*Case Report*

**SAGE Open Medical Case Reports**

SAGE Open Medical Case Reports
Volume 11: 1–4
© The Author(s) 2023
Article reuse guidelines:
sagepub.com/journals-permissions
DOI: 10.1177/2050313X231203465
journals.sagepub.com/home/sco
Sage

# Low-load exercises with concurrent blood flow restriction as rehabilitation for unspecific knee pain to a former American football player: A case report

**Inger Mechlenburg[1,2,3], Torsten Grønbech Nielsen[1,4], Nick Kristensen[2], Andreas Bentzen[1] and Stian Langgård Jørgensen[3,5]**

**Abstract**

Former athlete, 30 years of age, suffered several months of moderate anterior knee pain during daily life activities where daily life activities such as negotiating stairs and lifting heavy objects were moderately painful. Magnetic resonance imaging showed normal meniscus and cruciate ligaments and no extra joint fluid. The patient was referred to a physiotherapist who introduced a strengthening program. Low-load resistance training with concurrent blood flow restriction can induce significant gains in maximal muscle strength and mass with minimal exacerbation of knee-joint pain. We describe the outcome of 12 weeks low-load resistance training with concurrent blood flow restriction as a rehabilitation method for anterior knee pain. The patient performed low-load resistance training with concurrent blood flow restriction for the lower limbs (goblet squat, single-leg knee extensions and flexions). After the low-load resistance training with concurrent blood flow restriction, the patient increased isometric knee extensor muscle strength (31%), single-leg hop test performance (23%), obtained clinically relevant improvements in patient-reported outcomes and was able to return to his usual high-loading training regime. Low-load resistance training with concurrent blood flow restriction seems promising to transition patients back to a healthy lifestyle of training and being physically active.

**Keywords**

Blood flow restriction, low-load exercises, rehabilitation, anterior knee pain

Date received: 26 May 2023; accepted: 11 September 2023

## Introduction

Anterior knee pain is not a well-defined condition due to the variety of symptoms, pain location and pain level experienced by the patient. Underlying factors could be patella abnormalities, muscular imbalances or weakness leading to patella malalignment on flexion and extension.[1] Progressive resistance training (PRT) of quadriceps is recommended[2]; however, due to knee pain and joint swelling, PRT may be contraindicated. The feasibility of low-load exercises with concurrent blood flow restriction (LL-BFR) has previously been tested in patients with severe knee osteoarthritis,[3] with reactive knee arthritis[4] and with malleolus fracture.[5] LL-BFR was found to be a safe and well-accepted exercise modality that patients can administer with minimal supervision and induce gains in muscle strength and size comparable to that of conventional PRT.[6] The purpose of this case report is to describe the outcome of 12 weeks of LL-BFR as a rehabilitation method for anterior knee pain.

[1]Department of Orthopaedic Surgery, Aarhus University Hospital, Aarhus N, Denmark
[2]Department of Public Health, Section of Sports, Aarhus University, Aarhus, Denmark
[3]Department of Clinical Medicine, Aarhus University, Aarhus N, Denmark
[4]Department of Occupational and Physical Therapy, Aarhus University Hospital, Aarhus N, Denmark
[5]Department of Occupational and Physical Therapy, Horsens Regional Hospital, Horsens, Denmark

**Corresponding Author:**
Inger Mechlenburg, Department Orthopaedic, Aarhus University Hospital, Palle Juul-Jensens Boulevard 99, Aarhus N DK-8200, Denmark.
Email: inger.mechlenburg@clin.au.dk

## Case description

The case concerns a former male American football player, 30 years of age, from Denmark, now employed as a health care researcher. He has no prior medical or psychosocial history, and roughly adhering to the Danish Health Authority recommendation for diet and physical activity. He performed 12 repetitions (reps) of goblet squats with a 24 kg kettlebell with a maximal degree of knee flexion and felt pain in the left knee. This incident provoked several months of moderate pain levels, which was exacerbated by the usual heavy slow resistance training. Ultimately, the patient was unable to continue his usual high-loading exercise routine. Daily life activities such as negotiating stairs and lifting heavy objects were moderately painful. Magnetic resonance imaging showed normal meniscus and cruciate ligaments and no extra joint fluid. The patient was examined by a physiotherapist and introduced to 12 weeks of LL-BFR as knee rehabilitation after which he was followed up by the same physiotherapist. The patient accepted to engage in the study and signed a written informed consent in accordance with the Helsinki Declaration. According to Danish law, case studies do not require formal ethical approval. This manuscript was written in accordance with the CARE guidelines.[7]

## Low-load blood flow restriction training

The patient was instructed to perform three LL-BFR exercises three times per week; goblet squats, single-leg knee extensions and single-leg knee flexions for the affected and non-affected limb. A conically shaped pneumatic cuff (Occlude APS Aarhus, Denmark; size: large, width = 11.7 cm) was applied at the most proximal part of the exercising limb and inflated to 80% of the pressure required for complete restriction of the blood flow into the limb, measured seated on an examination table with ultrasound Doppler.[3] The patient was taught to correctly apply the cuff and regulate cuff pressure to ensure consistent inflation during the exercises. Exercises were performed in four sets with 30 reps in set 1, 15 reps in set 2–3, and to volitional in set 4 and 30 s rest between sets and 2–5 min rest between exercises[8] (Table 1). When more than 15 reps were achieved in set 4, the exercise load was increased with the smallest increment possible, that is, 2 kg for the goblet squat and 5 kg for the single-leg knee extensions and flexions. Load and reps were matched for the non-affected limb. The cuff was deflated immediately after the last set of each exercise. A physiotherapist instructed the patient to perform the exercises at baseline and again after 6 weeks of exercise. The patient completed all planned LL-BFR sessions.

## Outcome measures

Maximal voluntary isometric contraction (MVIC) of the patient's quadriceps was assessed using an isometric dynamometer (Humac Norm, CSMI, Stoughton, MA). The patient was seated with the hip flexed to approximately 90°. MVICs were performed at 70°, and the trial with the highest MVIC value was used to determine the patient's MVIC. The patient was instructed to perform the MVIC as rapidly and forcefully as possible, sustaining maximal force exertion for approximately 3 s, with 90 s of rest between each trial. Real-time visual feedback and strong verbal support were provided to the patient during the test. Single-legged hop test,[9] low-thigh circumference 10 cm above apex patella, the Knee Injury and Osteoarthritis Outcome Score (KOOS)[10] and the Forgotten Knee Joint Score (FJS)[11] was assessed at baseline and after 12 weeks of LL-BFR (Table 2).

**Table 1.** Exercise variables.

| Exercise variable | |
|---|---|
| Blood flow restriction | 80% LOP |
| Cuff width | 11.7 cm |
| Sets | 4 |
| Load intensity | 30% 1 RM |
| Repetitions first set | 30 |
| Repetitions second, third and fourth set | 15 |
| Contraction modes per repetition | 2 s concentric phase; 0 s isometric phase; 2 s eccentric phase |
| Range of motion | Maximum |
| Rest between sets | 30 s |
| Rest between exercises | 5 min |
| Rest between sessions | >24 h |

LOP: limb occlusion pressure; RM: repetition maximum.

## Results

The patient completed all planned exercise sessions. Total weight added to the exercises for the affected leg at the end of the intervention period equated to 20 kg. MVIC of knee extension improved from 286 to 326 Nm (14%) on the left limb, and from 328 to 350 Nm (7%) on the right limb. Single-legged hop test improved with 26 cm (23%) on the left limb and 3 cm (2%) on the right limb (Table 2). Thigh circumference increased 1.5 cm on the left limb and 2.4 on the right limb. KOOS pain, KOOS quality of life and FJS demonstrated improvements of 11, 6 and 40 points, respectively. After the LL-BFR rehabilitation, the patient was able to return to his usual lower-limb training regime consisting of traditional heavy-load exercises (i.e. barbell squats, deadlifts, lunges).

## Discussion

To our best knowledge, this is the first report of unsupervised LL-BFR provided to a patient suffering from patellofemoral pain. Thus, our case report extends our understanding about the applicability of home-based LL-BFR as a viable and safe

**Table 2.** Outcome measures from baseline to 12 weeks of low-load resistance training with concurrent blood flow restriction.

| Outcome measure | | Baseline | 12 weeks | Absolute difference | % Change |
|---|---|---|---|---|---|
| Maximal isometric voluntary contraction (Nm/kg) | Right | 3.5 | 3.7 | 0.2 | 6 |
| | Left | 3.1 | 3.5 | 0.4 | 13 |
| Single-leg hop test (cm) | Right | 143 | 146 | 3 | 2 |
| | Left | 115 | 141 | 26 | 23 |
| Low-thigh circumference (cm) | Right | 49.4 | 51.8 | 2.4 | 5 |
| | Left | 59.6 | 51.1 | 1.5 | 3 |
| KOOS (points) | | | | | |
| Pain | | 69.4 | 80.6 | 11.2 | 16 |
| Symptoms | | 92.9 | 96.4 | 3.6 | 4 |
| ADL | | 97.1 | 94.1 | −3 | −3 |
| Sport and Recreation | | 80.0 | 65.0 | −15.0 | −19 |
| Quality of life | | 43.8 | 50.0 | 6.3 | 14 |
| FJS | | 27.1 | 66.7 | 69.6 | 146 |

KOOS: Knee Osteoarthritis Outcome Score; ADL: activities of daily living; FJS: Forgotten Knee Joint Score; Nm: Newton meter; kg: kilogram; cm: centimeter.

rehabilitation strategy in patients suffering from patellofemoral, similar to that of heavy-load resistance training.[12,13] Interestingly, Giles et al. observed that patients who experience pain with quadriceps contractions (i.e. during knee extensions) induced significantly greater improvements in knee extensor torque after completing 8 weeks of LL-BFR leg press and knee extension compared to the same protocol with heavy loads. Thus, when pain is attenuating the load used during heavy-load resistance training, LL-BFR is more effective in terms of gains in maximal muscle strength and size.

The patient in our case report demonstrated excellent exercise adherence with no adverse events. This is in line with our previous studies where unsupervised LL-BFR has been suggested to be safe and feasible in various patient populations.[4–6,14]

Knee extensor MVIC increased 14% in the affected lower limb following the intervention. In contrast, no-to-minor improvements were observed in the non-affected lower limb. Thus, matching the workload to that of the affected limb may not have yielded a sufficient stimulus to promote gains in maximal muscle strength. The gains in knee extensor MVIC strength in the affected lower limb are lower than the improvements reported in Giles et al.[12] and Constantinou et al.[13] who both found that LL-BFR and conventional PRT improved knee extensor MVIC in patients with patellofemoral pain. This may be due to differences in the exercise protocols and the relatively high baseline fitness level of our patient.

The patient demonstrated a 23% improvement in single-legged hop test for the affected limb and no improvement in the non-affected limb, reducing the between-limb asymmetry from −28 cm at baseline to −5 cm at follow-up. Hence, as with knee extensor MVIC, the lack of improvements for the non-affected limb may reflect an insufficient exercise load to improve jumping performance.

Thigh circumference 10 cm above the apex patella was observed to increase more on the non-affected limb. However, the test-retest variability in mid-thigh circumference has been reported to be $-0.3 \pm 0.5$.[15] Therefore, it may be difficult to determine if the between-limb differences in thigh circumference are due to measuring error. Nonetheless, both thighs appear to have increased the circumference following the intervention.

The patient demonstrated clinically meaningful changes in KOOS pain and FJS. That is, a 10-point change for the KOOS subscales is considered to be a clinically relevant change. A 40-point change in FJS was observed, which is higher than the change observed in a previous case report of a patient suffering from reactive arthritis who performed 12 weeks of home-based unsupervised LL-BFR.[4] Ultimately, this indicates that the patient benefited from the LL-BFR protocol.

## Conclusion

The present case study indicates that even with low amounts of supervision, LL-BFR may increase muscle strength, functional performance and improve key patient-reported outcomes. LL-BFR seems to be a promising low-load exercise method to help patients back to a healthy lifestyle of training and being physically active.

### Acknowledgements

The authors would like to thank the patient for participating and accepting to let us use the data for the present case report.

### Author contributions

I.M., T.G.N., N.K., A.B. and S.L.J. drafted the manuscript, revised it for important intellectual content and were involved in the final approval of the version to be published. T.G.N. and N.K. tested the patient. S.L.J. supervised the exercises. I.M. and S.L.J. revised the article for important intellectual content and were involved in the final approval of the version to be published.

## Declaration of conflicting interests

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

## Funding

The authors received no financial support for the research, authorship and/or publication of this article.

## Ethics approval

Our institution does not require ethical approval for reporting individual cases or case series.

## Informed consent

Written informed consent was obtained from the patient for his anonymised information to be published in this article.

## ORCID iDs

Inger Mechlenburg https://orcid.org/0000-0001-5432-8691
Stian Langgård Jørgensen https://orcid.org/0000-0001-8195-8816

## References

1. D'Ambrosi R, Meena A, Raj A, et al. Anterior knee pain: state of the art. *Sports Med Open* 2022; 8(1): 98.
2. Kooiker L, Van De Port IG, Weir A, et al. Effects of physical therapist-guided quadriceps-strengthening exercises for the treatment of patellofemoral pain syndrome: a systematic review. *J Orthop Sports Phys Ther* 2014; 44(6): 391–402.
3. Jørgensen SL, Bohn MB, Aagaard P, et al. 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(10): e034376.
4. Jørgensen SL and 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.
5. Mortensen L, Mechlenburg I and Langgård Jørgensen S. Low-load blood-flow-restricted exercise to prevent muscle atrophy and decline in functional performance in a patient recovering from a malleolus fracture. A case report. *Clin J Sport Med* 2023; 33(1): 97–100.
6. Høgsholt M, Jørgensen SL, Rolving N, et al. Exercise with low-loads and concurrent partial blood flow restriction combined with patient education in females suffering from gluteal tendinopathy: a feasibility study. *Front Sports Act Living* 2022; 4: 881054.
7. Riley DS, Barber MS, Kienle GS, et al. CARE guidelines for case reports: explanation and elaboration document. *J Clin Epidemiol* 2017; 89: 218–235.
8. Conceição MS and Ugrinowitsch C. Exercise with blood flow restriction: an effective alternative for the non-pharmaceutical treatment for muscle wasting. *J Cachexia Sarcopenia Muscle* 2019; 10(2): 257–262.
9. Bremander AB, Dahl LL and Roos EM. Validity and reliability of functional performance tests in meniscectomized patients with or without knee osteoarthritis. *Scand J Med Sci Sports* 2007; 17(2): 120–127.
10. Roos EM and Lohmander LS. The knee injury and osteoarthritis outcome score (KOOS): from joint injury to osteoarthritis. *Health Qual Life Outcomes* 2003; 1: 64.
11. Bramming IB, Kierkegaard S, Lund B, et al. High relative reliability and responsiveness of the forgotten joint score-12 in patients with femoroacetabular impingement undergoing hip arthroscopic treatment. A prospective survey-based study. *J Hip Preserv Surg* 2019; 6(2): 149–156.
12. Giles L, Webster KE, McClelland J, et al. Quadriceps strengthening with and without blood flow restriction in the treatment of patellofemoral pain: a double-blind randomised trial. *Br J Sports Med* 2017; 51(23): 1688–1694.
13. Constantinou A, Mamais I, Papathanasiou G, et al. Comparing hip and knee focused exercises versus hip and knee focused exercises with the use of blood flow restriction training in adults with patellofemoral pain. *Eur J Phys Rehabil Med* 2022; 58(2): 225–235.
14. Petersson N, Langgård Jørgensen S, Kjeldsen T, et al. Blood flow restricted walking in elderly individuals with knee osteoarthritis: a feasibility study. *J Rehabil Med* 2022; 54: jrm00282.
15. Jakobsen TL, Christensen M, Christensen SS, et al. Reliability of knee joint range of motion and circumference measurements after total knee arthroplasty: does tester experience matter? *Physiother Res Int* 2010; 15(3): 126–134.