Title: Aerobic exercise may be a feasible therapeutic option for improving pain and function in patients with chronic lumbar radicular pain: a case series

Running title: Aerobic exercise for lumbar radicular pain

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ME currently works at RecoverPain, providing pain coaching support for people suffering from chronic low back pain and/or painful radiculopathy.

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Statement of Institutional Review Board

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TITLE

Aerobic exercise may be a feasible therapeutic option for improving pain and function in patients with chronic lumbar radicular pain: a case series

ABSTRACT

Background: Current first-line strategies to treat patients with lumbar radicular pain have limited benefits. Despite promising results in preclinical investigations, clinical studies investigating the effects of aerobic exercise (AE) is surprisingly scarce.

Case presentation: Five patients with lumbar radicular pain were included in this case series. AE was implemented into their pragmatic multi-component tele-rehabilitation plan.

Outcomes and Results: Patients were assessed before and after the tele-rehabilitation program through patient-reported outcome measures. Adherence rate and adverse events were collected at every session. AE proved to be safe and feasible. Patient-reported levels of pain and disability showed large clinically meaningful changes.

Discussion: AE might be considered as a feasible and potentially effective adjunct to improve pain and disability of patients with lumbar painful radiculopathy. Considering preclinical evidence and the safety/feasibility profile in patients, it might be useful to further investigate the potential benefits of AE in people with lumbar radicular pain.

Keywords: aerobic exercise; painful radiculopathy; sciatica; cycling; running; case series.

INTRODUCTION

Spine-related leg pain (SRLP, 'sciatica') is a common condition with a lifetime prevalence of up to 43%.[12] Patients with SRLP report worse clinical outcomes compared to patients with low back pain (LBP) only.[9] Previous findings suggest that this is particularly true for SRLP originating from neural structures.[14] This group of patients may have radicular pain or painful radiculopathy.[24] Unfortunately, conservative therapeutic options available for this population provide small relief at best, leaving patients with debilitating pain, disability and emotional distress.[5,18,22] Among physical therapy management strategies, most studies have investigated the efficacy of various forms of exercise (e.g., motor control, spine mobility exercises), manual therapy techniques, and neurodynamic movements.[5] These options are not any better than minimal interventions such as a single advice session, and are less effective than major interventions (e.g., surgery).[5] However, effect sizes differ among rehabilitation strategies and subgroups of patients; neurodynamic interventions, for instance, have medium to large effects in patients with heightened nerve mechanosensitivity.[3,16]

Just as preclinical evidence consistently shows beneficial effects of neurodynamic mobilizations, it also suggests that aerobic exercise (AE) improves pain-related behaviors in animal models of sciatic nerve injury.[15] AE reduces mechanical and thermal hypersensitivities compared to control interventions – a benefit likely linked to increases in neurotrophins and modulation of immune-responses.[21] These would be desirable effects in patients with focal entrapment neuropathies, where neuroinflammation is thought to play a role.[2,23] However, despite compelling preclinical literature, studies investigating the effectiveness of AE in humans are incredibly scarce, leading to a significant translational gap.[10] While a recent expert consensus statement recommends AE for chronic lumbar radiculopathy[27], current clinical practice guidelines include AE for chronic low back pain, but do not mention AE among suitable treatment options for spine-related leg pain due to the lack of studies investigating its efficacy in clinical populations.[8]

Given the lack of patient studies, the aim of this case series was twofold: first, to examine the details of the implementation of AE as part of a tele-rehabilitation plan for patients presenting with chronic lumbar radicular pain with or without radiculopathy, while exploring its feasibility and acceptability; second, to explore its potential effects on clinical outcomes.

CASE PRESENTATION

This case series aligned to the Case Report (CARE) guidelines.[20] We retrospectively described five case studies of patients seen between October 2024 to April 2025 in a private, secondary telemedicine care setting. The patients were selected as follows:

- Adults (≥18 years) presenting with a primary complaint of lumbar radicular pain, defined as pain radiating into the leg likely originating from nervous structures, with or without concomitant LBP and/or radiculopathy.
- Patients undergoing a physical therapy tele-rehabilitation program that included AE as part of their management plan.
- Sufficient data recorded regarding baseline characteristics, intervention details, and outcome measures.

Clinical records were excluded if they had missing data that would have led to inadequate reporting, and if patients presented with specific contraindications to AE, or had confirmed serious spinal pathology (e.g., fracture, malignancy, infection). Each patient's characteristics were summarized in **TABLE 1** and thoroughly reported in **Supplementary File 1**.

[Please, insert TABLE 1 here]

DIFFERENTIAL DIAGNOSIS

Details of the history and clinical assessment during the first consultations are reported in the **Supplementary File 1**. The criteria for diagnosing lumbar radicular pain with or without radiculopathy followed published clinical recommendations[11,26]: pins and needles or numbness in the involved lower limb; leg pain more severe than back pain; leg pain spreading below the knee; motor, sensory or reflex deficits upon neurological examination; positive neurodynamic test (e.g., Straight Leg Raise [SLR] or crossed SLR). The presence of a minimum sum score of 6 out of 10, representing 93% probability of sciatica, was required for inclusion.[26] The diagnosis of radicular pain was further supported by pain descriptors commonly associated with nerve pathology (e.g., burning, shooting, electric shock-like, tingling, pins and needles), imaging findings (e.g., Magnetic Resonance Imaging [MRI]) consistent with clinical observations, and leg symptoms modifiable through low back active movements (e.g., extension, lateral bending, forward bending) but not hip/knee movements.

The presence of radiculopathy was assessed through a modified neurological bedside examination, where any motor or sensory loss of function in the affected leg was interpreted as a sign of nerve pathology (see the **Supplementary File 2** for further details). [4,7]

TREATMENT

As these are case studies, we took a pragmatic rather than standardized approach, reporting on individualized treatment plans for each patient. Each patient participated in a multi-component tele-rehabilitation program until they considered themselves recovered. On average, patients attended 17.8 sessions (min-max: 10-25). The program was delivered via Zoom video calls. The intervention combined specific educational contents, graded strengthening exercises, and AE. Full details of each patient's program are available in **Supplementary File 3**.

Specific education messages were delivered using verbal explanations, metaphors, and educational resources. The aim was to help patients understand the difference between acute and persistent pain, the specifics of nerve pain, and the role of active recovery strategies such as AE.

The exercise component was progressive and tailored to each patient's functional capacity and goals outlined in their Patient Specific Functional Scale (PSFS). It typically began with nerve mobilization techniques (e.g., nerve sliders) performed daily within a pain-free range of motion. This was paired with a strengthening program, performed three times per week, that initially focused on unilateral exercises (e.g., single-leg gluteal bridges, single-leg box squats) to address strength deficits identified during the initial examination. As patients' tolerance and confidence improved, the program progressed to include more complex movements as well as specific activities that patients wanted to be able to perform again.

AE was prescribed to be performed 3-5 times per week. The specific modality was chosen based on the patient's preference and symptoms tolerance, utilizing either a stationary bike, walking, or a combination of walking and running. The initial prescription typically involved 20-30 minutes per session, with an intensity of 60-70% of their maximum heart rate (HRmax), monitored via a personal smartwatch. The HRmax was calculated through the Fox's equation (HRmax = 220 – age).[25] Although this formula presents some limitations (e.g., overestimation in younger people, underestimation in older people), it proved to be a feasible option for the general population.[25] For patients who chose running, a graded interval-based approach was used, starting with short running intervals (e.g., 1 minute) alternating with longer walking periods (e.g., 3 minutes). As tolerance improved, the duration and frequency of running intervals were progressively increased, while walking periods were reduced.

OUTCOMES, FOLLOW-UP and RESULTS

Patients were assessed at baseline and every month until the conclusion of their treatment plan, which lasted between three (2 cases) and six (3 cases) months. All outcomes were collected through questionnaires.

The primary outcomes were leg pain and function, measured by the Numeric Pain Rating Scale (NPRS) scale and PSFS, respectively. Minimally important differences were classified from small (NPRS -1.5, PSFS 1.3) to large (NPRS -3.5, PSFS 3.3).[1] Clinically meaningful improvements representing large effects were observed in all five cases (**TABLE 2** and **FIGURE 1**, **TABLE 2**). Four out of five patients (Patients 1, 3, 4, and 5) found AE decreased their pain immediately and for a few hours after exercise.

Adherence to the program was measured by asking patients in each session how much of the prescribed program they were able to perform. Adherence was high, with an average weekly adherence rate to the overall management plan of 87.6% (min-max: 82%-98%). Specific adherence to the aerobic exercise component was similarly high at 86.2% (min-max: 77%-98%). The main reported reasons for not performing the exercises or AE sessions were related to holidays, work travels, and family setbacks. Only Patient 5 did not perform the AE sessions of his first week due to fear of pain aggravation.

Adverse events were collected at each session through patient self-report. If symptoms worsened, a potential relationship with AE was investigated. Adverse events were classified into minor (i.e., any self-limiting exacerbation of symptoms lasting only during the AE or resolved in less than 24 hours), moderate (i.e., any temporary and self-limiting exacerbation of symptoms lasting less than 48 hours), and major (i.e., any exacerbation of symptoms that lasted longer than 48 hours and required the clinician to change the intensity of the rehabilitation plan). Four adverse events were classified as minor (Patients 1, 2, and 4), two as moderate (Patient 3), and none as major.

[Please, insert TABLE 2 here]

[Please, insert FIGURE 1 here]

DISCUSSION

This case series described the implementation and outcomes of a multi-component tele-rehabilitation program including tailored AE for five patients with chronic lumbar radicular pain. All cases demonstrated large clinically meaningful improvements with no major adverse events and high adherence rates. These findings suggest that this approach may be feasible, safe, and effective in reducing pain and improving function.

The positive outcomes observed in this report provide preliminary support in humans for the robust preclinical evidence suggesting the therapeutic potential of AE for nerve-related leg pain.[15,21] While the multi-component nature of our intervention and the pragmatic case series design prevent us from isolating the specific effects of AE and make any causal inferences, the consistent inclusion of AE and the positive results align with the hypothesized benefits of AE on neural health through enhanced neurotrophic factor expression and modulation of pro-inflammatory cytokines.[10,21] This approach contrasts with many conventional physical therapy strategies that often focused on manual therapy techniques and various forms of localized exercise (e.g., motor control, spine mobility), which have shown limited efficacy for lumbar radicular pain.[5] Notably, all five cases exhibited a directional preference toward lumbar extension. While expert consensus suggests considering directional-preference exercises in the acute stage, chronic-stage management prioritizes different types of exercises, which were implemented on a case-by-case basis here.[27]

Importantly, AE proved to be a safe intervention, with no major, 4 minor, and 2 moderate adverse events in these five patients. Despite what proved to be a safe implementation of AE, patients who started running needed to be reassured about its safety profile as they reported fears and beliefs similar to those highlighted in the Assessing Safety and Efficacy of Running on Intervertebral Discs (ASTEROID) trial by patients with chronic LBP and possibly due to online misinformation.[6,17] This safety concern was not found for cycling, highlighting its potential role as a first step to the implementation of AE in this population, complimented by the absence of adverse events related to it.

Four out of five patients found the AE particularly helpful in immediately reducing their pain. For this reason, patients 1, 3, and 5 performed AE sessions whenever their symptoms were at their worst (i.e., early morning hours in all cases), allowing them to go through the remainder of the day with significantly less pain and distress. While clinical research on this is lacking for patients with SRLP, immediate exercise induced hypoalgesia has consistently been shown in healthy people but is less consistent in low back pain populations.[19,28]

The strengths of this case series include the detailed description of a patient-centered, multi-modal intervention and the use of standardized outcome measures. The tele-rehabilitation delivery mode represents a modern and accessible approach to care. However, several limitations must be acknowledged. The design does not allow the establishment of a cause-and-effect relationship between the intervention and the observed outcomes. The improvements could be attributed to other components of the program or the natural history of the condition.[13] The small sample size, the patients' familiarity with exercise before treatment, and the high number of treatment sessions not available in many public healthcare settings limit the generalizability of our findings. Nevertheless, patients showed a gradual improvement of their pain and function which resulted in clinically meaningful moderate changes at 2 months, on average.[1] This suggests that high numbers of treatment sessions may not be required. While the online nature of consultations improves accessibility to this treatment, it led to unvalidated examination procedures, potentially causing misclassification or measurement error during the clinical examination. Finally, the intensity of AE might have been over- or underestimated, due to the known limitations of the Fox's equation[25] and we did not include long-term follow-up data beyond the completion of the tele-rehabilitation program.

Despite these limitations, this case series provides a valuable proof of concept. It suggested that AE, a low-cost and widely accessible intervention, can be safely and successfully integrated into the management plan for individuals with lumbar radicular pain, a population for whom effective conservative options are desperately needed. Future research, including randomized controlled trials, is warranted to confirm these findings, determine the optimal type and dosage of AE, and elucidate the underlying physiological mechanisms in humans.

LEARNING POINTS

1. Aerobic exercise appeared to be a feasible and safe adjunct to a multi-component rehabilitation program for patients with lumbar radicular pain.
2. Integrating aerobic exercise with specific education and graded strengthening might help reduce pain and improve function.
3. A graded, interval-based approach to introducing or re-introducing running could be an effective strategy for patients with radicular pain who wish to return to higher-impact activities.
4. Further high-quality research is needed to confirm the effectiveness of aerobic exercise and establish optimal treatment parameters for this patient population.

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FIGURE’S LEGEND

FIGURE 1. Development of leg pain over time – the graph shows each patient’s pain fluctuations throughout their rehabilitation program.

TABLES

TABLE 1. Characteristics of the included patients.

	Age	Sex	BMI	Country	Job	Leg Pain [a]	Symptom Duration	Disability [b]	N° of sessions	Aerobic exercise
Patient 1	25	M	27.3	USA	Purchasing agent	6	1 year	4	21	Alternating walk-run [c] Running
Patient 2	47	F	26.6	USA	Saleswoman	8	20 years	1.7	16	Alternating walk-run [c] Running
Patient 3	36	M	25.6	USA	Salesman	6	6 months	2	25	Alternating walk-run [c] Running (+ sprinting)
Patient 4	49	F	28.5	UK	Lawyer	7	2 years	2	17	Walking [d] Cycling
Patient 5	27	M	28.7	USA	Software engineer	7	1 year	2	10	Cycling Alternating walk-run

Abbreviations: BMI, body mass index; F, female; M, male; N°, number; UK, United Kingdom; USA, United States of America.

[a] Numeric Pain Rating Scale (0-10).

[b] Patient Specific Functional Scale, arithmetic mean of all the listed goals (0-10; the lower the score, the higher the disability).

[c] The alternating walk-run progressed to running without intervals over time.

[d] The walking was changed into cycling following the first week of her program due to consistent worsening of leg symptoms while walking.

TABLE 2. Outcome measures throughout the rehabilitation program.

	Patient 1		Patient 2		Patient 3		Patient 4		Patient 5	
	Baseline	**End [e]**	**Baseline**	**End [f]**	**Baseline**	**End [e]**	**Baseline**	**End [e]**	**Baseline**	**End [f]**
Pain [a]	6	2	8	0	6	1	7	1	7	1
Disability [b]	Total: 4 1) Touch the floor: 4 2) Workout: 2 3) Standing with confidence: 6	Total: 7.6 1) Touch the floor: 7 2) Workout: 7 3) Standing with confidence: 9	Total: 1.7 1) Walking: 2 2) Running: 0 3) Sitting: 3 4) Workout: 2	Total: 8 1) Walking: 10 2) Running: 7 3) Sitting: 7 4) Workout: 8	Total: 2 1) Sitting: 2 2) Sprinting: 0 3) Lower body workout: 1 4) Bending forward: 4 5) Sleeping: 3	Total: 8 1) Sitting: 8 2) Sprinting: 7 3) Lower body workout: 8 4) Bending forward: 9 5) Sleeping: 8	Total: 2 1) Daily walking: 2 2) Running: 0 3) Sitting at work: 3 4) Workout: 3	Total: 7.2 1) Daily walking: 8 2) Running: 6 3) Sitting at work: 9 4) Workout: 6	Total: 2 1) Badminton: 0 2) Sleeping: 4 3) Sitting: 4 4) Workout: 0 5) 10k steps: 2	Total: 7.2 1) Badminton: 6 2) Sleeping: 9 3) Sitting: 8 4) Workout: 6 5) 10k steps: 7
Adherence [c]	N/A	82% (77%)	N/A	93% (96%)	N/A	85% (80%)	N/A	98% (98%)	N/A	80% (80%)
Adverse events [d]	N/A	1 [g]	N/A	1 [h]	N/A	2 [j]	N/A	2 [k]	N/A	0

Abbreviations: N/A, not applicable; N/R, not reported.

[a] Numeric Pain Rating Scale (0-10).

[b] Patients Specific Functional Scale, specific values of all the listed goals (0-10; the lower the score, the higher the disability).

[c] Mean % of weekly adherence to the whole exercise plan (mean % of weekly adherence to the aerobic exercise component).

[d] Number of any reported adverse events attributed by patients to the aerobic exercise component of the program (e.g., pain exacerbations of any extent).

[e] Around six months total.

[f] Around three months total.

[g] Minor flare-up that resolved quickly – it occurred on a day, during his first week of the program, when he performed the walk-run intervals.

[h] Minor flare-up experienced as calf burning – it occurred during the first walk of her first week of the program and subsided as she continued walking.

[j] Moderate flare-up that lasted “a couple of days” and was experienced during the second week of the program, the day after having run for 20 minutes straight – he misinterpreted the protocol that involved alternated walks and runs. Moderate flare-up that lasted one night and was experienced during the sixth week of the program due to the recently increased running intensity and duration.

[k] Minor flare-ups experienced as leg tightness and foot pain at the beginning of the walks performed during her first week of the program – they did not lead to lasting increase in pain but were the reason why the walking was changed into the stationary bike.

SUPPLEMENTARY FILES

Supplementary File 1. Full description of each patient's characteristics and findings from their examination session.

Supplementary File 2. Details of online neurological examination.

Supplementary File 3. Full description of each patient's intervention.