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Effects of Physical Activity on Mental Health and Cognitive Function: A Review of Current Evidence

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Abstract. The relationship between physical activity and mental health has attracted sustained scientific interest, with a rapidly expanding evidence base charting both the psychological benefits of regular exercise and the neurobiological mechanisms through which movement shapes brain structure and function. This narrative review synthesises peer-reviewed literature published between 2015 and 2026 examining the effects of physical activity on mental health outcomes — including depression, anxiety, stress, and subjective well-being — and on cognitive functions encompassing executive function, memory, attention, and processing speed across the lifespan. Six primary mechanistic domains are reviewed: monoaminergic and endocannabinoid neurochemistry, hypothalamic-pituitary-adrenal axis modulation, neuroplasticity and brain-derived neurotrophic factor upregulation, anti-inflammatory effects, psychosocial and self-efficacy pathways, and sleep-mediated mechanisms. Evidence from randomised controlled trials, longitudinal cohort studies, and meta-analyses consistently supports the conclusion that regular moderate-to-vigorous physical activity produces clinically meaningful improvements across mental health and cognitive outcome domains, with effect sizes comparable to those of pharmacological and psychological therapies for common mental disorders. Moderating variables including exercise intensity, modality, duration, social context, and individual characteristics are identified and their implications for exercise prescription discussed. Gaps in the evidence base — including a relative scarcity of long-term mechanistic studies, inadequate representation of older adults and LMICs, and limited investigation of dose-response thresholds — are highlighted alongside priorities for future research.

Keywords: Physical activity, exercise, mental health, cognitive function, depression, anxiety, neuroplasticity, BDNF, executive function, well-being.

1. Introduction

The burden of mental health disorders and cognitive decline represents one of the defining public health challenges of the 21st century. According to the World Health Organization (2022), depression affects more than 280 million people globally and is the leading cause of disability worldwide, while anxiety disorders affect an estimated 301 million individuals. Concurrently, the global prevalence of dementia — projected to triple to 153 million cases by 2050 — and the widespread recognition of age-related cognitive decline as a determinant of quality of life and independence in older populations have intensified the search for modifiable protective factors (Nichols et al., 2022). Against this backdrop, physical activity has emerged as one of the most consistently evidence-supported and accessible interventions for the prevention and management of mental health disorders and cognitive impairment — an intervention whose benefits extend across the lifespan, require no prescription, and carry a favourable safety profile relative to pharmacological alternatives (Schuch et al., 2018). This review addresses the current state of evidence on the mental health and cognitive effects of physical activity, with particular attention to the mechanistic pathways through which movement influences brain function and the moderating variables that determine the magnitude and durability of these effects.

Physical activity is defined broadly as any bodily movement produced by skeletal muscle contraction that results in energy expenditure above resting levels, encompassing structured exercise, recreational sport, occupational activity, active transport, and domestic tasks (Caspersen et al., 1985, as cited in Warburton & Bredin, 2017). This breadth of definition is important for the review's scope: while the majority of experimental evidence is derived from structured aerobic and resistance exercise interventions, observational evidence on the mental health and cognitive benefits of physical activity in naturalistic settings provides complementary insights into the population-level public health significance of movement behaviour. The dose-response question — how much physical activity is needed, of what type, intensity, and duration, to produce clinically meaningful mental health and cognitive benefits — is a central analytical focus of the review, as it directly informs the physical activity guidelines and exercise prescription recommendations that practitioners apply in clinical and community settings.

The review is organised around six mechanistic domains through which physical activity is proposed to influence mental health and cognitive function, followed by a synthesis of evidence on specific outcome domains (depression, anxiety, stress, cognitive function, and dementia prevention), a discussion of moderating variables, and sections on clinical implications and future research priorities. The integration of mechanistic and outcomes-focused analysis reflects the dual purpose of the review: to advance scientific understanding of how physical activity affects the brain and mind, and to provide the evidence foundation for practice and policy recommendations that maximise the mental health and cognitive benefits of physical activity across the population.

2. Neurobiological Mechanisms Linking Physical Activity to Mental Health

The neurochemical mechanisms underlying exercise-induced improvements in mood and mental health have been most extensively investigated through the monoamine hypothesis, which attributes the antidepressant and anxiolytic effects of exercise to increased synaptic availability of serotonin, dopamine, and norepinephrine in limbic and cortical regions implicated in mood regulation. Heijnen et al. (2016) reviewed neuroimaging and neurochemical evidence demonstrating that aerobic exercise consistently elevates central monoamine activity, with the magnitude of effect correlated with exercise intensity and duration and with individual differences in baseline monoamine system function. The dopaminergic component of this effect has particular relevance for motivation, reward processing, and the hedonic valence of experience, providing a neurochemical mechanism for the improvements in anhedonia — the inability to experience pleasure that is a core symptom of depression — that meta-analyses have documented as a specific benefit of exercise alongside its general antidepressant effect. The endocannabinoid system contributes a complementary mechanism: Raichlen and Polk (2016) demonstrated that moderate aerobic exercise reliably elevates circulating anandamide, a principal endocannabinoid ligand with anxiolytic and analgesic properties, with implications for the stress-buffering and mood-enhancing effects of exercise that operate independently of the opioid and monoaminergic systems.

Neuroplasticity — the brain's capacity to reorganise its structure and function in response to experience — represents the most direct and structurally significant mechanism linking physical activity to cognitive function. Brain-derived neurotrophic factor (BDNF), a neurotrophin essential for neuronal survival, synaptic plasticity, and hippocampal neurogenesis, is robustly upregulated by aerobic exercise across species and is proposed as a primary molecular mediator of exercise-induced cognitive enhancement (Szuhany et al., 2015). Szuhany and colleagues conducted a meta-analysis of 29 randomised controlled trials and demonstrated that both acute exercise bouts and chronic exercise training programmes produced significant increases in resting and post-exercise BDNF levels, with larger chronic effects in individuals who trained at higher intensities and for longer durations. Hippocampal neurogenesis, driven partly by BDNF upregulation, has been directly demonstrated in rodent models through histological analysis of newly formed neurons in the dentate gyrus following aerobic exercise, and indirect evidence from human neuroimaging studies — demonstrating exercise-induced increases in hippocampal volume and grey matter density in regions critical for memory consolidation — suggests that analogous neuroplastic processes operate in the human brain (Erickson et al., 2017).

The hypothalamic-pituitary-adrenal (HPA) axis, the principal neuroendocrine mediator of

the stress response through cortisol secretion, is significantly modulated by habitual physical activity in ways that contribute to psychological resilience and stress tolerance. Zschucke et al. (2015) demonstrated in a controlled experimental paradigm that regular aerobic exercisers exhibited significantly attenuated HPA axis reactivity to standardised psychosocial stressors compared to sedentary controls, with the magnitude of cortisol blunting positively correlated with habitual aerobic fitness. This stress inoculation effect — in which repeated exercise-induced activation and subsequent downregulation of the HPA axis habituates the system to stress, reducing its reactivity to subsequent stressors of diverse types — provides a neurobiological mechanism for the well-documented relationship between physical fitness and psychological resilience. Complementing the HPA axis effects, exercise exerts anti-inflammatory actions through the suppression of pro-inflammatory cytokines including interleukin-6 (IL-6), tumour necrosis factor-alpha (TNF-α), and C-reactive protein, which have been mechanistically implicated in the aetiology of depression and cognitive impairment through their effects on neuroinflammation and microglial activation (Silverman & Deuster, 2022).

3. Physical Activity and Depression: Evidence and Effect Sizes

The evidence for the antidepressant effects of physical activity is among the most extensively documented in the exercise-mental health literature, with a hierarchy of evidence from randomised controlled trials and meta-analyses that places physical activity among the most evidence-supported non-pharmacological interventions for depression. The landmark meta-analysis by Schuch et al. (2018), drawing on 25 prospective studies with a combined sample of 1,487,172 participants, found that high physical activity levels were associated with a 35% lower risk of incident depression compared to low physical activity levels, with a dose-response relationship in which each unit increase in physical activity was associated with a further reduction in depression risk — establishing physical activity as a protective factor against depression onset at the population level. In the treatment domain, a meta-analysis of 33 randomised controlled trials by Morres et al. (2019) found a large and significant antidepressant effect of aerobic exercise (Hedges' g = 0.79) in individuals with diagnosed major depressive disorder, with effects comparable to those of antidepressant medication in head-to-head comparisons and without the side effects, discontinuation syndrome, and long-term medication dependence concerns associated with pharmacotherapy.

The mechanisms through which exercise produces antidepressant effects — reviewed in the preceding section — are complemented by psychosocial mechanisms that may be equally important in determining the practical effectiveness of exercise as a depression treatment in real-world settings. Self-efficacy enhancement — the increased confidence in one's capacity to accomplish demanding tasks that derives from successful physical performance — has been consistently identified as a mediator of the antidepressant effects of exercise in both experimental and naturalistic studies, consistent with Bandura's Social Cognitive Theory of the role of mastery experiences in building generalised self-efficacy and counteracting the learned helplessness that characterises many presentations of depression (Fernandez et al., 2019). Distraction from ruminative thought, increased social interaction through group exercise, and the mastery of physical skills each contribute additional psychosocial mechanisms that operate in parallel with the neurobiological pathways. Blumenthal et al. (2016) conducted a pivotal randomised controlled trial comparing exercise, antidepressant medication, and their combination in adults with major depressive disorder and found that exercise alone produced remission rates comparable to medication after 16 weeks of treatment, with superior long-term maintenance of antidepressant effects at 10-month follow-up in participants who maintained exercise behaviour post-trial — a finding with profound implications for the sustainability of physical activity as an antidepressant intervention.

4. Physical Activity and Anxiety: Mechanisms and Outcomes

The anxiolytic effects of physical activity have been documented across acute and chronic timescales, with distinct mechanistic underpinnings at each level. Acute exercise — a single bout of moderate aerobic activity lasting 20 to 60 minutes — produces immediate reductions in state anxiety that persist for up to several hours post-exercise, a phenomenon attributed to the endocannabinoid, monoaminergic, and thermogenic mechanisms reviewed in section 2 alongside the psychological absorption and attentional engagement that vigorous physical activity demands (Stonerock et al., 2015). A meta-

analysis of acute exercise effects on anxiety by Ensari et al. (2015) found a moderate and significant anxiolytic effect of single exercise bouts (Cohen's d = 0.48), with aerobic modalities demonstrating larger effects than resistance exercise and moderate intensities producing larger reductions in anxiety than low or high intensities — suggesting an inverted-U dose-response relationship that has practical implications for the prescription of exercise-based anxiety management strategies.

Chronic exercise training produces more durable anxiolytic effects through structural and functional neuroplastic changes, including HPA axis habituation, BDNF-mediated hippocampal neurogenesis, and the progressive development of stress tolerance that repeated exercise-induced HPA activation confers. A systematic review and meta-analysis by Aylett et al. (2018) examining the effects of exercise on anxiety disorders — including generalised anxiety disorder, social anxiety disorder, panic disorder, and post-traumatic stress disorder — found significant reductions in anxiety symptom severity across disorder types, with moderate effect sizes (Hedges' g = 0.38–0.60) that, while somewhat smaller than for depression, are clinically meaningful and supported by a mechanistic plausibility that is well specified in the literature. Anxiety sensitivity — the tendency to interpret benign physiological arousal cues as threatening, a cognitive vulnerability factor central to the maintenance of panic disorder and anxiety-related avoidance — has been specifically reduced by repeated exposure to the physiological arousal of vigorous exercise, through a process of interoceptive exposure that desensitises the threat appraisal system to the bodily sensations of cardiovascular exertion, providing a mechanism of particular relevance for the anxiety-reducing effects of exercise in individuals with elevated anxiety sensitivity (Smits et al., 2016).

The social context of exercise participation moderates anxiolytic effects in ways that have implications for exercise programme design. Group exercise formats — fitness classes, team sports, walking groups, and supervised exercise sessions — confer social support and belonging benefits that amplify the individual psychological effects of physical activity and that address the social avoidance that characterises many anxiety presentations. Conversely, highly competitive or performance-evaluated exercise contexts may exacerbate social anxiety symptoms in vulnerable individuals, underscoring the importance of matching exercise environment to individual psychological needs rather than applying a one-size-fits-all approach to exercise prescription for anxiety management (Stubbs et al., 2017). Exercise as an adjunct to established anxiety treatments — particularly cognitive-behavioural therapy, with which the interoceptive exposure mechanism of exercise most directly aligns — has been evaluated in several trials and may offer synergistic benefits by simultaneously addressing the cognitive, behavioural, and neurobiological maintaining factors of anxiety disorders, although the evidence base for combination approaches remains smaller than for exercise as a standalone intervention.

5. Effects of Physical Activity on Cognitive Function and Executive Control

The effects of physical activity on cognitive function — encompassing executive function, working memory, attention, processing speed, and long-term memory — represent one of the most active areas of exercise neuroscience, with a compelling evidence base spanning epidemiological cohort studies, experimental acute exercise paradigms, and chronic exercise training trials. A definitive meta-analysis by Northey et al. (2018), drawing on 39 randomised controlled trials involving 2,788 participants aged 50 years and older, found that physical activity interventions significantly improved overall cognitive function (Hedges' g = 0.29), with the largest effects observed on cognitive composite scores and memory outcomes, and with aerobic exercise, resistance training, and combined exercise modalities all demonstrating significant positive effects relative to active and inactive controls. These findings extended prior meta-analytic evidence and resolved earlier debates about modality specificity by demonstrating that multiple exercise types produce cognitive benefits, with the possible advantage of combined aerobic and resistance training over single modalities in producing the broadest cognitive improvement profiles.

Executive function — the suite of higher-order cognitive processes including working memory, cognitive flexibility, inhibitory control, and planning that depend on prefrontal cortex integrity and are essential for goal-directed behaviour in everyday life — shows particularly robust and consistent improvement following physical activity, with acute effects demonstrable within 30 minutes of moderate aerobic exercise and chronic effects building

over weeks to months of regular training. Chang et al. (2015) conducted a comprehensive meta-analysis of acute exercise effects on executive function and found significant improvements in inhibitory control, working memory updating, and cognitive flexibility immediately following exercise, with effects persisting for up to 60 minutes post-exercise and larger effects observed following moderate-intensity aerobic exercise relative to low-intensity or high-intensity conditions — a finding consistent with the inverted-U hypothesis of arousal and performance and with the neurochemical evidence on intensity-dependent monoamine and BDNF responses. The neuroimaging evidence underlying these executive function improvements includes exercise-induced increases in prefrontal cortex activation, enhanced functional connectivity between prefrontal and hippocampal regions, and greater cerebral blood flow to anterior cortical regions — structural and functional adaptations that collectively support the upregulation of the prefrontal networks subserving executive control.

The cognitive benefits of physical activity across the lifespan show particularly important patterns of effect at the developmental extremes. In children and adolescents, a systematic review by Donnelly et al. (2016) found consistent evidence that physical activity and aerobic fitness were associated with superior academic achievement, attention, and executive function, with classroom-based physical activity breaks demonstrating acute improvements in on-task behaviour and cognitive performance that have practical implications for school-based physical activity policy. In older adults — a population for whom age-related cognitive decline and dementia prevention are priority concerns — aerobic exercise produces structural hippocampal plasticity that partially reverses the age-related volumetric reduction that predicts memory impairment and dementia risk (Erickson et al., 2017). A landmark randomised controlled trial by Erickson et al. demonstrated that 12 months of moderate aerobic exercise increased hippocampal volume by 2% in older adults, effectively reversing 1–2 years of age-related hippocampal shrinkage, with corresponding improvements in spatial memory performance and serum BDNF levels that provided direct evidence for the neuroplastic mechanism.

6. Physical Activity in the Prevention of Dementia and Cognitive Decline

The evidence that regular physical activity reduces the risk of dementia — including Alzheimer's disease and vascular dementia, the two most prevalent dementia subtypes — is among the most clinically significant findings in the exercise-mental health literature, given the catastrophic personal, family, and societal burden of dementia and the current absence of disease-modifying pharmacological treatments. A meta-analysis by Livingston et al. (2020), published as part of the Lancet Commission on Dementia Prevention, Intervention, and Care, estimated that physical inactivity accounted for approximately 2% of the global dementia burden — a population-attributable fraction that, while modest in proportional terms, translates to millions of preventable dementia cases given the scale of global dementia prevalence. Prospective cohort studies with follow-up periods of 10 to 25 years have consistently demonstrated that individuals in the highest physical activity tertiles experience 25–45% lower dementia incidence than those in the lowest tertiles, with dose-response relationships extending into very high activity levels and effects observed for both aerobic and mixed activity types (Northey et al., 2018).

The mechanisms through which physical activity reduces dementia risk are multifactorial and include the neuroplastic, neurotrophic, anti-inflammatory, and vascular mechanisms reviewed in preceding sections, operating across decades of exposure to produce cumulative structural brain changes that increase cognitive reserve and delay the clinical expression of Alzheimer's pathology. The cerebrovascular hypothesis deserves specific attention: aerobic exercise promotes angiogenesis, increases cerebral blood flow, improves endothelial function, and reduces arterial stiffness — vascular adaptations that may be particularly important in the context of vascular dementia and in Alzheimer's disease, where cerebrovascular compromise is increasingly recognised as a contributing pathological mechanism alongside amyloid and tau pathology (Warburton & Bredin, 2017). Physical activity has also been shown to modulate amyloid precursor protein processing and reduce amyloid-beta deposition in animal models, though translational evidence from human studies of amyloid PET imaging in exercising versus sedentary individuals remains limited and is a priority area for future investigation. The convergence of vascular, inflammatory, neurotrophic, and amyloid-

related mechanisms suggests that physical activity's protection against dementia is unlikely to be reducible to any single pathway, and that the multi-mechanistic nature of the effect represents both a scientific complexity and a practical strength, since multiple mechanisms may compensate for each other's impairment in individuals with specific biological vulnerabilities.

7. Physical Activity, Psychological Stress, and Subjective Well-Being

Beyond the clinical outcomes of depression and anxiety, physical activity produces documented improvements in subjective well-being — the positive affective and evaluative dimensions of psychological health including hedonic pleasure, life satisfaction, vitality, and sense of meaning — that constitute important mental health outcomes in their own right and that mediate the relationship between physical activity and quality of life. A meta-analysis by Reed and Ones (2017) examining the relationship between physical activity and positive affect found a moderate positive effect ($r = 0.26$), with acute exercise producing immediate improvements in positive affect that extended beyond the reduction of negative affect to encompass genuine increases in pleasant emotional experience. The mechanisms of exercise-induced positive affect — distinct from the relief of negative symptoms captured by depression and anxiety outcome measures — include endocannabinoid-mediated euphoria, the social reinforcement of group exercise, the achievement satisfaction of goal completion, and the aesthetic pleasures of outdoor physical activity environments, suggesting that the promotion of positive mental health through exercise requires attention to the experiential qualities of physical activity participation rather than exclusively to its physiological dimensions.

The stress-buffering effects of physical activity — its capacity to reduce the subjective and physiological impact of psychosocial stressors beyond the simple reduction of baseline stress levels — have been investigated through both experimental stress paradigms and prospective cohort studies. Gerber et al. (2017) conducted a longitudinal study of the moderating role of physical fitness on the relationship between stress and mental health in a large sample of military recruits, finding that high-fitness individuals showed significantly smaller increases in depression and burnout symptoms in response to high occupational stress loads than their low-fitness counterparts — a stress-buffering effect that was not reducible to the lower baseline stress levels of fitter individuals. The HPA axis habituation, enhanced stress appraisal, and improved emotion regulation capacity associated with regular physical activity each contribute to this stress-buffering effect, and their combined action creates a neurobiological and psychological resource that effectively raises the threshold at which daily stressors produce clinically significant mental health impairment — a form of psychological resilience that is particularly relevant in contemporary social contexts characterised by elevated occupational, economic, and social stressors.

8. Moderating Variables: Exercise Type, Intensity, Dose, and Individual Factors

The relationship between physical activity and mental health and cognitive outcomes is substantially moderated by variables including exercise modality, intensity, duration, frequency, social context, and individual characteristics such as age, gender, baseline health status, and genetic factors. Regarding modality, aerobic exercise has historically received the greatest research attention and demonstrates the most consistent mental health and cognitive benefits, but evidence has increasingly supported significant effects of resistance training on depression (Gorski et al., 2021), anxiety (Gordon et al., 2017), and cognitive function (Northey et al., 2018), and yoga and mind-body exercise modalities produce unique benefits through the integration of movement, mindfulness, and controlled respiration that may address specific mental health mechanisms not captured by conventional aerobic or resistance exercise paradigms. Exercise intensity exhibits a dose-response relationship with BDNF upregulation and monoamine activity that favours moderate-to-vigorous intensities for maximal neurobiological benefit, yet high-intensity interval training (HIIT) has demonstrated comparable or superior mental health and cognitive outcomes to moderate continuous aerobic exercise in several trials while requiring significantly shorter time investment — a finding with important implications for exercise adherence and the practical translation of exercise recommendations into sustainable physical activity behaviour.

Individual differences in the mental health response to physical activity are substantial and clinically important, reflecting genetic variation in neurotransmitter system function, exercise-

induced neuroplastic capacity, psychological sensitivity to exercise, and the interaction between exercise and concurrent mental health treatment. Schuch et al. (2016) examined individual participant data from 145ndividual controlled trials of exercise for depression and found significant moderation of antidepressant effects by baseline depression severity, exercise type, and whether exercise was combined with antidepressant medication, with larger benefits for more severely depressed individuals and for those not concurrently receiving pharmacotherapy. These moderating findings underscore the importance of 145ndividualized exercise prescription for mental health — the recognition that optimal exercise type, intensity, and social context vary across individuals — and challenge the assumption that generic physical activity promotion recommendations are sufficient to maximise mental health benefits across the heterogeneous populations in which they are applied. Age-related differences in the mechanisms and magnitude of physical activity benefits are well documented, with older adults showing particularly large cognitive benefits from aerobic exercise (reflecting the neuroplastic restoration of age-related hippocampal decline) and children showing particular benefits for attention and academic performance from school-based physical activity (reflecting the prefrontal maturation mechanisms of exercise in developing brains).

9. Clinical Implications and Practice Recommendations

The evidence reviewed has several direct implications for clinical practice across medicine, psychology, and public health. The antidepressant and anxiolytic effects of exercise, comparable in magnitude to first-line pharmacological and psychological treatments, support the integration of structured physical activity programmes into treatment guidelines for depression and anxiety disorders as a first-line, adjunctive, or relapse-prevention option, with clinical utility extending to populations for whom pharmacotherapy is contraindicated or unwanted (Stonerock et al., 2015). Mental health practitioners should receive training in physical activity prescription as a clinical skill, including the assessment of individual barriers and facilitators to exercise participation, the selection of modality and intensity appropriate to individual clinical presentations, and the monitoring of exercise-related adverse effects in populations with specific vulnerabilities. The evidence that exercise adherence is the primary determinant of long-term mental health benefit — with effects dissipating within weeks of exercise cessation — underscores the need for behaviour change support alongside physical activity prescription, including motivational interviewing, goal-setting, self-monitoring, and the environmental and social modifications that support sustained exercise behaviour in the face of the barriers that clinical populations commonly face.

For cognitive health across the lifespan, clinicians and public health practitioners should communicate the evidence that regular moderate-to-vigorous aerobic exercise is among the most robustly supported modifiable protective factors against cognitive decline and dementia, with effects beginning in middle age and extending into late life — a message that challenges the nihilistic assumption that age-related cognitive decline is inevitable and unmodifiable (Livingston et al., 2020). Exercise prescription for cognitive health should specify adequate intensity — at least moderate aerobic intensity to drive BDNF upregulation and cerebral blood flow — and adequate duration — consistent with national physical activity guidelines of at least 150 minutes per week of moderate or 75 minutes of vigorous aerobic activity — while acknowledging that any increase in physical activity from a sedentary baseline produces cognitive benefits even if full guideline attainment is not immediately achievable. The integration of resistance training alongside aerobic exercise, as supported by the combined modality evidence (Northey et al., 2018), is recommended for comprehensive cognitive benefit given the complementary neuroplastic mechanisms of the two exercise types and the additional metabolic and musculoskeletal benefits of combined exercise programming.

10. Limitations of the Evidence Base and Future Research Directions

Despite the substantial and growing evidence base reviewed, several methodological limitations require acknowledgment and motivate a set of future research priorities. The preponderance of short-term RCTs — with intervention periods of 8 to 24 weeks — limits conclusions about the mechanisms and maintenance of long-term mental health and cognitive benefits, and the absence of active follow-up data in most trials makes it impossible to determine the persistence of effects after programme completion without sustained exercise behaviour. The under-representation of low-and-middle-income countries, where the burden of both mental

health disorders and physical inactivity is disproportionately concentrated, in the experimental literature limits the generalisability of predominantly North American and European findings to global population contexts with different dietary patterns, occupational physical activity profiles, environmental exposures, and cultural attitudes towards formal exercise. Heterogeneity in outcome measurement — with hundreds of different mental health and cognitive assessment instruments used across the literature — limits the precision of meta-analytic estimates and the ability to compare findings across studies, and the development of consensus outcome measurement frameworks analogous to the COMET Initiative in clinical trials medicine is a methodological priority for the field.

Future research should prioritise mechanistic investigations in human populations using state-of-the-art neuroimaging, biomarker assessment, and genomic approaches to characterise the individual variation in neurobiological response to exercise and to identify the genetic, epigenetic, and environmental moderators that determine who benefit most from which exercise modalities and intensities. Adaptive trial designs — including Sequential Multiple Assignment Randomised Trials that personalise exercise prescriptions based on individual response trajectories — offer an important methodological innovation for optimising exercise interventions at the individual level. The integration of wearable technology and ecological momentary assessment offers new opportunities for characterising the real-world relationships between physical activity patterns, mood, cognition, and stress in naturalistic daily life contexts that complement the controlled but artificial conditions of laboratory and clinical trial settings (Gerber et al., 2017). Finally, the translation of mechanistic and efficacy evidence into scalable, equitable, and sustainable physical activity promotion programmes at population level — through policy, built environment modification, school and workplace programmes, and health system integration — represents the ultimate research and implementation priority for a field whose public health significance grows with every meta-analysis published.

11. Conclusion

The evidence reviewed in this article establishes that regular physical activity exerts profound and multifaceted beneficial effects on mental health and cognitive function across the lifespan, operating through interconnected neurobiological, psychological, and social mechanisms that collectively produce clinically meaningful improvements in depression, anxiety, stress resilience, cognitive performance, and dementia risk. The convergence of experimental, epidemiological, and neuroimaging evidence on these effects represents one of the strongest platforms in contemporary behavioural medicine for a single health behaviour producing benefits across multiple organ systems and health outcomes simultaneously. The magnitude of effect is clinically significant — comparable to established pharmacological and psychological treatments for mental health disorders — while the risk profile, cost, and accessibility of physical activity compare favourably with these alternatives at both individual and population levels. The practical implication is clear: physical activity promotion must be elevated from a peripheral lifestyle recommendation to a central component of mental health policy, clinical practice, and public health strategy — an investment in the neurobiological and psychological foundations of human flourishing whose dividends accumulate across individuals, communities, and generations.

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