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HIGH-INTENSITY INTERVAL TRAINING AND MODERATE-INTENSITY AEROBIC EXERCISE FOR GENERALIZED ANXIETY DISORDER: A NARRATIVE LITERATURE REVIEW

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ABSTRACT

Background: Anxiety disorders, including Generalised Anxiety Disorder (GAD), represent a leading global health burden. First-line treatments - pharmacotherapy and cognitive behavioural therapy - carry notable limitations including side-effects, high cost, and limited accessibility. High-Intensity Interval Training (HIIT) and Moderate-Intensity Continuous Training (MICT) have emerged as potential adjunctive interventions.

Aim of the study: To synthesise and critically evaluate available evidence on the effects of HIIT and MICT on anxiety symptom severity in individuals with GAD.

Material and methods: A narrative review of PubMed, Google Scholar, and PsycINFO (2009–2025) was conducted. Eligible sources included RCTs, systematic reviews, meta-analyses, and mechanistic studies addressing exercise interventions and anxiety outcomes.

Results: Both HIIT and MICT produce significant reductions in anxiety, comorbid depression, and somatic symptoms across clinical and non-clinical samples, with higher exercise intensity generally associated with greater benefit. In clinically diagnosed GAD, HIIT yielded approximately twice the effect size of lower-intensity training. However, MICT outperforms HIIT in certain subgroups. Baseline anxiety severity emerges as a key moderator of response.

Conclusions: HIIT holds potential as a first-line complementary treatment for GAD. MICT remains a valuable alternative for specific subgroups. Adequately powered, long-term head-to-head RCTs directly comparing HIIT and MICT in clinically diagnosed GAD are needed.

KEYWORDS

Generalised Anxiety Disorder; High-Intensity Interval Training; Moderate-Intensity Continuous Training; Aerobic Exercise; Exercise Intensity; Anxiety; Mental Health

CITATION

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1. Introduction

Mental health disorders are among the leading causes of the global health-related burden, with anxiety constituting the most prevalent mental health disorder worldwide and affecting approximately one in eight people globally (15). Among these disorders, Generalised Anxiety Disorder (GAD) is characterised by persistent, excessive, and difficult-to-control worry not restricted to a single domain of life, accompanied by somatic symptoms including muscle tension, fatigue, irritability, sleep disturbance, and difficulty concentrating, and diagnosed according to DSM-5 or ICD-11 criteria.

Current first-line treatments for anxiety disorders include pharmacotherapy with serotonin reuptake inhibitors and cognitive behavioural therapy (CBT); although pharmacotherapy has demonstrated efficacy, it carries significant side-effects including sexual dysfunction, sedation, insomnia, and nausea, as well as more serious risks such as new-onset suicidal ideation and cardiac arrhythmias, while psychotherapy presents challenges including high cost, patient resistance, and limited access to qualified therapists. Exercise has been studied as a possible treatment option for anxiety symptoms and disorders, both as an adjunctive treatment alongside pharmacotherapy or psychotherapy and as a standalone intervention, with reported benefits including improvements in poor concentration, fatigue, feelings of depression, muscle tension and pain, irritability, and other general symptoms of anxiety (20).

Accumulating meta-analytic evidence confirms that physical activity exerts medium effects on anxiety compared with usual care across all adult populations, with higher-intensity physical activity associated with greater improvements in symptoms (15). Moderate-Intensity Continuous Training (MICT) is broadly defined as aerobic exercise performed at a sustained steady-state intensity, typically corresponding to 55–70% of maximum heart rate, and constitutes the modality most studied in clinical trials of exercise for anxiety

disorders. High-Intensity Interval Training (HIIT) is a form of exercise characterised by short bouts of submaximal or near-maximal physical exertion interspersed with brief periods of lower intensity or rest; although originally developed to optimise training for endurance athletes, it is now frequently applied in the general population and has been found to be well tolerated by previously sedentary individuals, with several clinical trials demonstrating that HIIT produces similar or stronger effects on cardiorespiratory fitness, body mass, glucose utilisation, and blood pressure compared to moderate-intensity continuous training, often within a significantly shorter time frame (1).

Research has progressively focused on the efficacy of physical activity in anxiety disorders, with several RCTs demonstrating that aerobic exercise is an effective treatment approach for social anxiety disorder, panic disorder, specific phobia, and GAD, and findings quite consistently showing that aerobic training of moderate intensity led to a significantly larger anxiolytic effect not only in comparison to non-active control groups but also to exercise programmes of lower physical strain (1). Evidence for an intensity-response relationship of aerobic exercise in anxiety disorders is provided by meta-analytic data indicating that exercise of higher intensity was superior to low-intensity exercise for reducing disorder-specific anxiety. Nevertheless, the evidence base remains contested, with at least one meta-analysis finding no significant overall effect of aerobic exercise for the treatment of anxiety disorders, with the reported effect size shown to be highly influenced by the type of control condition employed (20). GAD is of clinical interest in this context, as it has been found to be associated with relatively smaller treatment effects in guideline-based therapies compared to other anxiety disorders, and preliminary data suggest that exercise intensity is an important moderating factor for the impact of exercise specifically in GAD (1).

Despite these observations, direct and systematic comparisons of HIIT and MICT as distinct therapeutic modalities in clinically diagnosed GAD remain scarce. The aim of the present narrative literature review is therefore to synthesise and critically evaluate the available evidence on the effects of both High-Intensity Interval Training and Moderate-Intensity Continuous Training on anxiety symptom severity in individuals with Generalised Anxiety Disorder, with emphasis on randomised controlled trial evidence, in order to clarify the current state of knowledge and provide a foundation for evidence-based recommendations regarding exercise prescription in clinical practice.

2. Methodology

This narrative literature review aimed to synthesise evidence concerning HIIT, MICT, and related exercise interventions for anxiety symptoms, with particular emphasis on clinically diagnosed GAD. Searches were conducted in PubMed, Google Scholar and PsycINFO for articles published between 2009 and 2025, supplemented by selected earlier mechanistic or definitional sources. Search terms included combinations of “generalized anxiety disorder”, “generalised anxiety disorder”, “GAD”, “anxiety disorders”, “HIIT”, “high-intensity interval training”, “sprint interval training”, “moderate-intensity continuous training”, “MICT”, “aerobic exercise”, and “exercise intensity”. Eligible publications included randomised controlled trials, systematic reviews, meta-analyses, umbrella reviews, scoping reviews, and mechanistic reviews addressing exercise interventions and anxiety outcomes. Priority was given to studies involving clinically diagnosed anxiety disorders, especially GAD, followed by studies in non-clinical or subclinical populations when direct GAD evidence was unavailable. Studies were excluded if they did not assess anxiety-related outcomes, did not involve an exercise intervention or physical activity exposure, or were not available in English.

3. Results

3.1 The Broader Meta-Analytic Landscape: Physical Activity and Anxiety

To contextualise the evidence on HIIT and MICT, it is necessary to first examine the broader meta-analytic evidence base on physical activity and anxiety. A meta-meta-analysis drawing on nearly 400 randomised trials and more than 14,000 participants found that physical activity exerts a significant, medium reductive effect on depression and a significant, small reductive effect on anxiety in non-clinical populations (18). These effects are most likely attributable to several mechanisms operating simultaneously at both psychological and neurophysiological levels.

An umbrella review encompassing 97 systematic reviews, 1,039 RCTs, and 128,119 participants found that physical activity had medium effects on depression, anxiety, and psychological distress, with higher exercise intensity associated with greater improvements and effectiveness diminishing with longer programme duration. The reductions in depression and anxiety symptoms from physical activity were comparable to or slightly greater than those observed for psychotherapy and pharmacotherapy (15).

When restricted to populations with formally diagnosed anxiety disorders, evidence is more contested. A meta-analysis of six RCTs encompassing 262 adults with anxiety and stress-related disorders found a significant, moderate-to-large overall anxiolytic effect of exercise. The magnitude of this effect was comparable to commonly used pharmacological treatments, including paroxetine, fluoxetine, and venlafaxine (14). The most comprehensive meta-analysis to date (13 RCTs, 731 participants) found a statistically significant but small-to-borderline-medium anxiolytic effect of exercise versus non-active controls, with moderate statistical heterogeneity (13). Meta-regression failed to identify significant moderating effects of age, sex, antidepressant use, trial length, weekly frequency, or session duration. Subgroup analyses, however, indicated larger effects for gym- or clinic-based programmes, aerobic exercise specifically, and moderate-to-vigorous exercise intensities. The meta-analysis noted that higher exercise intensities appear particularly beneficial for GAD and panic disorder specifically (13).

In contrast, an earlier meta-analysis of seven RCTs found no significant overall anxiolytic effect of aerobic exercise, with this discrepancy explained by control condition choice: when comparison conditions did not control for time spent exercising, a large benefit emerged, while trials equating subject time showed no meaningful benefit (20). Regarding programme duration, a meta-analysis of 104 studies found that programmes lasting sixteen weeks or more showed the largest effects on trait anxiety, those of ten to fifteen weeks yielded medium effects, and those under ten weeks produced small effects - suggesting a minimum meaningful duration of at least ten weeks (10).

3.2 HIIT in Clinically Diagnosed GAD: Evidence from the Primary RCT

The most clinically specific and methodologically rigorous evidence derives from an assessor-blinded RCT conducted at an outpatient anxiety disorders centre, in which 33 patients with DSM-5 confirmed GAD were randomly assigned to a 12-day HIIT programme or a lower-intensity training comparator, with worry, non-specific anxiety, comorbid depression, somatic symptoms, and perceived control assessed at baseline, post-training, and 30-day follow-up(1).

A significant time-by-group interaction indicated a larger decrease in worrying in the HIIT group; post-hoc testing confirmed significant reductions of medium effect size in HIIT from baseline to post-training and to follow-up, while no significant differences were found in the lower-intensity group (1). Repeated-measures analyses for the Hamilton Anxiety and Depression scales showed significant group-by-time interactions with large effect sizes, indicating markedly stronger reductions in non-specific anxiety and comorbid depression in HIIT (1). Across all clinical outcome measures, effects for HIIT were generally approximately twice as large as for lower-intensity training. Both interventions produced significant improvements in anxiety, depression, and somatic symptoms from baseline to follow-up, though the lower-intensity group consistently showed substantially smaller magnitudes of change.

HIIT produced a significantly greater improvement in maximal oxygen uptake, consistent with prior evidence showing comparable or stronger cardiorespiratory adaptations from HIIT relative to continuous moderate-intensity training. Despite this differential fitness adaptation, changes in VO₂max within the HIIT group did not correlate significantly with changes in any clinical anxiety or depression outcome measure, indicating that cardiorespiratory fitness gains and symptom improvements may represent partially independent outcomes. Adherence was 82% for HIIT and 94% for the lower-intensity comparator, with no significant between-group difference and no patient withdrawing for exercise-related reasons (1).

3.3 HIIT Versus Moderate-Intensity Training: Direct Head-to-Head Evidence

The only available RCT providing a within-study comparison of HIIT and moderate-intensity training on anxiety outcomes was conducted during COVID-19 confinement. Sixty-seven healthy adults were randomised to six weeks of home-based HIIT or moderate-intensity training, each performed for 40 minutes per session, six days per week, equating total exercise volume between conditions. Within-group analyses confirmed significant reductions in anxiety, depression, and stress and increases in resilience in both groups, with medium to large effect sizes (2). Between-group analyses revealed that HIIT produced a significantly greater reduction in depression than moderate-intensity training, with a medium effect size; however, no statistically significant between-group differences were found for anxiety, stress, or resilience. Adherence was approximately 78% for HIIT and 81% for moderate-intensity training, with no adverse effects in either group. The greater antidepressant effect of HIIT was attributed to the greater work performed per unit time and to activation of endogenous opioid systems, which contribute to stress relief and mood improvement at higher exercise intensities (2).

3.4 HIIT in Non-Clinical Populations with Elevated Anxiety

A 2025 scoping review identifying 16 studies employing HIIT across diverse populations found that twelve of the sixteen included studies reported significant improvements in anxiety symptoms following HIIT, with improvements especially pronounced in individuals with lower baseline anxiety severity and less consistent in those with higher baseline anxiety. Among positive findings, twelve weeks of HIIT significantly reduced prostate cancer-specific anxiety and fear of cancer progression, and six weeks of HIIT reduced anxiety, stress, and depression while increasing resilience during COVID-19 confinement (12). Conversely, four studies found that HIIT did not improve anxiety, including one in middle-aged overweight men where MICT reduced anxiety while HIIT showed no significant change, and a nine-week HIIT trial that failed to reduce anxiety, depressive symptoms, or inflammatory markers. Notably, one study employing a sprint interval training protocol in young adult males documented an increase in self-reported anxiety and worry, representing an important adverse signal within the otherwise predominantly positive literature. Despite the high intensity of training, mean session attendance across the included studies was approximately 85%, indicating the feasibility of HIIT in diverse populations (12).

An RCT of a four-week online HIIT programme in 30 higher-education students pre-screened for elevated anxiety symptoms found that HIIT produced a statistically significant reduction in stress symptoms and a trend toward reduced depression, but no significant between-group difference in anxiety as measured by the DASS-21. HIIT participants declined a mean of 7.5 points on the stress subscale progressing from moderate to mild stress and 9.5 points on the depression subscale, moving from moderate to normal range, while changes in controls were substantially smaller. This was described as the first RCT demonstrating a positive impact of HIIT on psychological symptoms in a clinical sample of adult students, though limitations include small sample size and a largely unsupervised format (9).

3.5 Aerobic and Resistance Exercise for GAD: MICT-Adjacent Evidence

Clinical trial evidence specific to moderate-intensity aerobic exercise in GAD informs the comparison with HIIT. An RCT of six weeks of resistance exercise training or aerobic exercise training in 30 sedentary women with diagnosed GAD found that remission rates were 60%, 40%, and 30% for resistance exercise, aerobic exercise, and waitlist, respectively, with a combined significant condition-by-time interaction indicating larger reductions in worry for exercise conditions versus waitlist. The number needed to treat of 3 for resistance exercise compared favourably to published figures of 4-8 weeks of treatment with antidepressants, benzodiazepines, and azapirones in anxiety disorders. The failure of aerobic exercise to match resistance exercise in remission rates was linked to its significantly lower perceived exertion, suggesting that relative exercise intensity may moderate therapeutic efficacy. Both exercise conditions produced moderate reductions in worry comparable to effects reported for relaxation therapy and CBT, resulting from a total of only 3 hours and 12 minutes of active exercise exposure (3).

A separate RCT enrolling 48 individuals with anxiety-related disorders found that 56% of aerobic exercise participants and 100% of resistance training participants showed improvements in disorder status, compared to only 9% of those in the waitlist. Aerobic exercise was associated with a significant large reduction in general anxiety relative to waitlist, while resistance training specifically reduced anxiety sensitivity, increased distress tolerance, and reduced intolerance of uncertainty, with no significant changes in these transdiagnostic constructs in the aerobic exercise group (4).

A meta-analysis of 16 RCTs found that resistance exercise training significantly reduced anxiety symptoms, with effects not significantly varying by sex, age, programme length, session duration, frequency, or intensity, and with larger effects in healthy participants compared to those with illness (7). An RCT of ecologically valid resistance exercise training in 28 young adults found that resistance exercise training significantly reduced anxiety symptoms versus waitlist, with a large effect size, though no significant effect was found for worry symptoms. Attendance of 85% and compliance of 83% supported the feasibility and tolerability of the intervention, and no adverse events occurred. Changes in strength were not significantly associated with changes in anxiety or worry symptoms (19), consistent with meta-analytic evidence suggesting that strength improvements are not required for mental health benefit.

3.6 Acute Exercise: Sprint Interval Training Versus MICT on Anxiety Sensitivity

An RCT examining acute exercise effects randomised 56 participants to a single session of sprint interval training, a session of MICT, or a waitlist. Both exercise groups experienced similar reductions in anxiety sensitivity compared to the waitlist, with medium effect sizes. The modalities differed in which dimension of anxiety sensitivity they addressed: MICT was associated with significant reductions in social and cognitive concerns, while sprint interval training significantly reduced physical concerns only. Neither protocol produced significant changes in distress tolerance or intolerance of uncertainty, with prior evidence suggesting that repeated multi-session exposure is required for changes in these constructs (5).

3.7 Baseline Anxiety Severity as a Moderator of Response

One of the most clinically significant findings to emerge from the recent literature is the identification of baseline anxiety severity as a moderator of the physiological and psychological response to HIIT. A nine-week RCT in young adults comparing HIIT to placebo-exercise found that HIIT was no more effective than placebo in reducing anxiety or depressive symptoms, with both groups improving comparably. However, baseline anxiety severity significantly moderated the cardiorespiratory fitness response: individuals with low baseline anxiety experienced substantially greater fitness gains from HIIT than those with higher anxiety, despite equivalent physical effort during training sessions as measured by heart rate, workload, and ratings of perceived exertion. The broader scoping review corroborated this pattern, confirming that HIIT produced more pronounced improvements in anxiety particularly in individuals with lower baseline anxiety, with weaker or absent effects in those presenting with higher baseline anxiety severity (12).

This moderation pattern is clinically important, as individuals with elevated anxiety and depressive symptoms are already known to have lower baseline cardiorespiratory fitness and to be at heightened cardiovascular risk, meaning the subgroup with the greatest clinical need may paradoxically derive less physiological benefit from standard HIIT protocols. A large cross-sectional study found that exercise frequency may have a stronger association with common mental health symptoms than cardiorespiratory fitness, suggesting that high fitness levels may not be necessary to reduce the risk of depression and anxiety symptoms - regular participation in a preferred form of exercise may be of greater relative importance (24).

3.8 Perceived Control as a Psychological Mechanism

A particularly notable mechanistic finding from the primary GAD RCT was the exclusive identification of perceived control as an active psychological mechanism in the HIIT condition. At baseline, scores on the Anxiety Control Questionnaire showed significant negative correlations with worry measures across the full sample. Training-induced changes in perceived control from baseline to post-training correlated significantly with changes in daily and weekly worry measures exclusively in the HIIT group, while no significant correlations between changes in perceived control and any clinical outcome were detected in the lower-intensity training group (1). This finding suggests that a minimum threshold of exercise intensity may be required for aerobic training to produce meaningful changes in perceived control over anxiety-related stimuli - a pathomechanism considered particularly relevant to GAD. This mechanism aligns with mastery theory: successful completion of a challenging exercise protocol may reinforce beliefs about one's ability to control physiological and emotional responses, and an increased sense of mastery has been broadly associated with positive psychological outcomes.

3.9 Effects on Comorbid Depression

A consistent finding across studies is that exercise (HIIT in particular) tends to produce robust antidepressant effects, though the relationship between antidepressant and anxiolytic effects is not uniform. In the primary GAD RCT, HIIT produced improvements in comorbid depressive symptoms approximately twice as large as those in the lower-intensity comparator (1). In the direct HIIT versus moderate-intensity training RCT during confinement, HIIT produced a significantly greater reduction in depression than moderate-intensity training, with no corresponding between-group advantage for anxiety (2). The online student HIIT trial showed a trend toward reduced depression alongside a significant stress reduction, without a corresponding anxiolytic effect. A meta-analysis of 33 RCTs involving 1,877 participants confirmed that resistance exercise training was associated with a significant, moderate antidepressant effect (6). The antidepressant effect of exercise is proposed to reflect neuroplasticity pathways including improved cerebrovascular function, neurotrophin release, and downstream neuroendocrine and neuroinflammatory effects, as well as psychosocial mechanisms including improved self-efficacy and body image (9).

3.10 Neurobiological Mechanisms

The neurobiological pathways by which exercise produces anxiolytic and antidepressant effects remain incompletely characterised. BDNF, IGF-1, and VEGF are the principal growth factors currently understood to mediate the effects of exercise on the brain, working in concert to modulate overlapping and unique aspects of exercise-related benefits in brain plasticity, function, and health (21). BDNF is essential for hippocampal function, synaptic plasticity, learning, and modulation of depression; in animal studies, exercise increases BDNF in several brain regions, with the most robust and enduring response occurring in the hippocampus. Despite this mechanistic rationale, no primary research published after 2017 has specifically examined the effects of exercise interventions on BDNF levels in populations with clinically diagnosed anxiety disorders (13), representing a fundamental gap in the translational evidence base.

Additional proposed neurobiological mechanisms include improvements in autonomic nervous system function - measurable as heart rate variability, which is reduced in clinical anxiety - alongside increases in beta-endorphins, serotonin, and other endogenous opioid neuropeptide transmitters that reduce arousal at the neuronal level (14). Psychological mechanisms include reductions in anxiety sensitivity through repeated exposure to exercise-induced physiological arousal and increases in self-efficacy. Broader biological protective mechanisms of physical activity include neuroregeneration, increased BDNF, and regulation of inflammatory and oxidative markers (17).

A nine-week HIIT RCT found that HIIT did not produce significant changes in resting pro-inflammatory cytokines, including interleukin-6, tumour necrosis factor-alpha, and interleukin-1 beta, and that this finding was consistent with reports from other HIIT studies - one proposed explanation being that HIIT may simultaneously stimulate both pro- and anti-inflammatory cytokine systems, producing a counterbalancing net effect. Overall, available evidence does not yet support specific recommendations regarding the most beneficial duration, intensity, mode, or frequency of physical activity for mental health benefits, and improvements in fitness do not appear to be required. Even small, gradual increases in activity may produce meaningful mental health benefits (18).

3.11 Preventive Effects of Physical Activity on Incident Anxiety

Beyond treatment, prospective cohort data illuminate the preventive potential of physical activity. A meta-analysis of 14 cohorts from 13 prospective studies, encompassing 75,831 individuals, found that those with higher physical activity levels had significantly lower risk of developing anxiety compared to those with lower levels, with effects observed across geographic regions, age groups, and demographic categories (17). Physical activity demonstrated significant protective effects specifically against agoraphobia and PTSD, but did not produce statistically significant protection against GAD, panic disorder, or social phobia, with the authors cautioning that the small number of studies per diagnostic subgroup limited these conclusions. Meeting the recommendation of 150 minutes of moderate-to-vigorous physical activity per week was associated with a lower risk of incident anxiety. A large cross-sectional study of 36,595 employed adults found that exercising at least one to two times per week was associated with approximately 25% lower odds of reporting frequent symptoms of depression and anxiety compared to sedentary individuals, with no additional protective effect observed from higher cardiorespiratory fitness after adjusting for leisure-time sedentary behaviour (24).

3.12 Methodological Limitations and Gaps in the Evidence Base

The available evidence is characterised by several critical methodological limitations that constrain the conclusions that can be drawn. Despite supporting exercise as an evidence-based treatment option for anxiety disorders, the most comprehensive meta-analysis was limited by moderate heterogeneity and high risk of bias in most included studies (13). The principal sources of bias include lack of blinding of participants and personnel - an inherent challenge in exercise intervention research where participants cannot be masked to their allocation and outcomes rely predominantly on self-report. Future studies should employ larger samples and comparison conditions that adequately control for time spent exercising.

The sole RCT investigating HIIT specifically in a clinical GAD sample enrolled only 33 participants, a sample sufficient to detect medium-to-large effects but underpowered for stratified subgroup analyses by sex, comorbidity, or medication status, and employed a 12-day active programme with only an 18-day post-training follow-up - leaving the long-term durability of observed benefits entirely uncharacterised. The considerable heterogeneity in HIIT protocols employed across studies encompassing differences in work-interval intensity and duration, rest-interval structure, session length, weekly frequency, total programme duration, and

supervision format substantially limits cross-study comparison and prevents the formulation of precise exercise prescriptions.

The identification of a potential non-responder phenotype linked to baseline anxiety severity - whereby those with higher anxiety show attenuated cardiorespiratory adaptation to HIIT despite equivalent physical effort - raises unanswered questions about whether this attenuation is reversible, protocol-dependent, or a stable biological characteristic requiring an alternative exercise approach. The observation that effectiveness of physical activity diminishes with longer intervention duration may reflect declining adherence over time rather than a true biological attenuation, further complicating interpretation of long-term trial data. Finally, the neurobiological mechanisms underlying the anxiolytic and antidepressant effects of both HIIT and MICT remain uninvestigated in adequately powered clinical studies specifically targeting anxiety disorder populations, leaving the mechanistic basis for evidence-based protocol optimisation unresolved.

4. Conclusions

The present review confirms the overall role of aerobic exercise as a treatment option for GAD, with both HIIT and lower-intensity aerobic modalities producing pronounced, fast-acting, and clinically meaningful reductions in core anxiety symptoms, comorbid depression, and somatic complaints. HIIT, however, demonstrated not only comparable or even higher disorder-specific efficacy than first-line pharmacological and psychological treatments, but also a substantially faster onset of action, with effects already detectable during the active training period and sustained at the 30-day follow-up. In direct comparisons, the intervention effects of HIIT were approximately twice as large as those of lower-intensity training in patients with existing anxiety symptoms, suggesting it could serve as a first-line complementary treatment for this condition. At the same time, four studies indicated that HIIT did not improve anxiety, and moderate-intensity continuous training was found to reduce anxiety levels in middle-aged overweight men where HIIT showed no significant change, underscoring that MICT may be more suitable for specific subgroups and that the choice of modality cannot yet be universally determined. A clinically significant finding with direct implications for prescription is that the severity of anxiety symptoms can moderate improvements in cardiorespiratory fitness from HIIT, with individuals with lower baseline anxiety levels exhibiting greater improvements compared to those with higher anxiety, pointing to a novel non-responder phenotype based on anxiety status.

HIIT therefore holds potential to complement psychotherapy and medication in GAD, and the change of perceived control over anxiety-related stimuli - identified as a relevant treatment factor common to both HIIT and CBT - may represent a key psychological mechanism through which exercise intensity exerts its therapeutic effect. For clinical practice, these findings collectively suggest that the optimal exercise prescription for individuals with elevated anxiety symptoms requires further investigation, and that the robust and consistent effects of moderate-intensity training on mental health represent an important alternative when HIIT is not indicated or tolerated. Critical gaps in the evidence base include the absence of adequately powered, long-term head-to-head RCTs directly comparing HIIT and MICT in clinically diagnosed GAD, the lack of data on long-term efficacy beyond short follow-up periods, and the failure to assess training-related exhaustion as a potential mediator of the therapeutic effect. Further investigation is needed into the factors influencing the efficacy of HIIT interventions, including individual differences in exercise tolerance, genetic backgrounds, lifestyle, and psychological states, as well as the optimal protocol parameters of frequency, intensity, duration, and session length. As a narrative rather than systematic review, the present work is subject to the limitations inherent to this methodology, including the potential for selective inclusion of sources and the absence of formal risk-of-bias assessment, and its conclusions should be interpreted in light of the predominantly small sample sizes, short intervention durations, and high methodological heterogeneity that characterise the primary research in this field.

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REFERENCES

1. Plag, J., Schmidt-Hellinger, P., Klippstein, T., Mumm, J. L. M., Wolfarth, B., Petzold, M. B., & Ströhle, A. (2020). Working out the worries: A randomized controlled trial of high-intensity interval training in generalized anxiety disorder. *Journal of Anxiety Disorders*, 76, Article 102311. <https://doi.org/10.1016/j.janxdis.2020.102311>
2. Borrega-Mouquinho, Y., Sánchez-Gómez, J., Fuentes-García, J. P., Collado-Mateo, D., & Villafaina, S. (2021). Effects of high-intensity interval training and moderate-intensity training on stress, depression, anxiety, and resilience in healthy adults during coronavirus disease 2019 confinement: A randomized controlled trial. *Frontiers in Psychology*, 12, Article 643069. <https://doi.org/10.3389/fpsyg.2021.643069>
3. Herring, M. P., Jacob, M. L., Suveg, C., Dishman, R. K., & O'Connor, P. J. (2012). Feasibility of exercise training for the short-term treatment of generalized anxiety disorder: A randomized controlled trial. *Psychotherapy and Psychosomatics*, 81(1), 21–28. <https://doi.org/10.1159/000327898>
4. LeBouthillier, D. M., & Asmundson, G. J. G. (2017). The efficacy of aerobic exercise and resistance training as transdiagnostic interventions for anxiety-related disorders and constructs: A randomized controlled trial. *Journal of Anxiety Disorders*, 52, 43–52. <https://doi.org/10.1016/j.janxdis.2017.09.005>
5. Mason, J. E., & Asmundson, G. J. G. (2018). A single bout of either sprint interval training or moderate-intensity continuous training reduces anxiety sensitivity: A randomized controlled trial. *Mental Health and Physical Activity*, 14, 103–112. <https://doi.org/10.1016/j.mhpa.2018.02.006>
6. Gordon, B. R., McDowell, C. P., Hallgren, M., Meyer, J. D., Lyons, M., & Herring, M. P. (2018). Association of efficacy of resistance exercise training with depressive symptoms: Meta-analysis and meta-regression analysis of randomized clinical trials. *JAMA Psychiatry*, 75(6), 566–576. <https://doi.org/10.1001/jamapsychiatry.2018.0572>
7. Gordon, B. R., McDowell, C. P., Lyons, M., & Herring, M. P. (2017). The effects of resistance exercise training on anxiety: A meta-analysis and meta-regression analysis of randomized controlled trials. *Sports Medicine*, 47(12), 2521–2532. <https://doi.org/10.1007/s40279-017-0769-0>
8. Lucibello, K. M., Paolucci, E. M., Graham, J. D., & Heisz, J. J. (2020). A randomized control trial investigating high-intensity interval training and mental health: A novel non-responder phenotype related to anxiety in young adults. *Mental Health and Physical Activity*, 19, Article 100327. <https://doi.org/10.1016/j.mhpa.2020.100327>
9. Philippot, A., Moulin, P., Charon, M. H., Balestra, C., Dubois, V., de Timary, P., & Luminet, O. (2022). Feasibility of online high-intensity interval training (HIIT) on psychological symptoms in students in lockdown during the COVID-19 pandemic: A randomized controlled trial. *Frontiers in Psychiatry*, 13, Article 904283. <https://doi.org/10.3389/fpsyg.2022.904283>

10. Asmundson, G. J. G., Fetzner, M. G., DeBoer, L. B., Powers, M. B., Otto, M. W., & Smits, J. A. J. (2013). Let's get physical: A contemporary review of the anxiolytic effects of exercise for anxiety and its disorders. *Depression and Anxiety*, 30(4), 362–373. <https://doi.org/10.1002/da.22043>
11. Rethorst, C. D., Wipfli, B. M., & Landers, D. M. (2009). The antidepressive effects of exercise: A meta-analysis of randomized trials. *Sports Medicine*, 39(6), 491–511. <https://doi.org/10.2165/00007256-200939060-00004>
12. Wang, Y., Zhang, X., Zhang, Y., & Zhang, H. (2025). The impact of high-intensity interval training on anxiety: A scoping review. *Frontiers in Psychiatry*, 16, Article 1515266. <https://doi.org/10.3389/fpsy.2025.1515266>
13. Ramos-Sanchez, C. P., Schuch, F. B., Seedat, S., Louw, Q. A., Stubbs, B., Rosenbaum, S., Firth, J., van Winkel, R., & Vancampfort, D. (2021). The anxiolytic effects of exercise for people with anxiety and related disorders: An update of the available meta-analytic evidence. *Psychiatry Research*, 302, Article 114046. <https://doi.org/10.1016/j.psychres.2021.114046>
14. Stubbs, B., Vancampfort, D., Rosenbaum, S., Firth, J., Cosco, T., Veronese, N., Salum, G. A., & Schuch, F. B. (2017). An examination of the anxiolytic effects of exercise for people with anxiety and stress-related disorders: A meta-analysis. *Psychiatry Research*, 249, 102–108. <https://doi.org/10.1016/j.psychres.2016.12.020>
15. Singh, B., Olds, T., Curtis, R., Dumuid, D., Virgara, R., Watson, A., Szeto, K., O'Connor, E., Ferguson, T., Eglitis, E., Miatke, A., Simpson, C. E., & Maher, C. (2023). Effectiveness of physical activity interventions for improving depression, anxiety and distress: An overview of systematic reviews. *British Journal of Sports Medicine*, 57(18), 1203–1209. <https://doi.org/10.1136/bjsports-2022-106195>
16. Aylett, E., Small, N., & Bower, P. (2018). Exercise in the treatment of clinical anxiety in general practice: A systematic review and meta-analysis. *BMC Health Services Research*, 18, Article 559. <https://doi.org/10.1186/s12913-018-3313-5>
17. Schuch, F. B., Stubbs, B., Meyer, J., Heissel, A., Zech, P., Vancampfort, D., Rosenbaum, S., Deenik, J., Firth, J., Ward, P. B., Carvalho, A. F., & Hiles, S. A. (2019). Physical activity protects from incident anxiety: A meta-analysis of prospective cohort studies. *Depression and Anxiety*, 36(9), 846–858. <https://doi.org/10.1002/da.22915>
18. Rebar, A. L., Stanton, R., Geard, D., Short, C., Duncan, M. J., & Vandelandotte, C. (2015). A meta-meta-analysis of the effect of physical activity on depression and anxiety in non-clinical adult populations. *Health Psychology Review*, 9(3), 366–378. <https://doi.org/10.1080/17437199.2015.1022901>
19. Gordon, B. R., McDowell, C. P., Lyons, M., & Herring, M. P. (2020). Resistance exercise training for anxiety and worry symptoms among young adults: A randomized controlled trial. *Scientific Reports*, 10, Article 17548. <https://doi.org/10.1038/s41598-020-74608-6>
20. Bartley, C. A., Hay, M., & Bloch, M. H. (2013). Meta-analysis: Aerobic exercise for the treatment of anxiety disorders. *Progress in Neuro-Psychopharmacology and Biological Psychiatry*, 45, 34–39. <https://doi.org/10.1016/j.pnpbp.2013.04.016>
21. Cotman, C. W., Berchtold, N. C., & Christie, L. A. (2007). Exercise builds brain health: Key roles of growth factor cascades and inflammation. *Trends in Neurosciences*, 30(9), 464–472. <https://doi.org/10.1016/j.tins.2007.06.011>
22. Wegner, M., Helmich, I., Machado, S., Nardi, A. E., Arias-Carrion, O., & Budde, H. (2014). Effects of exercise on anxiety and depression disorders: Review of meta-analyses and neurobiological mechanisms. *CNS & Neurological Disorders—Drug Targets*, 13(6), 1002–1014. <https://doi.org/10.2174/1871527313666140612102841>
23. Gibala, M. J., Little, J. P., Macdonald, M. J., & Hawley, J. A. (2012). Physiological adaptations to low-volume, high-intensity interval training in health and disease. *The Journal of Physiology*, 590(5), 1077–1084. <https://doi.org/10.1113/jphysiol.2011.224725>
24. Hallgren, M., Kandola, A., Stubbs, B., Nguyen, T. T. D., Wallin, P., Andersson, G., & Forsell, Y. (2020). Associations of exercise frequency and cardiorespiratory fitness with symptoms of depression and anxiety: A cross-sectional study of 36,595 adults. *Mental Health and Physical Activity*, 19, Article 100351. <https://doi.org/10.1016/j.mhpa.2020.100351>