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Type D Personality, Back Pain, and Vagus Nerve Stimulation in Orthopaedic Rehabilitation: A Systematic Narrative Review with Clinical Case

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Abstract

Background: Type D personality (negative affectivity and social inhibition) is associated with poor outcomes in cardiovascular and orthopaedic populations. Recent studies show significant associations with chronic back pain. Vagus nerve stimulation (VNS), particularly in its non-invasive form of transcutaneous auricular stimulation (taVNS), has emerged as a promising neuromodulatory approach to restore autonomic balance and attenuate inflammatory signaling.

Methods: A systematic narrative review (2005–2025) was conducted in PubMed, Scopus, PsycINFO, and Web of Science. Inclusion criteria: validated DS14 assessment, pain outcomes, and autonomic/inflammatory measures. Studies were screened according to PRISMA guidelines.

Results: Eight studies showed that Type D personality is associated with higher pain, disability, and increased risk of pain chronification. Mechanisms include maladaptive stress processing, movement avoidance, and inflammatory activation (IL-6, TNF-α). Nine taVNS studies demonstrated reductions in cytokines, improved HRV, postoperative analgesia, and enhanced wound healing. A clinical case illustrates successful taVNS application in delayed recovery after knee arthroplasty. No studies have directly tested taVNS in Type D patients; however, mechanistic overlaps suggest that taVNS may counteract pathophysiological features of Type D personality.

Conclusion: Type D personality represents a biopsychosocial risk factor with biological underpinnings in autonomic and inflammatory dysregulation. VNS and taVNS provide a biologically plausible, safe, and scalable intervention with potential relevance for this population. Future randomized controlled trials are required to establish efficacy of taVNS in Type D patients within cardiovascular and orthopedic rehabilitation.

Keywords: Type D Personality; Back Pain; Vagus Nerve Stimulation; taVNS; Orthopaedics; Rehabilitation; Inflammation

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List of Abbreviations

ANS – Autonomic Nervous System, CV – Cardiovascular, DS14 – Denollet Scale (14-item questionnaire for Type D personality), HRV – Heart Rate Variability, HPA axis – Hypothalamic-Pituitary-Adrenal axis, IL-6 – Interleukin-6, LBP – Low Back Pain, NA – Negative Affectivity, ODI – Oswestry Disability Index, QoL – Quality of Life, RCT – Randomized Controlled Trial, RA – Rheumatoid Arthritis, SI – Social Inhibition, taVNS – Transcutaneous Auricular Vagus Nerve Stimulation, TKA – Total Knee Arthroplasty, TNF-α – Tumor Necrosis Factor-alpha, VAS – Visual Analogue Scale, VNS – Vagus Nerve Stimulation

Introduction

Chronic back pain is one of the most common musculoskeletal disorders worldwide and contributes significantly to disability and socioeconomic burden [1]. While structural abnormalities often fail to correlate with pain intensity, psychosocial factors are increasingly recognised as determinants of chronicity [2]. The Type D personality construct, defined by negative affectivity (NA) and social inhibition (SI). It is linked to worse prognosis after myocardial infarction, impaired recovery following orthopedic surgery, increased chronic pain, and heightened systemic inflammation [3–5]. Mechanistically, Type D is associated with autonomic nervous system (ANS) imbalance, particularly reduced vagal activity as indicated by decreased heart rate variability (HRV) and exaggerated sympathetic tone and pro-inflammatory cytokine elevation [6].

Vagus nerve stimulation (VNS) and transcutaneous auricular vagus nerve stimulation (taVNS) activate the cholinergic anti-inflammatory reflex, modulating both peripheral cytokine release and central pain circuits [7, 8]. Recent studies highlight potential applications in postoperative pain, wound healing, and orthopaedic rehabilitation [9].

Given the biological convergence of Type D-related autonomic dysregulation and taVNS-mediated vagal modulation, exploring their intersection is warranted. This review synthesizes current evidence linking Type D personality, chronic back pain with the emerging field of taVNS-based interventions, complemented by a clinical case example.

Methods

Search strategy: PubMed, Scopus, PsycINFO, and Web of Science were searched (2005–2025) using combinations of ('Type D personality' OR 'distressed personality') AND ('back pain' OR 'low back pain') AND ('vagus nerve stimulation' OR 'taVNS').

Inclusion criteria: Original studies or systematic reviews (human and preclinical), or meta-analyses; validated DS14 for Type D; adult populations; outcomes related to pain, rehabilitation, autonomic or inflammatory parameters, english language.

Exclusion criteria: Case reports (except as illustrative), editorials, unrelated populations.

Two reviewers independently screened abstracts and full texts. Data were extracted on population, intervention/exposure, outcomes, and methodological quality. A PRISMA flow diagram was constructed (Figure 1).

Results

Type D Personality and Back Pain

Cross-sectional analyses demonstrated higher pain intensity, longer duration, and greater disability among Type D patients [10–13]. A meta-analysis reported medium effect sizes (d=0.4–0.6) linking Type D with pain and disability [14]. Longitudinal cohorts confirmed increased risk of chronicity and poor rehabilitation outcomes [15]. Mechanisms included maladaptive cognitions (catastrophising, reduced self-efficacy), avoidance behaviour, reduced social support, and biological correlates such as HPA axis hyperactivity and elevated IL-6 and TNF-α [16–18].

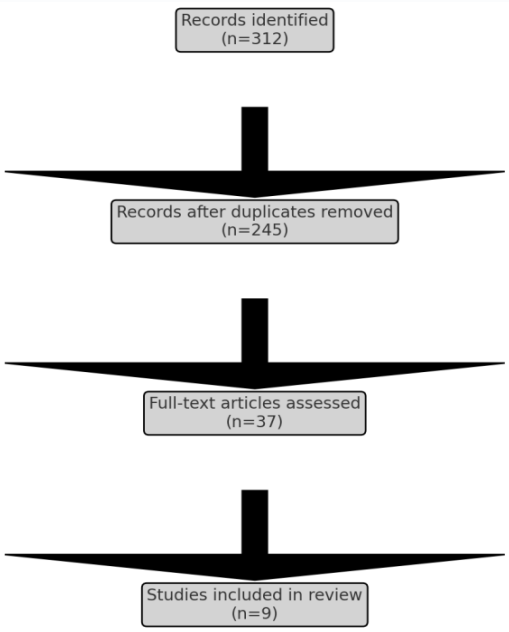


Figure 1: PRISMA flow diagram of literature selection.

Autonomic Dysregulation: Type D individuals exhibit significantly lower HRV, impaired vagal baroreflex sensitivity, and heightened sympathetic activation [6, 19].

Inflammatory Profiles: Elevated circulating TNF-α and IL-6 are consistently reported in Type D patients [11].

Orthopedic & Rehabilitation Outcomes: Type D predicts delayed wound healing, more severe pain after surgery, and poorer physical recovery trajectories [12].

Vagus Nerve Stimulation (taVNS)

Nine studies addressed taVNS in musculoskeletal and rehabilitation contexts. In rheumatoid arthritis, invasive VNS reduced TNF-α and improved disease activity in some RCTs [19, 20], although results varied. Randomised controlled trials showed taVNS reduced postoperative pain and opioid use [21, 22], supported by meta-analysis confirming modest analgesic effects [23]. Preclinical work suggested benefits for wound healing and bone remodeling [24–26]. A summary of included studies and their critical appraisal is provided in Table 1.

Inflammation: VNS reduces pro-inflammatory cytokines in rheumatoid arthritis [18, 19].

Pain Control: taVNS decreases postoperative and trauma-related pain, and reduces opioid consumption [20, 21].

Wound Healing & Tissue Repair: Preclinical data suggest vagal modulation accelerates repair and perfusion [23].

Bone Remodeling: Animal studies indicate vagal involvement in osteoblast/osteoclast regulation [24, 25].

Integration: Type D ↔ taVNS

The pathophysiological overlaps are striking:

Autonomic imbalance: Type D patients show reduced HRV; taVNS restores vagal activity.

Inflammation: Type D linked to elevated IL-6 and TNF-α; taVNS suppresses these cytokines.

Table 1: Critical appraisal of included VNS/taVNS studies relevant to rehabilitation.

Author, Year	Population/Model	Intervention/Endpoints	Quality rating
Koopman 2016	RA patients	Invasive VNS ↓TNF-α, ↓DAS28	+++
Staats 2021	RA patients	Invasive VNS no significant effect	++
Williams 2020	RA patients	Invasive VNS heterogeneous results	++
Yin 2025	Postoperative patients	taVNS ↓Pain, ↓Opioids	++
Li 2025	Orthopedic trauma	taVNS ↓Pain, improved function	+
Costa 2024	Systematic review	Modest pain reduction	+++
Budhiraja 2024	Review	Wound healing	++
Liu 2024	Animal models	VNS Bone remodeling	++
Xia 2025	Animal models	VNS Bone metabolism	++

Table 2: Conceptual Overlap: Type D vs. taVNS Mechanisms.

Pathophysiological Feature	Type D Personality	taVNS Effects
Autonomic Tone	Low HRV, reduced vagal activity	Increased vagal activity, restored HRV
Inflammation	↑TNF-α, ↑IL-6	↓Pro-inflammatory cytokines
Pain	Higher chronic and postoperative pain	Analgesia, reduced opioid use
Recovery	Delayed wound healing, poor rehab outcomes	Improved tissue repair, perfusion, function

Table 3: Timeline of clinical course showing pain (VAS), oxycodone dose, and wound status.

Week	Pain (VAS)	Oxycodone Dose (mg/day)	Wound Status
Baseline (Week 0)	8	40	Delayed healing, serous discharge
Week 2	5	20	Improving, partial closure
Week 3	4	0	Marked improvement
Week 5	2	0	Complete closure

Pain outcomes: Type D predicts higher chronic pain; taVNS reduces pain and opioid use.

Rehabilitation: Type D delays recovery; taVNS enhances wound healing and tissue repair.

The conceptual overlap between Type D pathophysiology and taVNS mechanisms is presented in Table 2.

Clinical Case Example

Clinical Box: Adjunctive taVNS in Delayed Recovery after Knee Arthroplasty.

A 67-year-old female presented with persistent pain (VAS 8/10) and delayed wound healing three weeks after total knee arthroplasty, despite multimodal analgesia (40 mg oxycodone/day). Adjunctive taVNS was applied (25 Hz, 30 min, 5 sessions/week for 4 weeks) alongside standard rehabilitation. Within two weeks, pain decreased to VAS 5 and oxycodone reduced to 20 mg/day. By week 3, pain improved to VAS 4 and no opioids were required. At week 5, the wound was fully closed and function improved markedly (Table 3 and Figure 2). No adverse events occurred. This case illustrates the potential of taVNS as a safe adjunctive therapy for pain reduction, opioid sparing, and wound healing in orthopaedic rehabilitation.

Discussion

This review highlights the overlap between Type D personality-related pathophysiology and mechanisms targeted by taVNS. Type D predisposes to chronic pain via autonomic imbalance, maladaptive behaviour, and systemic inflammation. taVNS counters these processes by restoring vagal tone and activating the cholinergic anti-inflammatory pathway.

The clinical vignette exemplifies how taVNS may reduce pain, decrease opioid dependence, and promote tissue healing in postoperative rehabilitation. This aligns with preclinical and pilot clinical evidence, strengthening the biological plausibility of integrating taVNS into orthopaedic care.

Limitations

Most studies on Type D and back pain are cross-sectional, limiting causal inference. Methodological heterogeneity in both Type D and taVNS research limits cross-study comparisons. Psychosocial moderators (e.g., depression, anxiety) need to be disentangled from Type D effects. Future research should include randomized controlled trials testing taVNS in Type D subgroups within orthopedic and cardiac rehabilitation. Mechanistic studies combining psychometrics, HRV, cytokine assays, and taVNS biomarkers. Development of personalized rehabilitation strategies integrating psychological and neuromodulatory interventions.

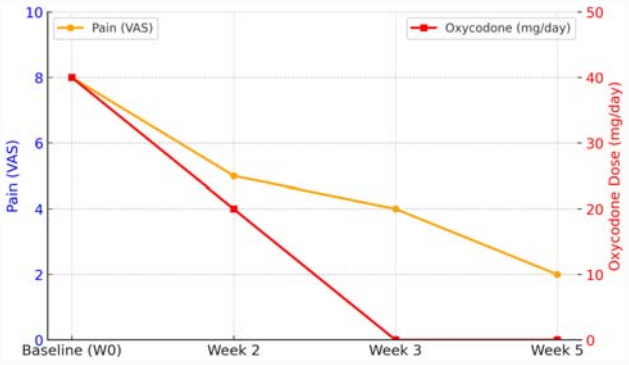


Figure 2: Timeline of clinical course showing reduction in pain (VAS) and opioid use during rehabilitation with adjunctive taVNS.

Conclusion

Type D personality is a psychosocial and biological risk factor for back pain chronicity and poor orthopaedic outcomes. Vagus nerve stimulation and taVNS are biologically plausible interventions targeting these mechanisms. While no direct evidence currently links taVNS efficacy to Type D patients, the convergence of pathophysiology provides a compelling rationale for future clinical trials.

Declarations

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Availability of data and materials: Not applicable.

Authors' contributions: Christian Riediger and Agnieszka Halm-Pozniak conceived the study. Mark Ferl and Maria Schönrogge performed the literature search. Christian Riediger and Maria Schönrogge drafted and revised the manuscript. All authors approved the final version.

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