthritis: a randomized controlled pilot study "	Jønsson et al. [36]	2021	Non-blinded, randomized, controlled pilot trial
"Efficacy of low-load blood flow restricted resistance EXercise in patients with Knee osteoarthritis scheduled for total knee replacement (EXKnee): protocol for a multicentre randomised controlled trial".	Jørgensen et al. [37]	2020	Controlled, multicenter (two sites), randomized, assessor-blinded trial.
"Effects of Low-Load Blood- Flow Restricted Resistance Training on Functional Capacity and Patient- Reported Outcome in a Young Male Suffering From Reactive Arthritis".	Jørgensen and Mechlenbur [38]	2021	Case study

Table 2. *Cont.*

Title	Author(s)	Year	Type of Study
"Blood Flow Restriction Training Does Not Improve Quadriceps Strength After Anterior Cruciate Ligament Reconstruction".	Curran et al. [39]	2019	Randomized, controlled trial
"Blood flow restricted walking in elderly individuals with knee osteoarthritis: a feasibility study"	Petersson et al. [40]	2022	Feasibility study
"Functional and molecular adaptations of quadriceps and hamstring muscles to blood flow restricted training in patients with ACL rupture".	Kacín et al. [41]	2021	Prospective, single-center, single-blind, quasi-randomized, controlled trial.
"Vascular Occlusion for Optimizing Functional Improvement in Patients With Knee Osteoarthritis (VOFIKO)".	Jacobs et al. [42]	2025	Randomized clinical trial
"Effects of Blood-flow Restricted Exercise Compared to Standard Rehabilitation in Patients With Knee Osteoarthritis".	Johannsen, M.D. [43]	2022	Randomized clinical trial

Table with articles selected for analysis in the review, detailing the title, author, year and type of study.

The flowchart in Figure 1 details the study selection. It summarizes the phases of identification, pre-screening, eligibility and inclusion in the review. It was adapted from the PRISMA 2020 statement [32] and developed using the official template.

3.1. Methodological Quality Assessment

After applying the Critical Review Form scale, the scores of the selected articles ranged between 7 and 12 points. This indicates that the level of evidence is high (see Table 3). The study conducted by Petersson et al. [40] registers the highest score of the final sample included in the systematic review, with a total of 13 points. The studies by Segal et al. [35] and Kacín et al. [41] have a score of 12, indicating better methodological quality, whereas the studies by Jønsson et al. [36]; Jørgensen et al. [37]; Jørgensen and Mechlenbur [38]; Jacobs et al. [42] and Johannsen [43] ranged between 8 and 11 points, corresponding to a good methodological quality. However, only the study conducted by Curran et al. [39] scored 7, which means moderate methodological quality.

Table 3. Critical Review Form—Quantitative Studies Scale.

Items to be Assessed / Author(s)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total Score
Segal et al. [35]	1	1	1	1	1	1	1	1	0	0	1	1	1	1	0	12/15
Jønsson et al. [36]	1	1	1	1	0	1	1	1	0	0	1	1	1	0	1	11/15
Jørgensen et al. [37]	1	1	1	1	0	1	1	1	0	0	1	1	1	0	1	11/15
Jørgensen and Mechlenbur [38]	1	1	1	1	1	1	1	1	0	0	0	1	0	0	1	10/15
Curran et al. [39]	1	0	1	1	0	0	1	1	0	0	1	1	0	0	0	7/15
Petersson et al. [40]	1	1	1	1	1	1	1	1	0	0	1	1	1	1	1	13/15
Kacín et al. [41]	1	1	1	1	1	1	1	1	0	0	1	1	1	0	1	12/15
Jacobs et al. [42]	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	8/15
Johannsen [43]	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	8/15

Results table. The Critical Review Form scale is a 15-item questionnaire. One point will be awarded for each criterion met, whereas a negative response will result in zero points.

To complement this quantitative assessment, the risk of bias in the randomized trials was examined using the revised Cochrane Risk of Bias tool (RoB 2) presented in Table 4. This instrument covers five domains, including randomization, deviations from intended

interventions, missing outcome data, outcome measurement and selection of reported results, and classifies each domain as low risk, some concerns or high risk, thereby providing a structured judgement of methodological reliability [33].

Table 4. Risk-of-bias assessment of the included studies.

Article	Bias due to Randomization Process	Bias due to Deviations from Intended Interventions	Bias in Measurement of Outcomes	Bias due to Missing Outcome Data	Bias in Selection of Reported Results	Overall Risk of Bias
Segal et al. [35]	Low (–)	Low (–)	Low (–)	Low (–)	Low (–)	Low (–)
Jønsson et al. [36]	Low (–)	High (+)	Low (–)	Some concerns (~)	Low (–)	Some concerns (~)
Jørgensen et al. [37]	Some concerns (~)	Some concerns (~)	Some concerns (~)	Low (–)	Low (–)	Some concerns (~)
Jørgensen and Mechlenbur [38]	High (+)	Some concerns (~)	Low (–)	Some concerns (~)	Some concerns (~)	High (+)
Curran et al. [39]	Some concerns (~)	Some concerns (~)	Low (–)	Low (–)	Some concerns (~)	Some concerns (~)
Petersson et al. [40]	Some concerns (~)	Some concerns (~)	High (+)	Some concerns (~)	Low (–)	Some concerns (~)
Kacín et al. [41]	High (+)	Some concerns (~)	Low (–)	Low (–)	Low (–)	Low (–)
Jacobs et al. [42]	Low (–)	Some concerns (~)	Low (–)	Low (–)	Low (–)	Low (–)
Johannsen [43]	Some concerns (~)	Some concerns (~)	Some concerns (~)	Some concerns (~)	Low (–)	Some concerns (~)

Risk ratings: low (–), some concerns (~) and high (+). A low rating denotes minimal risk of bias, 'some concerns' indicates a moderate risk that could affect result validity and a high rating indicates substantial risk that may compromise reliability.

Regarding the Oxford scale results in this review, the investigations conducted by Segall et al. [35], Jørgensen et al. [37], Curran et al. [39], Petersson et al. [40], Jacobs et al. [42] and Johannsen [43] are significant since they provide high-quality evidence (level 1b) and receive a strong grade A recommendation. These investigations contribute to robust and consistent findings in favor of the technique. On the other hand, studies by Jønsson et al. [37] and Kacín et al. [41] present moderate-quality evidence (level 2b) and are graded with a C recommendation, suggesting some benefits but with more caution in interpretation. Similarly, the study by Jørgensen and Mechlenburg [38], which presents lower-quality evidence (level 3b), also received a grade C recommendation.

3.2. Description of Studies and Synthesis of Results

We found variability with regard to the type of study. The characteristics of these study types vary significantly: seven out of a total of nine research studies we have selected for this review are RCTs, i.e., randomized clinical trials. Nevertheless, Petersson et al. [40] presented a feasibility study and Jørgensen and Mechlenburg [38] presented a case study.

All randomized clinical trials included one control group and one experimental group, except Kacín et al. [41] and Jacobs et al. [42], who presented three types of experimental groups.

The included studies presented significant clinical and methodological heterogeneity in (1) population (knee osteoarthritis, ACL reconstruction, rheumatoid arthritis; wide range of ages and sexes), (2) type of intervention (low-load resistance training vs. walking with BFR), (3) training dosage (3–12 weeks; 2–4 sessions/week; typical loads 20–30% 1 RM) and (4) pressure prescription (absolute values versus percentage of LOP, commonly 40–80% LOP), in addition to variations in comparators. Due to this variability and the mix of designs, a meta-analysis was not performed, and a structured narrative synthesis was chosen, supported by methodological quality assessment (Critical Review Form), risk of bias (RoB 2) and the Oxford evidence levels. This decision aims to minimize spurious inferences and offer a clinically prudent interpretation of the findings.

3.3. Participant Characteristics

The number of patients in each study varied significantly. Some of them presented only one patient, whereas other studies recruited a large number of participants. In particular, Jacobs et al. [28] presented the largest sample, with a total of 234 patients. A total of 540 participants were ultimately included, resulting in an average of 60 participants in each

study. In terms of gender, the studies included both men and women. As regards the age of the participants, it ranged from 17 to 65 years.

3.4. Main Measurement Variables

The primary measurement in these studies was maximal isometric and isokinetic knee extensor and flexor strength, using a dynamometer. They also analyzed cross-sectional areas by magnetic resonance imaging and pain by visual analogue scale.

3.5. Type and Time of Training

Segal et al. [35] evaluated the effectiveness of low-load resistance training (30% 1 RM) combined with blood flow restriction (BFR) in women over 45 years of age with risk factors for symptomatic knee osteoarthritis. After 4 weeks of supervised training (3/times/week), the results showed that the BFR group achieved significantly greater improvements in leg press strength (1 RM) and isokinetic knee extension strength compared to the control group without BFR. No significant differences were observed between groups in quadriceps volume, leg press power, stair climbing power, or knee pain. However, both groups improved stair climbing power, and no worsening of joint pain was reported, indicating good tolerance to the intervention. Taken together, these results suggest that training with BFR and low loads may be a useful strategy for increasing strength without aggravating joint symptoms in this population.

Jønsson et al. [36] achieved through their training protocol a significant improvement in both groups, with better results in the group exposed to BFR obtaining a change of 11.5 kg of muscle mass, whereas the control group only achieved 8.4 kg.

Jørgensen et al. [37] did not show the results that were achieved in the study at three months and in the months following the re-evaluation of the patient to contrast the improvement or involution of the selected patients, whereas in the study conducted by Jørgensen and Mechlenbur, I. [28], a single patient completed the planned exercise protocol. In this sense, there was an improvement in the 30CST test by increasing by seven repetitions on the right limb and by five on the left limb. In addition, it was observed that the circumference of the lower thigh was reduced by 1.1 cm in the right leg and 1.0 cm in the left leg, respectively. There was a clinically relevant change in KOOS, ADL, quality of life, and FJS symptoms, with increases of 10, 14 and 23 points, respectively.

In the study conducted by Jørgensen, S.L., and Mechlenbur, I. [38], after 12 weeks of resistance training with blood flow restriction and low load, the patient showed significant functional improvement. In the unilateral 30 s chair stand test (u30 s CST), the patient increased by seven repetitions on his right leg and four on his left leg, corresponding to relative improvements of 41% and 28%, respectively. Thigh circumference was reduced by 1.1 cm in the right leg and 1.0 cm in the left, indicating decreased joint edema, while pain remained at zero throughout the study. In terms of self-reported results, clinically relevant improvements were observed in the domain of symptoms (+10), activities of daily living (+14) and quality of life (+13) of the KOOS questionnaire, while the sport and recreation subscale showed a minor change (+5). In addition, the Forgotten Joint Score increased by 23 points, reflecting a lower negative perception of the joint in daily activities.

Curran et al. [39] obtained significant results in both isotonic 1 RM and isokinetic knee extensor strength in those patients who underwent blood flow restriction compared to the control group. Nevertheless, changes in quadriceps volume, leg press power and knee-related pain did not differ significantly between groups. No change between both groups was obtained. Therefore, in an 8-week period, a combined intervention of blood flow resistance training and exercise did not result in a significant increase in quadriceps muscle strength in patients who had undergone anterior cruciate ligament (ACL) reconstruction.

Petersson et al. [40] showed that the results of the intervention were not as good as expected, since only nine participants were able to complete their intervention, whereas five patients dropped out. However, the results obtained were significant in those participants who did not meet the baseline body mass index (BMI) (p = 0.05), in which knee pain (p = 0.06) was higher and gait performance (p = 0.04) was lower. As regards the complete case data, the training adherence rate was 93%, whereas the average knee pain in the affected leg was 7 on a numerical rating scale from 0 to 10. A walking exercise with blood flow restriction appeared feasible in patients with knee osteoarthritis. Therefore, participants who completed the intervention protocol demonstrated improvements in functional performance.

Kacín et al. [41] achieved significant increases in quadriceps and hamstring strength with low loads, with improvements comparable to those obtained through traditional high-load training. Likewise, increases in muscle cross-sectional area were observed, reflecting relevant hypertrophic adaptations in both muscle groups. At the molecular level, the BFR protocol stimulated pathways associated with protein synthesis and hypertrophy, similar to those activated by high-intensity exercise. In addition, improvements in functional capacity and muscle endurance were evident, suggesting that the benefits of training go beyond hypertrophy.

Jacobs et al. [42] showed that, despite recruitment difficulties, the intervention was well-tolerated, with high adherence, overall satisfaction, and no serious adverse effects. Both groups (BFR and control with low-intensity training without restriction) improved muscle strength and endurance without increasing joint pain, but the BFR group showed a significantly greater gain in knee extensor strength compared to the control group. These findings suggest that BFR training may be a safe and potentially more effective alternative to conventional low-intensity exercise for improving muscle strength in this population.

Table 5 summarizes the method and the use of the blood flow restriction technique in each of the studies in the review.

Table 5. Details on how to use occlusion with BFR.

Article	Time (Weeks)	Pressure	Load	Repetitions	Series	Occlusion Time
Segal et al. [35]	4	Progressive weekly pressure	30% (1 RM)	Not specified	Not specified	12 sessions 3 for week
Jønsson et al. [36]	4	Individual participant	20–30% (1 RM)	Not specified	Not specified	12 sessions 3 for week
Jørgensen et al. [37]	8	40–80% LOP	30% (1 RM)	Not specified	Not specified	Not specified
Jørgensen and Mechlenbur [38]	12	Not specified	20% (1 RM)	Not specified	Not specified	Not specified
Curran et al. [39]	8	80% Limb occlusion pressure (LOP)	70% (1 RM)	10	4	16 sessions 2 for week
Petersson et al. [40]	8–10	Partial pressure %LOP	Walking (4 km/h)	Not applied	Not applied	32–40 sessions 4 for week
Kacín et al. [41]	3	Not specified	≤30% (1 RM)	Not specified	Not specified	9 sessions 3 for week
Jacobs et al. [42]	12	60% (LOP)	<50% (1 RM)	Variable	Variable	24 sessions 2 for week
Johannsen [43]	12	Partial pressure %LOP	<30% (1 RM)	Not reported	Not reported	24 sessions 2 for week

Table with information on the specifics of using the blood flow restriction technique in review articles.

4. Discussion

The purpose of this review was to analyse the available literature regarding the effectiveness of blood flow restriction in knee pathologies such as rheumatoid arthritis, anterior cruciate ligament rupture and osteoarthritis. The results found were appropriate

for both the main objective and the specific or secondary objectives. According to the results of the evaluation of the methodological quality and the scientific evidence of the studies, the effectiveness of the use of this technique in the investigated profile of patients has been confirmed.

Firstly, a comparison of the use of the intervention groups is established, taking into account that the majority of the authors [35–40,43] include one group in which blood flow restriction was applied, whereas the other group did not have blood flow restriction. However, Kacín et al. [41] include three intervention groups; the first with a flow restriction (BFR group), the second with a cuff simulating vascular occlusion (SHAM- BFR group) and finally, a biopsy group, which does not perform any intervention, whereas Jacobs et al. [42] include the first two groups, with the third only receiving conventional physiotherapy.

On the other hand, there are differences in the type of training. Segal et al. [35] performed the training program three times per week, Jørgensen et al. [37] twice per week and, finally, Johannsen [43] did not present any specification regarding the training volume. However, these three studies perform the training at 30% of 1 RM. It is also worth noting that Jønsson et al. [37] propose the same type of training, but pre-set a time period of 45 min at 20–30% of 1 RM.

Jørgensen, S.L., and Mechlenbur, I. [38] employ in their study a totally different methodology from that applied in a previous study published in 2020 by Jørgensen et al. [33]. In their study, they use body weight for four sets, applying different repetitions.

In comparison with the remaining articles, we can observe that Curran et al. [39] establish a higher 1 RM reaching 70%, whereas the values of the other authors oscillate at around 40–50% of the 1 RM. The only article which does not present this type of training is the study proposed by Petersson et al. [40], because their program establishes the use of BFR by means of a fast walk with the device.

Another important aspect to consider in the results of this literature review is the duration of the treatment. In this sense, a significant difference can be observed between both groups.

Segal et al. [35] and Jønsson et al. [36] were the only authors who applied a duration of 4 weeks in their study. However, the authors who applied the technique for a shorter period of time were Kacín et al. [41], with a duration of only 3 weeks.

Jørgensen, S.L., and Mechlenbur, I. [38] and Curran et al. [39] presented a total duration of 8 weeks. Nevertheless, Curran et al. specified that these 8 weeks would cover concretely a postoperative period. Petersson et al. [40] applied the same duration opting for the possibility of increasing it to 10 weeks if it was necessary. Finally, the studies with the longest duration were Jørgensen, S.L., and Mechlenbur, I. [38], Jacobs et al. [42] and Johanssen [43], who applied this technique for 12 weeks. A significant aspect to consider is that the latter author performed the intervention consecutively.

On the other hand, variables such as cuff type, cuff pressure and cuff time must be taken into account. The most commonly used cuff in the different studies is the pneumatic cuff [37,38,40,41,43]. Jønsson et al. [36] used an occlusion cuff with manometer, whereas Jacobs et al. [38] made use of a Smart-cuff pro.

It must be emphasized that all those studies in which a pneumatic cuff was used showed differences in width. Jørgensen et al. [37] used a 12 cm wide cuff, whereas in a later study Jørgensen, S.L., and Mechlenbur, I. [38] used an 11.7 cm wide cuff. On the other hand, Kacín et al. [41] applied a 13.5 cm wide asymmetric pressure.

However, there were authors who did not specify which type of cuff they used, such as Segal et al. [35] and Curran et al. [39]. Furthermore, Segal et al. [35] were the only ones to specify how long the cuff was applied to the patients in their study.

Vascular occlusion was, therefore, performed on three main arteries (femoral, tibial and posterior tibial). Only four of the nine authors specified which of these were involved with BFR. Thus, Segal et al. [35] applied occlusion in the femoral artery, while Jønsson et al. [36], Jørgensen et al. [37] and Petersson et al. [40] applied flow restriction in the posterior tibial and tibial arteries, respectively.

To conclude with these variables, the cuff pressure was mainly based on the OAP (total occlusion pressure), which is the point at which blood flow is totally occluded and prevented from passing through. Nevertheless, some authors did not follow this approach but gradually increased the cuff pressure according to their professional judgement until a certain range was reached.

The average range of OAP used by the authors [36,37,40,43] was based on 50–80%. On the other hand, Segal et al. [35] gradually increased it from 20 mmHg to reach 140 whereas Jørgensen, S.L., and Mechlenbur, I. [38] used an absolute pressure with a gradual increase to reach 110–150 mmHg. This pressure was also used by Kacín et al. [41] in their study.

The only study which applied a pressure without specifying its type or on which criteria it was based was the study conducted by Curran et al. [39], who applied 80% pressure, whereas Jacobs et al. [42] did not specify anything about it in their study.

The evidence analyzed in OA (or risk of OA) suggests that the use of BFR at low loads (approximately 20–30% 1 RM) appears to enhance strength and some functional problems intrinsic to the pathology itself, without increasing pain. With the use of BFR during walking, feasibility is good, but the perceived change may require more time or even combination with strength exercises [35,37,40,42,43].

On the other hand, in reference to rheumatoid arthritis patients, the use of BFR is considered promising for preserving/gaining function with low mechanical load [36,38].

The effects produced using BFR in patients with anterior cruciate ligament injuries depend largely on the context. Preoperatively, it is useful for preconditioning; postoperatively, the priority is to choose a low load for BFR use at the start of recovery [39,41].

According to the results of the studies reviewed and their analyses, the data reproduced in the BFR intervention methodology include occlusion pressure in the range of 40–80% of individualized LOP for OA [35,37,40,42,43], with a recommendation of greater than $\geq$60–70% LOP for low loads and post-operative 70–80% LOP [39]. The load used is between 20 and 30% of 1 RM in chronic pathologies and 70% of 1 RM in the post-surgical population. In terms of sets and repetitions, they usually follow a pattern of four sets of 10–15 repetitions. The number of sessions ranges from 9 to 40, with a usual frequency of two to three times per week. Clinical trials with larger sample sizes indicate that in OA, the recommendation would be 24 sessions over 12 weeks [42].

The use of blood flow restriction during walking improves joint tolerance according to objective tests in studies. In OA and RA, high treatment adherence, mild adverse effects, and good tolerance are reported when pressure and progression are individualized. Rejection of the intervention is often associated with high baseline pain and high body mass index during walking with BFR, suggesting adjustments in the selection and dosage of the regimen.

In comparison with other systematic reviews published in recent years, our findings show both concordances and divergences. Gopinatth et al. reported significant improvements in isokinetic strength, IKDC score and pain following ACL reconstruction when BFR was combined with rehabilitation, although no differences in muscle volume were observed [44]. Similarly, Butt et al. highlighted in their systematic review that BFR generally provided superior outcomes in terms of strength and functional measures compared to conventional rehabilitation, despite the heterogeneity of the included trials [45]. On the contrary, He et al. conducted a meta-analysis in patients with knee osteoarthritis and found

no significant differences in pain, strength or function between BFR and conventional resistance training, although BFR was associated with a lower incidence of adverse events [46]. More recently, Zeitlin et al. synthesized evidence from 15 trials including patients with knee pain (OA and ACLR) and concluded that, although BFR may reduce pain, the certainty of evidence was rated as very low, with no clear superiority in strength or functional outcomes [47]. Taken together, these results reinforce that the effectiveness of BFR may strongly depend on the clinical population and the training variables applied. Our review supports this perspective, suggesting that standardization of protocols (duration, occlusion pressure and training load) and long-term multicenter trials are essential to strengthen the evidence base for clinical recommendations.

The variability between studies reflects the reality of clinical practice and limits the direct extrapolation of effects to all patients and contexts, but it does allow patterns to be drawn from this analysis: (a) BFR combined with low loads (≈20–30% 1 RM) promotes strength improvements without worsening pain; (b) the use of pressures relative to %LOP (≈40–80%) seems more defensible than absolute pressures due to its individualization; (c) BFR is feasible and shows good adherence and an absence of serious adverse events in the samples analyzed.

This systematic review includes nine studies (540 participants), a number that, although modest, represents the currently available evidence following a PRISMA screening with predefined eligibility criteria. The mix of designs found (mostly RCTs, along with a feasibility study and a case study) and the heterogeneity in population, protocols (load, volume and frequency), and pressure dosage (absolute vs. %LOP) restrict the possibility of quantitative synthesis and limit the generalization of the results. In addition, the wide diversity of outcome variables and evaluation times complicates direct comparison between studies. Although tolerability was good and no serious adverse events were reported, publication bias and small study effect cannot be ruled out. Consequently, the findings should be interpreted with caution, and it is recommended that future multicenter RCTs use standardized protocols and longer follow-ups, with detailed reports of LOP, cuff width and adherence.

Future lines of research should be proposed to conduct randomized clinical trials with a rigorous and established protocol to employ standardized reporting (cuff width, method of determining LOP, exact dosage and compliance). In addition, new research should specify the application time, with a similar duration and, above all, supervised by a blinded physiotherapist, so that the results obtained are as reliable as possible.

5. Conclusions

Following a thorough analysis of the available studies, blood flow restriction (BFR) training appears to be a promising and safe complement to conventional physiotherapy for knee conditions. Overall, BFR may be associated with improvements in muscle strength, functional performance and treatment of adherence, without significant adverse effects. Slight reductions in pain and inflammation may be observed, although these are not statistically significant or consistent.

However, due to the limited number of studies and methodological heterogeneity, the level of certainty of the evidence is moderate to low, and the results should be interpreted with caution.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/app152111739/s1, Table S1: PRISMA Checklist. According to the study design specifications, the PRISMA 2020 Checklist is added as supplementary material.

Author Contributions: Conceptualization, M.G.-Q. and J.d.C.L.-S.; methodology, M.G.-Q.; software, J.d.C.L.-S.; validation, J.d.C.L.-S., M.G.-Q. and R.M.-R.; formal analysis, J.d.C.L.-S.; investigation, J.d.C.L.-S.; resources, R.M.-R.; data curation, J.d.C.L.-S.; writing—original draft preparation, J.d.C.L.-S., D.D.Á.-A. and R.M.-R.; writing—review and editing, M.S.M.-M., D.D.Á.-A. and R.M.-R.; visualization, M.G.-Q., M.S.M.-M. and R.M.-R.; supervision, M.G.-Q., M.S.M.-M. and R.M.-R.; project administration, R.M.-R.; funding acquisition, not applicable. All authors have read and agreed to the published version of the manuscript.

Funding: This research did not receive any specific grant from funding agencies in the public, commercial or not-for-profit sectors.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: All data from the studies are shown in the tables and in the written work.

Conflicts of Interest: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Abbreviations

The following abbreviations are used in this manuscript:

BFR	Blood Flow Restriction
OCT	Occlusive Training
GH	Growth Hormone
mTOR	Mammalian Target of Rapamycin
HSP-72	Heat Shock Protein
NE	Norepinephrine
NO	Nitric Oxide
IGF-1	Growth Factor-1
VEGF	Endothelial Growth Factor
ACL	Anterior Cruciate Ligament
OA	Osteoarthritis
RA	Rheumatoid Arthritis
PICO	Patient, Intervention, Comparison, Outcomes
PRISMA	Preferred Reporting Items for Systematic Review and Meta-Analysis
MESH	Medical Subject Headings
Rob2	Risk of Bias tool
CEBM	The Oxford Centre for Evidence-Based Medicine

References

1. Sato, Y. The history and future of KAATSU Training. *Int. J. Kaatsu Train. Res.* **2005**, *1*, 1–5. [CrossRef]
2. Bowman, E.N.; Elshaar, R.; Milligan, H.; Jue, G.; Mohr, K.; Brown, P.; Watanabe, D.M.; Limpisvasti, O. Upper-extremity blood flow restriction: The proximal, distal, and contralateral effects—A randomized controlled trial. *J. Shoulder Elb. Surg.* **2020**, *29*, 1267–1274. [CrossRef] [PubMed]
3. Scott, B.R.; Loenneke, J.P.; Slattery, K.M.; Dascombe, B.J. Exercise with blood flow restriction: An updated evidence-based approach for enhanced muscular development. *Sports Med.* **2015**, *45*, 313–325. [CrossRef]
4. Martínez González, D. Aplicación del Entrenamiento Oclusivo como Prevención y Tratamiento de Lesiones. Universidad de Valladolid. 2017. Available online: https://uvadoc.uva.es/handle/10324/23224 (accessed on 22 March 2025).
5. Pope, Z.K.; Willardson, J.M.; Schoenfeld, B.J. Exercise and blood flow restriction. *J. Strength Cond. Res.* **2013**, *27*, 2914–2926. [CrossRef]
6. Brandner, C.R.; Warmington, S.A.; Kidgell, D.J. Corticomotor excitability is increased following an acute bout of blood flow restriction resistance exercise. *Front. Hum. Neurosci.* **2015**, *9*, 652. [CrossRef]

7. Neto, G.R.; Novaes, J.S.; Dias, I.; Brown, A.; Vianna, J.; Cirilo-Sousa, M.S. Effects of resistance training with blood flow restriction on haemodynamics: A systematic review. *Clin. Physiol. Funct. Imaging* **2017**, *37*, 567–574. [CrossRef]
8. Park, S.-Y.; Kwak, Y.S.; Harveson, A.; Weavil, J.C.; Seo, K.E. Low intensity resistance exercise training with blood flow restriction: Insight into cardiovascular function, and skeletal muscle hypertrophy in humans. *Korean J. Physiol. Pharmacol.* **2015**, *19*, 191–196. [CrossRef]
9. Staron, R.S.; Malicky, E.S.; Leonardi, M.J.; Falkel, J.E.; Hagerman, F.C.; Dudley, G.A. Muscle hypertrophy and fast fiber type conversions in heavy resistance-trained women. *Europ. J. Appl. Physiol.* **1990**, *60*, 71–79. [CrossRef]
10. Plotkin, D.L.; Roberts, M.D.; Haun, C.T.; Schoenfeld, B.J. Muscle Fiber Type Transitions with Exercise Training: Shifting Perspectives. *Sports* **2021**, *9*, 127. [CrossRef]
11. Henning, F.; Kohn, T.A. Preservation of shortening velocity and power output in single muscle fibres from patients with idiopathic inflammatory myopathies. *J. Muscle Res. Cell Motil.* **2023**, *44*, 1–10. [CrossRef] [PubMed]
12. Panesso, M.C.; Trillos, M.C.; Guzmán, I.T. *Biomecánica Clínica de la Rodilla*; Editorial Universidad del Rosario: Bogotá, Colombia, 2009. [CrossRef]
13. George, M.S.; Dunn, W.R.; Spindler, K.P. Current Concepts Review: Revision Anterior Cruciate Ligament Reconstruction. *Am. J. Sports Med.* **2006**, *34*, 2026–2037. [CrossRef] [PubMed]
14. Márquez Arabia, J.J.; Márquez Arabia, W.H. Lesiones del ligamento cruzado anterior de la rodilla. *Iatreia* **2009**, *22*, 256–271. [CrossRef]
15. Ranalletta, A.; Ranalletta, M.; Rossi, W.; Vieta, R.D.; Paoletta, R.E.; Hamilton, P.G. Ligamento cruzado posterior. Anatomía aplicada a la técnica quirúrgica. *Artroscopia* **2011**, *18*, 60–64.
16. Ayala-Mejías, J.D.; García-Estrada, G.A.; Pérez-España, A. Lesiones del ligamento cruzado anterior. *Acta Ortopédica Mex.* **2014**, *28*, 57–67.
17. Sánchez-Alepuz, E.; Miranda, I.; Miranda, F.J. Evaluación funcional de los pacientes con rotura del ligamento cruzado anterior. Estudio analítico transversal. *Rev. Española Cir. Ortop. Traumatol.* **2020**, *64*, 99–107. [CrossRef]
18. Fineberg, M.S.; Zarins, B.; Sherman, O.H. Practical considerations in anterior cruciate ligament replacement surgery. *J. Arthrosc.* **2020**, *16*, 715–724. [CrossRef]
19. Mayoral Rojals, V. Epidemiología, repercusión clínica y objetivos terapéuticos. *Rev. Soc. Esp. Dolor* **2021**, *28*, 4–10. [CrossRef]
20. Spain, V.V. La Artrosis se Convertirá en la Cuarta Causa de Discapacidad en el Mundo en 2020, Según la OMS. 2013. Available online: https://www.vademecum.es/noticia-131011-la+artrosis+se+convertir+aacute++en+la+cuarta+causa+de+discapacidad+en+el+mundo+en+2020%2C+seg+uacute+n+la+oms_7506 (accessed on 19 December 2024).
21. Tornero Crespo, M.M.; Montero Matamala, A. Review of the pharmacological treatment of osteoarthritis pain with paracetamol, nonsteroid anti-inflammatory (NSAIDSS) and selective cyclooxygenase-2 inhibitors (COXIB). *Rev. Soc. Española Dolor* **2021**, *28*, 43–48. [CrossRef]
22. Fernández, G.A. Fisioterapia y Artrosis de Rodilla. RCA Grupo Editor. 2023, Volume 6. Available online: https://www.npunto.es/revista/64/fisioterapia-y-artrosis-de-rodilla (accessed on 1 April 2025).
23. McInnes, I.B.; Schett, G. The pathogenesis of rheumatoid arthritis. *N. Engl. J. Med.* **2011**, *365*, 2205–2219. [CrossRef] [PubMed]
24. Turrión Nieves, A.; Martín Holguera, R.; Pérez Gómez, A.; Álvarez De Mon-Soto, M. Artritis reumatoide. *Med. Programa Form. Méd. Contin. Acreditado* **2017**, *12*, 1615–1625. [CrossRef]
25. Tornero Molina, J.; Sanmartí Sala, R.; Rodríguez Valverde, V.; Martín Mola, E.; Marenco De La Fuente, J.L.; González Álvaro, I.; Muñoz Fernández, S.; Gómez-Reino Carnota, J.; Carreño Pérez, L.; Batlle Gualda, E.; et al. Actualización del Documento de Consenso de la Sociedad Española de Reumatología sobre el uso de terapias biológicas en la artritis reumatoide. *Reum. Clin.* **2010**, *6*, 23–36. [CrossRef]
26. Butt, J.; Ahmed, Z. Blood Flow Restriction Training and Its Use in Rehabilitation After Anterior Cruciate Ligament Reconstruction: A Systematic Review and Meta-Analysis. *J. Clin. Med.* **2024**, *13*, 6265. [CrossRef] [PubMed]
27. Xie, S.Y.; Jiang, X.; Yuan, J.B.; Luo, J.; Song, S.; Hu, H.Y. Mechanisms of blood flow restriction training for knee pain: A mini review. *Front. Physiol.* **2025**, *16*, 1542322. [CrossRef]
28. Ma, F.; He, J.; Wang, Y. Blood flow restriction combined with resistance training on muscle strength and thickness improvement in young adults: A systematic review, meta-analysis, and meta-regression. *Front. Physiol.* **2024**, *15*, 1379605. [CrossRef]
29. Kwon, S.; Bae, K.C.; Yon, C.J.; Kim, D.H. Current Narrative Review-Application of Blood Flow Restriction Exercise in Clinical Knee Problems. *Medicina* **2025**, *61*, 1377. [CrossRef]
30. Martínez Díaz, J.D.; Ortega Chacón, V.; Muñoz Ronda, F.J. El Diseño de Preguntas Clínicas en la Práctica Basada en la Evidencia: Modelos de Formulación. *Enferm. Global.* **2016**, *15*, 431–438. [CrossRef]
31. Moher, D.; Liberati, A.; Tetzlaff, J.; Altman, D.G. Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *Int. J. Surg.* **2010**, *8*, 336–341. [CrossRef]

32. Letts, L.; Wilkins, S.; Law, M.; Stewart, D.; Bosch, J.; Westmorland, M. Guidelines for Critical Review Form—Qualitative Studies (Version 2.0), Mcmaster University Occupational Therapy Evidence-Based Practice Research Group. 2007. Available online: https://www.semanticscholar.org/paper/Guidelines-for-critical-review-form-Qualitative-Letts-Wilkins/74513fac0424cd8210f9fc9577d3e9bc721bd06c (accessed on 21 December 2024).
33. Sterne, J.A.C.; Savović, J.; Page, M.J.; Elbers, R.G.; Blencowe, N.S.; Boutron, I.; Cates, C.J.; Cheng, H.Y.; Corbett, M.S.; Eldridge, S.M.; et al. RoB 2: A revised tool for assessing risk of bias in randomised trials. *BMJ* **2019**, *366*, l4898. [CrossRef]
34. Mella Sousa, M.; Zamora Navas, P.; Mella Laborde, M.; Ballester Alfaro, J.J.; Uceda Carrascosa, P.; Mella Sousa, M.; Zamora Navas, P.; Mella Laborde, M.; Ballester Alfaro, J.J.; Uceda Carrascosa, P. Niveles de Evidencia Clínica y Grados de Recomendación. *Rev. Soc. Andal. Traumatol. Ortop.* **2012**, *29*, 59–72.
35. Segal, N.A.; Williams, G.N.; Davis, M.C.; Wallace, R.B.; Mikesky, A.E. Efficacy of blood flow–restricted, low-load resistance training in women with risk factors for symptomatic knee osteoarthritis. *PM&R* **2015**, *7*, 376–384. [CrossRef]
36. Jønsson, A.; Johansen, C.; Rolving, N.; Pfeiffer-Jensen, M. Feasibility and estimated efficacy of blood flow restricted training in female patients with rheumatoid arthritis: A randomized controlled pilot study. *Scand. J. Rheumatol.* **2021**, *50*, 169–177. [CrossRef]
37. Jørgensen, S.L.; Bohn, M.B.; Aagaard, P.; Mechlenburg, I. Efficacy of low-load blood flow restricted resistance EXercise in patients with Knee osteoarthritis scheduled for total knee replacement (Exknee): Protocol for a multicentre randomised controlled trial. *BMJ Open.* **2020**, *10*, e034376. [CrossRef]
38. Jørgensen, S.L.; Mechlenburg, I. Effects of low-load blood-flow restricted resistance training on functional capacity and patient-reported outcome in a young male suffering from reactive arthritis. *Front. Sports Act. Living* **2021**, *3*, 798902. [CrossRef]
39. Curran, M.; Bedi, A.; Mendias, C.; Wojtys, E.M.; Kujawa, M.; Palmieri-Smith, R. Blood flow restriction training does not improve quadriceps strength after anterior cruciate ligament reconstruction. *Orthop. J. Sports Med.* **2019**, *7* (Suppl. S5), 2325967119S00293. [CrossRef]
40. Petersson, N.; Langgård Jørgensen, S.; Kjeldsen, T.; Mechlenburg, I.; Aagaard, P. Blood flow restricted walking in elderly individuals with knee osteoarthritis: A feasibility study. *J. Rehabil. Med.* **2022**, *54*, jrm00282. [CrossRef] [PubMed]
41. Kacin, A.; Drobnič, M.; Marš, T.; Miš, K.; Petrič, M.; Weber, D.; Tomc Žargi, T.; Martinčič, D.; Pirkmajer, S. Functional and molecular adaptations of quadriceps and hamstring muscles to blood flow restricted training in patients with ACL rupture. *Scand. J. Med. Sci. Sports* **2021**, *31*, 1636–1646. [CrossRef]
42. Jacobs, E.; Stroobant, L.; Victor, J.; Elewaut, D.; Tampere, T.; Wallaert, S.; Witvrouw, E.; Schuermans, J.; Wezenbeek, E. Vascular occlusion for optimising the functional improvement in patients with knee osteoarthritis: A randomised controlled trial. *Ann. Rheum. Dis.* **2025**, *84*, 341–350. [CrossRef] [PubMed]
43. Johannsen, M.D. Effects of Blood-flow Restricted Exercise Compared to Standard Rehabilitation in Patients with Knee Osteoarthritis. ClinicalTrials.gov ID NCT05437770. *Ins. Sports Med.* **2025**, *35*, e70069.
44. Gopinatth, V.; Garcia, J.R.; Reid, I.K.; Knapik, D.M.; Verma, N.N.; Chahla, J. Blood Flow Restriction Enhances Recovery After Anterior Cruciate Ligament Reconstruction: A Systematic Review and Meta-analysis. *Arthroscopy* **2025**, *41*, 1048–1060. [CrossRef] [PubMed]
45. Zhou, L.; Rothrauff, B.; Chen, L.; Jin, S.; He, S.; He, J. Comparison of blood flow restriction training rehabilitation and general rehabilitation exerciseafter anterior cruciate ligament reconstruction: A meta-analysis of randomized controlled trials. *Knee Surg Sports Traumatol Arthrosc.* **2025**, *33*, 2713–2728. [CrossRef]
46. He, J.; Zhang, L.; Wu, Q.; Zhang, J. Credibility of Blood Flow Restriction Training in Patients with Knee Osteoarthritis: A Meta-analysis. *Orthop. J. Sports Med.* **2025**, *13*, 23259671241300145. [CrossRef] [PubMed]
47. Zeitlin, C.; Shepherd, M.; Lack, S.; Neal, B. Blood Flow Restriction Training Compared to Conventional Training in People with Knee Pain: A Systematic Review with Meta-analysis. *Phys. Ther. Sport.* **2025**, *74*, 65–74. [CrossRef] [PubMed]

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.