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Review Article

Mediating Mechanisms Linking Exercise and Mental Health: A Sports-Science Perspective with Implications for Athlete Performance

Short title: Exercise, Mental Health, and Mediating Mechanisms

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Abstract

Although exercise consistently improves mental health, sports scientists and coaches need evidence about *how* exercise produces those benefits and how those mechanisms translate into athletic performance and training practice. We conducted a PRISMA-guided systematic review of studies that formally tested mediators in the exercise → mental-health pathway to identify mechanisms most relevant to sport performance and coaching. Electronic searches (PubMed, Scopus, Web of Science, PsycINFO, SPORTDiscus; inception-March 2025) identified 30 mediation studies (cross-sectional, longitudinal, RCTs) that together sampled adolescents, athletes, older adults and clinical groups. We extracted study characteristics, indirect effect estimates or required statistics for conversion, risk-of-bias ratings, and sport-relevant moderators (sport vs non-sport samples; competitive level; modality). Across studies, psychosocial mediators (self-efficacy, body-esteem, mastery) and affective responses (increases in positive affect, reductions in negative affect) were the most robust pathways. Behavioural mediators (sleep quality, fatigue reduction) and physiological mediators (fitness, functional capacity, BDNF in clinical samples) contributed especially in physically demanding or rehabilitative contexts. Importantly, when studies involved sport participants or sport-structured training, mediators linked more directly to performance outcomes (motivation, training adherence, competitive anxiety). We present subgroup analyses and sensitivity checks (excluding cross-sectional designs) that strengthen causal interpretation and propose a mechanism-driven framework for coaches: (1) design mastery-based progressions to boost self-efficacy, (2) structure sessions to maximise positive affect and recovery, and (3) monitor sleep and fatigue as mediators of both mental health and performance. These sport-focused mechanistic insights support targeted training prescriptions that maximise athlete well-being and performance.

Key words: Exercise, Physical Activity, Mental Health, Depression, Anxiety, Self-Efficacy

Introduction

Regular physical activity (PA) is robustly associated with better mental health across the lifespan, encompassing reductions in depressive and anxiety symptoms and increases in subjective well-being and quality of life (Battalio, Huffman, & Jensen, 2020). While early work established that exercise can serve as a treatment component for depression, more recent research has begun to focus on how PA achieves these benefits (Rhiannon L. White et al., 2024). From a mechanistic standpoint, it is no longer sufficient to ask whether PA benefits mental health; rather, the field must now ask why, for whom, and through what pathways.

One central barrier to advancing mechanistic understanding has been the emphasis on correlational associations rather than pathway analyses, coupled with heterogeneity in how PA exposures, mediators, and outcomes are defined. Although meta-analyses show consistent links between domain-specific PA and mental health (Rhiannon Lee White et al., 2017), there remains a scarcity of systematic syntheses focused exclusively on mediation analysis, i.e., whether changes in hypothesised mechanisms statistically account for PA's effects on mental health (Rhodes & Pfaeffli, 2010).

Contemporary behavioural and health psychology frameworks advocate for mediation models to unpack behaviour-change processes and guide targeted intervention design (Cerin, Barnett, & Baranowski, 2009; Lubans, Foster, & Biddle, 2008). In parallel, theory-based models such as Social Cognitive Theory (Bandura, 1978) and Self-Determination Theory (Deci & Ryan, 1985) emphasise constructs such as self-efficacy, autonomy, and competence as proximal drivers of adaptive psychological outcomes. Therefore, building a coherent mechanistic map of PA's mental-health benefits requires synthesising studies that explicitly test mediators rather than infer them retrospectively.

Against this backdrop, the present review pursues three aims. First, to systematically identify and synthesise studies that formally test mediation in the PA-mental-health relationship across populations and settings, following PRISMA 2020 reporting guidance to ensure transparency and reproducibility (Moher, Liberati, Tetzlaff, Altman, & PRISMA Group, 2009; Page et al., 2021). Second, to organise identified mediators into coherent domains: psychosocial (self-efficacy, self-esteem, body esteem, meaning in life), affective (positive/negative affect, arousal), behavioural (sleep health), biological/physiological (fitness, fatigue, BDNF, inflammation), and cognitive (executive function), and to identify which domains show the most consistent evidence across

designs and outcomes. Third, to translate mechanistic evidence into actionable implications for intervention design, emphasising how PA programme features (e.g., mastery-progression, autonomy support, sleep-friendly scheduling, conditioning for fatigue) may be deliberately selected to activate high-yield pathways, and how mediator measurement can support mechanism-informed adaptation.

In recent years, a growing body of primary research has adopted formal mediation designs across diverse populations and settings. For example, adult and clinical samples report that improvements in self-efficacy and positive affect during structured exercise or home-based PA partly explain gains in quality of life and reductions in psychological distress (Aguiñaga et al., 2018; Awick et al., 2017). Among adolescents and young adults, habitual PA or higher intensity bouts appear to link to well-being through body-related cognitions (body esteem, physical self-worth) and affective responses (Chae, Kang, & Ra, 2017; Costigan, Lubans, Lonsdale, Sanders, & Del Pozo Cruz, 2019; Pickett, Yardley, & Kendrick, 2012). Behavioural mediators such as sleep health have emerged in older adult cohorts as partial pathways in the PA–depression/anxiety link (Barham, Buysse, Kline, Kubala, & Brindle, 2022; Choi, Choi, & Marti, 2024). Moreover, physiological and biological mediators (e.g., improved fitness, reduced fatigue, neurotrophic and inflammatory markers) are increasingly examined in clinical populations such as cancer survivors and adults with metabolic conditions (Adams et al., 2018; Booij, Bos, de Jonge, & Oldehinkel, 2015; Buffart et al., 2014; Donyaei, Kiani, Bahrololoum, & Moser, 2024). Cognitive control mechanisms, though less frequently studied, have also shown mediation potential for anxiety outcomes in college-student samples (Z. Dong et al., 2022). Collectively, this evidence suggests that PA's mental-health benefits are multidetermined and pathway-specific, varying by population, PA exposure type, and context.

Despite this progress, the literature remains fragmented, hampering cumulative inference. First, mediators are inconsistently operationalised across studies testing exercise-specific self-efficacy, global self-efficacy, physical self-worth, body esteem, meaning in life, and more, often with differing measurement properties and timing. Second, PA exposures vary widely, from habitual activity captured via self-report to structured interventions (including high-intensity interval training, resistance training, walking) and these likely recruit different mechanisms (Adams et al., 2018; Costigan et al., 2019). Third, outcomes differ in theoretical linkage: depressive and anxiety symptoms, subjective well-being, life satisfaction, and health-related quality of life each

relate to different mediators such as affect, sleep, or self-esteem. Fourth, study designs range from cross-sectional surveys and daily diary analyses to longitudinal cohorts and randomised controlled trials (RCTs), and only the latter support stronger inference about mediation (Page et al., 2021). As a result, while individual studies provide compelling evidence, a coherent synthesis of mediation-based pathways is required to identify which mechanisms are robust and generalisable.

Equally critical is the need for stronger reporting and methodological rigour in systematic reviews that aim to inform practice. Suboptimal planning, opaque selection criteria and inconsistent handling of heterogeneous evidence may hamper the validity and utility of reviews (Bero, 2019). Adoption of the PRISMA 2020 guidelines improves transparency and reproducibility from protocol registration through to risk-of-bias assessment and synthesis (Page et al., 2021). For mechanism-focused research, mapping mediators to theory (e.g., self-efficacy, autonomy, mastery) enhances translation into intervention design, such as autonomy-supportive coaching, mastery-oriented task structures and social environments that reduce evaluative threat. Extracting detailed information, including mediator definitions, measurement properties, temporal ordering, and statistical modelling (parallel versus serial mediation), strengthens the interpretive value of systematic reviews. This review is distinguished by its mediation-only inclusion criterion. Rather than aggregating all studies linking PA and mental health, we prioritise research that explicitly tests indirect effects via parallel or serial mediation models so that conclusions rest on statistical evidence of mechanism rather than correlational inference.

While the salutary effects of PA on mental health are well established, clarity about the active ingredients has lagged. The present review addresses this gap by systematically assembling and evaluating mediation evidence. It argues that PA confers mental-health benefits through interacting psychosocial, affective, behavioural, biological/physiological, and cognitive pathways; that the prominence of each pathway depends on population characteristics, exposure type and context; and that intervention effectiveness can be enhanced by deliberately designing for mechanisms. Guided by PRISMA standards and theory-based mediator models, the review offers a mechanism-specific roadmap to inform research, clinical practice and public health, advancing the field from “exercise works” to “exercise works via these pathways, for these people, under these conditions.

Although the present review synthesises mechanistic evidence across general populations, these mediating pathways have direct relevance to sports science.

Psychological resources such as self-efficacy, affect regulation, perceived competence, and sleep quality are strongly linked to training adherence, recovery quality, competitive anxiety, and ultimately sport performance. By identifying which mechanisms are consistently activated through physical activity, sport practitioners can deliberately design training environments that enhance mental well-being while simultaneously optimising performance readiness. Integrating a mechanism-based approach in sports contexts strengthens athlete development models, supports coach decision-making, and promotes holistic athlete welfare, which is an increasingly important priority in contemporary sports science.

Materials and Methods

Study Design

This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) guidelines and followed a pre-specified methodological plan to ensure transparency, reproducibility, and sports-science relevance (Moher et al., 2009; Page et al., 2021). As this review focused on identifying formal mediation pathways rather than estimating pooled effect sizes, methodological decisions were aligned with mechanism-oriented synthesis.

Eligibility Criteria

Studies were eligible if they employed quantitative designs such as randomized controlled trials, longitudinal, or cross-sectional studies that included mediation analysis; involved human participants of any age, sex, or health status; examined exercise or physical activity of any type, intensity, frequency, or duration as the main exposure; and reported mental health outcomes including depression, anxiety, stress, psychological distress, well-being, or quality of life. Only studies that explicitly tested mediating variables such as self-efficacy, affect, sleep, coping, cognitive function, or biological markers were included. Exclusion criteria were studies without mediation analysis, non-human or laboratory studies, those reporting only physical health outcomes, non-exercise interventions such as diet or smoking, reviews, editorials, conference abstracts, dissertations, or non-peer-reviewed reports, insufficient statistical data to evaluate mediation, and non-English publications.

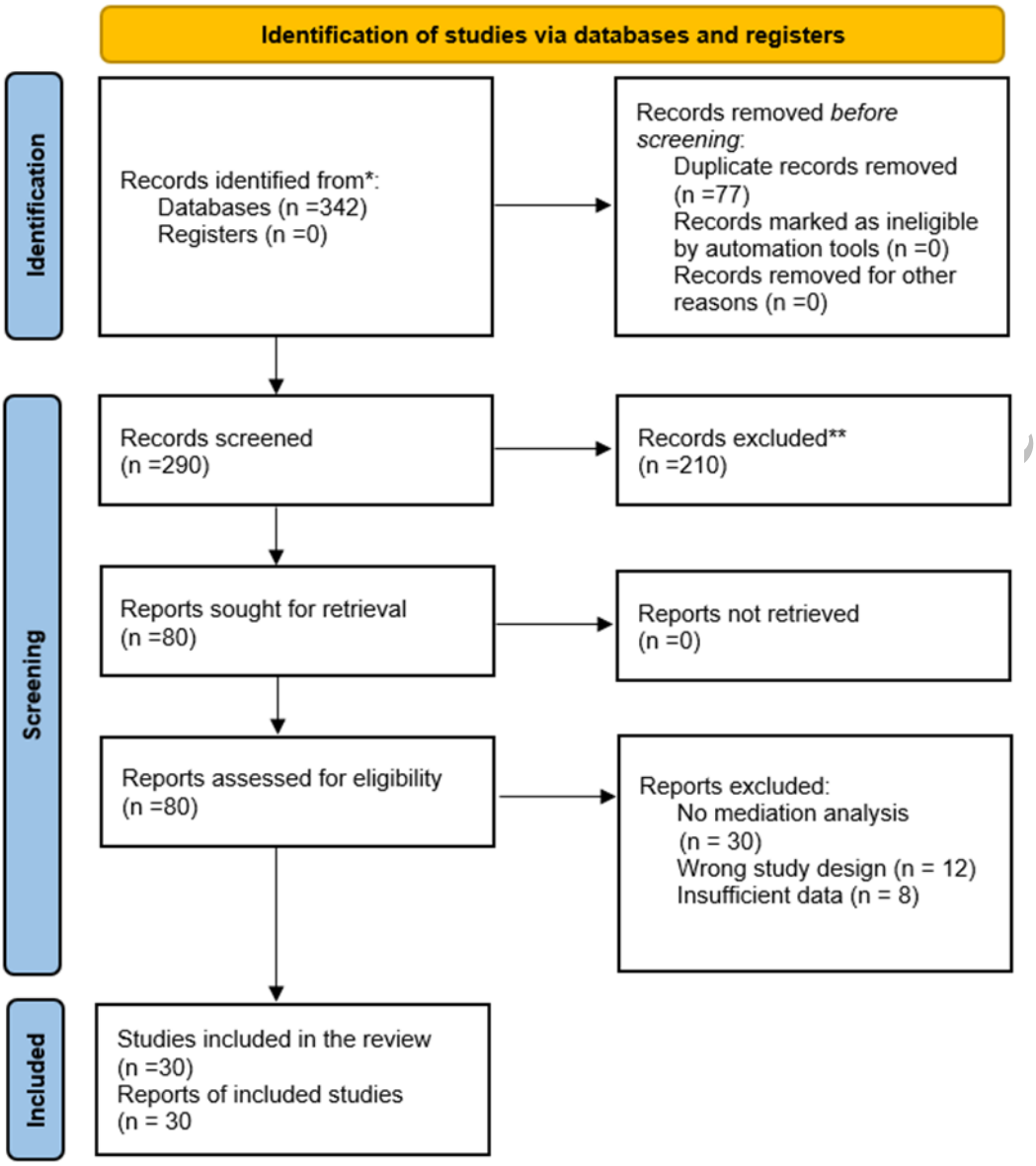

Figure 1. PRISMA 2020 flow diagram of study selection

Information Sources

Relevant literature was searched across multiple electronic databases, including PubMed/MEDLINE, Scopus, Web of Science, PsycINFO, and SPORTDiscus, from inception to March 2025. Grey literature was also identified through Google Scholar searches and manual screening of reference lists of included studies and related reviews. Only peer-reviewed journal articles published in English were considered. Only peer-reviewed journal articles published in English were considered, and no date restrictions were applied beyond database inception.

Search Strategy

The search strategy was developed with the support of an academic librarian to optimise sensitivity and specificity. Three domains of keywords were combined using Boolean operators: exercise/physical activity (e.g., "exercise," "physical activity," "fitness," "sport"), mental health outcomes (e.g., "mental health," "depression," "anxiety," "stress," "well-being," "quality of life"), and mediation analysis (e.g., "mediation," "mediator," "mechanism," "pathway," "indirect effect"). An example search string for PubMed was: ("exercise" OR "physical activity" OR "sport") AND ("mental health" OR "depression" OR "anxiety" OR "well-being" OR "quality of life") AND ("mediation" OR "mediator" OR "indirect effect"). Equivalent adaptations were made for each database. Search filters were limited to human studies and English-language publications; equivalent adaptations of the search strategy were applied across databases according to their specific indexing systems.

Table 1. Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
Quantitative studies (RCTs, longitudinal, cross-sectional) reporting mediation analysis	Studies reporting only associations or moderation without testing mediation
Human participants of any age, sex, or health status	Animal studies or laboratory-only experimental work
Exercise or physical activity as the primary exposure (any type, frequency, or intensity)	Studies focusing solely on physical health outcomes (e.g., BMI, cardiovascular fitness)
Mental health outcomes (e.g., depression, anxiety, stress, QoL, subjective well-being)	Studies without mental health outcomes
Studies explicitly testing mediating variables (e.g., self-efficacy, affect, sleep, cognitive function, coping, BDNF)	Studies of non-exercise interventions (e.g., diet, smoking, lifestyle factors only)
Published in English	Non-English publications
Peer-reviewed journal articles	Reviews, editorials, commentaries, conference abstracts, dissertations, or grey literature
	Articles with insufficient data for mediation evaluation

Study Selection

All retrieved records were imported into EndNote X9 for duplicate removal, and the remaining records were managed in Rayyan QCRI. Duplicate records were automatically removed (n = 77), leaving 290 records for screening. Two independent

reviewers screened titles and abstracts (n = 290), excluding 210 as irrelevant. Eighty full-text articles were assessed for eligibility, of which 50 were excluded for reasons such as no mediation analysis (n = 30), wrong study design (n = 12), or insufficient data (n = 8). A total of 30 studies met the inclusion criteria. Disagreements were resolved through discussion, and when consensus could not be reached, consultation with a third reviewer was undertaken.

Data Extraction

Data were extracted independently by two reviewers using a pre-designed form, with discrepancies resolved through consensus. Extracted information included author(s), publication year, country, population characteristics, study design, exercise or physical activity exposure, mental health outcomes, mediators tested, analytical methods (e.g., structural equation modelling, regression-based mediation), and key findings. The extracted study characteristics are summarised in Table 3.

Quality Assessment (Risk of Bias)

The methodological quality of the included studies was assessed using a modified risk-of-bias framework adapted from previous systematic reviews of physical activity and mental health (Rhiannon Lee White et al., 2017). This framework was particularly valuable as it was designed to assess study quality across both experimental and observational designs. However, because our review focused specifically on mediation analyses, additional considerations were required. To ensure that our appraisal captured methodological rigour in mediation-based research, we integrated relevant items from mediation study checklists proposed by Lubans et al. (2008), Rhodes & Pfaeffli (2010), and Cerin et al. (2009). These additions allowed us to evaluate whether the included studies reported valid measures of mediators, used appropriate mediation analytic methods, and accounted for key confounding variables. The final criteria, listed in Table 2, covered participant eligibility, statistical power, validity of physical activity and mental health outcome measures, validity of mediator assessment, appropriateness of mediation analysis, and adjustment for covariates. All criteria were weighted equally, as no validated weighting scheme currently exists for mediation-focused quality appraisal. Each criterion was rated as either present (score = 1) or absent/inadequately described (score = 0). Studies were then categorised as high quality (score of 6-7), acceptable quality (score of

4-5), or low quality (score ≤ 3), following the grading approach described by Asker et al. (2018). Two reviewers independently applied the criteria, and any discrepancies were resolved through discussion until full consensus was achieved.

Table 2. Risk of Bias Criteria Used for Quality Assessment

1. Participant eligibility criteria clearly stated and adequately described, and appropriate to the aims of the research.
2. Power calculation reported, and the study was adequately powered to detect mediation effects.
3. Valid measure of physical activity used (e.g., objective assessments; validated self-report measures; or experimental allocation to PA intervention).
4. Valid measure of the mental health outcome reported, with psychometric properties within accepted ranges (e.g., Cronbach's α, test–retest reliability > .60).
5. Valid measure of mediator variable used, with psychometric evidence reported and within accepted ranges.
6. Statistically appropriate and acceptable methods of data analysis used for mediation testing.
7. Confounding factors or covariates (e.g., sex, age, weight status) were adequately adjusted for in the analyses.

Compliance and Registration

This systematic review adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. Although the review protocol was not preregistered in any public database, every stage of the process, including literature search, study screening, data extraction, and synthesis, was systematically executed to maintain methodological rigour and transparency. This is acknowledged as a methodological limitation of the present review.

Data Synthesis

Due to heterogeneity in study designs, populations, mediators, and mental health outcomes, a narrative synthesis was conducted rather than meta-analysis. A meta-analysis was not attempted because the included studies differed substantially in their definitions of mediators, analytical models, populations, and outcome measures. Pooling such heterogeneous mediation effects would have risked producing misleading summary estimates. Given the wide variety of mediators examined in the included studies, meta-analyses were not possible, as combining dissimilar studies would not provide meaningful results (Bero, 2019). Studies were grouped into categories of mediators, including psychosocial (e.g., self-efficacy, self-esteem, coping), affective (e.g., positive and

negative affect), behavioural (e.g., sleep, resilience), cognitive (e.g., executive function, body esteem), and biological (e.g., BDNF, inflammation, fatigue, fitness). Findings within each group were synthesised to identify consistent patterns and theoretical implications. As this systematic review synthesised previously published data, no new data were collected, and therefore, ethical approval was not required.

Results

The systematic search and selection process is illustrated in the PRISMA 2020 flow diagram Figure 1. A total of 367 records were initially identified from databases and other sources. After removing 77 duplicates, 290 records were screened based on titles and abstracts. Of these, 210 were excluded for failing to meet eligibility criteria. A full-text review of 80 reports was conducted, of which 50 were excluded due to a lack of mediation analysis, an inappropriate study design, or insufficient statistical data. Ultimately, 30 studies met the inclusion criteria and were synthesised in this review.

The included studies demonstrated considerable methodological and contextual diversity, covering a wide range of populations (adolescents, university students, adults, older adults, and clinical groups), study designs (cross-sectional, longitudinal, and randomized controlled trials), geographical locations (North America, Europe, Asia, and Australia), and forms of physical activity (habitual exercise, structured interventions, sport participation, high-intensity interval training, and walking).

Across the included studies, a broad spectrum of mental health outcomes was examined, including depression, anxiety, stress, well-being, quality of life, and psychological functioning. Importantly, all studies incorporated mediation analyses, thereby enabling identification of the mechanistic pathways through which exercise and physical activity exert their influence on mental health. These mediators could be grouped into five broad domains: psychosocial (e.g., self-efficacy, self-esteem, coping), affective (e.g., positive affect, mood), cognitive (e.g., executive function, cognitive performance), biological (e.g., brain-derived neurotrophic factor, inflammatory markers, fatigue, fitness), and behavioural (e.g., sleep, resilience).

Due to substantial heterogeneity in study designs, populations, mediator operationalisation, and statistical mediation models, quantitative synthesis of mediation effect sizes was not feasible. As a result, effect size estimates and pooled indirect effects are not reported, as such aggregation would have risked producing misleading

interpretations. Instead, a narrative synthesis was adopted to systematically describe patterns of evidence across mediator categories. In addition, graphical summaries were not included because the diversity of outcomes and mediation metrics across studies precluded meaningful visual aggregation.

Table 3 provides a comprehensive overview of the 30 included studies that investigated mediation mechanisms in the exercise–mental health relationship. For each study, the table lists the author, year of publication, country of origin, population characteristics, study design, type of exercise or physical activity exposure, mental health outcomes assessed, mediators tested, and a brief summary of key findings.

Table 3. Characteristics of Included Studies Examining Mediating Mechanisms Between Exercise and Mental Health (n = 30)

Author (Year)	Country	Population	Design	Exercise / PA Exposure	Mental Health Outcome(s)	Mediator(s)	Key finding (1–2 lines)
Pickett et al. (2012)	UK	Adults with depressive symptoms	Cross-sectional	Habitual PA level	Depressive symptoms	Positive/negative affect, PA self-efficacy, coping self-efficacy, exercise-induced feelings	Multiple psychosocial mediators explain a sizable portion of the PA–depression association.
Kayani et al. (2021)	China	University students	Cross-sectional	Habitual PA	Anxiety (state/trait)	Self-system (self-enhancement, self-criticism)	Self-system variables significantly mediate the inverse PA–anxiety link.
Baker et al. (2023)	Australia	Women in disadvantaged areas	Cross-sectional	Habitual PA	Depressive symptoms	Psychosocial & behavioural (e.g., self-efficacy, social support, sitting)	Psychosocial/behavioural factors jointly mediate lower depression among more active women.
Barham et al. (2022)	USA	Adults	Cross-sectional	Total PA	Depressive symptoms	Sleep health index	Better sleep health statistically mediates the protective effect of PA on depression.
Baruth et al. (2016)	USA	Adults with arthritis	Prospective program	Self-directed exercise	Depressive symptoms	Serial: self-efficacy → PA → affect/social support	A chained psychosocial pathway accounts for reductions in depressive symptoms.
Birch et al. (2016)	USA	Older adults	Cross-sectional	Habitual PA	Depression status	Cognitive function	Higher cognitive function partially explains the PA–depression relationship.
Booij et al. (2015)	Netherlands	Adolescents	Longitudinal	Exercise participation	Depressive symptoms	Cortisol/inflammation markers	Stress and inflammatory indices mediate exercise's antidepressant effects over time.
Buffart et al. (2014)	Netherlands	Cancer survivors	RCT (mediation analysis)	Exercise intervention	Quality of life	Fatigue, cardiorespiratory fitness, physical function	Improvements in fatigue/fitness mediate QoL gains from exercise.
Castan, Bonilla, Chamarro, & Saurí (2024)	Spain	Adults with spinal cord injury	Cross-sectional	PA type/intensity	Psychosocial outcomes	Self-efficacy, functionality	Self-efficacy and functionality mediate PA's positive psychosocial effects.
Chae et al. (2017)	South Korea	Adolescents	Cross-sectional	Habitual PA	Depression	Body esteem	Body esteem significantly mediates the inverse PA–depression association.
Chair et al. (2020)	Singapore	CHD patients	Cross-sectional	Leisure-time PA	Depressive symptoms	PA self-efficacy	Self-efficacy mediates the association between LTPA and lower depressive symptoms.
Chen, Liu, Huang, & Wu (2022)	China	Older adults	Cross-sectional	Exercise frequency	Subjective well-being	Meaning in life, self-esteem	Both variables act as parallel mediators linking exercise to well-being.
Choi et al. (2024)	USA	Older adults	Cross-sectional	Exercise	Depression, anxiety	Pain problems, sleep problems	Pain and sleep problems jointly mediate the exercise–mental health relationship.
Chu et al. (2023)	China	Breast cancer survivors	Cross-sectional	Walking activity	Emotional distress	Post-traumatic growth, body image	Walking reduces distress via parallel mediation through PTG and body image.

Clément et al. (2024)	Canada	Adolescents → emerging adults	Longitudinal	Team sports → PA use as coping	Mental health problems	Physical activity used as coping	Use of PA as a coping strategy mediates long-term mental health benefits.
Condello et al. (2016)	Italy	Older adults	Cross-sectional	Habitual PA	Health perception	BMI, body satisfaction (3-path)	A three-step chain (PA → BMI → body satisfaction) mediates perceived health.
Dahlstrand et al. (2021)	Sweden	Adolescents	Cross-sectional	Habitual PA	Mental health problems	Shift–persist coping	Coping strategy mediates the PA–mental health link in youth.
Deng, Liu, Chen, & Wang (2023)	China	University students	Cross-sectional	Habitual PA	Life satisfaction	Self-efficacy, resilience	Both self-efficacy and resilience significantly mediate PA → life satisfaction.
R.-B. Dong, Dou, & Luo (2023)	China	Adolescents	Cross-sectional	Habitual PA	Mental & physical health	General self-efficacy, sleep duration	Multiple mediation supports PA's broad health benefits.
Dong et al. (2022)	China	College students	Cross-sectional	Habitual PA	Trait anxiety	Executive function	Executive function mediates the inverse PA–anxiety association.
Donyaei et al. (2024)	Iran	Women with T2DM	RCT	Combined aerobic + resistance training	Depression	BDNF	Training-induced BDNF increases mediate reductions in depression.
Elavsky & Gold (2009)	USA	Midlife women	Longitudinal	Habitual PA	Perceived stress	Depressed mood	Reduced depressed mood mediates the PA–stress relationship.
Elavsky & McAuley (2005)	USA	Older adults	RCT	PA intervention	Long-term QoL	Self-efficacy, self-esteem, affect	Classic psychosocial mediation explains sustained QoL improvements.
Costigan et al. (2019)	Australia	Adolescents	Cross-sectional	PA intensity	Well-being	Positive affect, arousal	Affective responses mediate the intensity–well-being relationship.
Adams et al. (2018)	Canada	Testicular cancer survivors	RCT (HIIT vs usual care)	High-intensity interval training	Fatigue, QoL	Fatigue, cardiorespiratory fitness	Fitness and fatigue changes mediate HIIT's QoL and fatigue benefits.
Aguiñaga et al. (2018)	USA	Older adults	RCT (home-based)	Home-based PA program	Depression, anxiety	Self-efficacy, affect	Improvements in self-efficacy/affect mediate reductions in depression/anxiety.
Awick et al. (2017)	USA	Older adults	RCT	Exercise intervention	Psychological distress, QoL	Affect, self-efficacy	Affect/self-efficacy mediate QoL gains and distress reductions.
Broman-Fulks, Abraham, Thomas, Canu, & Nieman (2018)	USA	Adults	Cross-sectional	Exercise frequency	Anxiety, depression	Anxiety sensitivity	Lower anxiety sensitivity mediates the mental-health benefits of exercise.
Feuerhahn et al. (2012)	Germany	Working adults	Daily diary	After-work exercise	Daily affect, well-being	Positive affect	Daily positive affect mediates the exercise → well-being pathway.
Foroughi et al. (2023)	Iran	Adults	Cross-sectional	Habitual PA	Psychological functioning	Positive/negative affect	Affect mediates the association between PA and psychological functioning.

Note- PA = Physical Activity; QoL = Quality of Life; CHD = coronary heart disease; HIIT = High-Intensity Interval Training; BDNF = Brain-Derived Neurotrophic Factor; PTG = Post-Traumatic Growth; SWB = Subjective Well-Being.

This table highlights the diversity in study settings, populations (ranging from adolescents to clinical groups such as cancer survivors and patients with type 2 diabetes), and methodological approaches (cross-sectional, longitudinal, and randomised controlled trials). It also allows readers to quickly identify which mediators were tested and in what context, showing that multiple psychosocial, affective, cognitive, biological, and behavioural pathways have been examined.

Table 4 summarises the distribution of the included studies across key research variables. It categorises studies by study design, population, geographical distribution, type of exercise/physical activity exposure, mental health outcomes, and mediators tested. This table provides an at-a-glance understanding of the evidence base.

Table 4. Distribution of Included Studies by Study Variables

Variable	Categories	No. of Studies (n = 30)
Study Design	Cross-sectional (n = 16), Longitudinal (n = 4), RCTs (n = 8), Daily diary (n = 1), Prospective program (n = 1)	30
Population	Adolescents (n = 6), University/college students (n = 4), Adults (general) (n = 6), Older adults (n = 6), Clinical populations (cancer, T2DM, CHD, arthritis, spinal cord injury) (n = 8)	30
Geographical Distribution	USA (n = 10), China (n = 6), Europe (UK = 1, Spain = 1, Italy = 1, Sweden = 1, Germany = 1, Netherlands = 1), Canada (n = 2), Australia (n = 2), Iran (n = 2), South Korea (n = 1), Singapore (n = 1)	30
Type of PA / Exercise	Habitual PA (n = 15), Structured exercise interventions (n = 6), HIIT (n = 1), Walking (n = 1), Self-directed programs (n = 1), After-work exercise (n = 1), PA intensity studies (n = 2), Sport participation (n = 3)	30
Mental Health Outcomes	Depression (n = 14), Anxiety (n = 8), Stress (n = 2), Well-being / Life satisfaction (n = 6), Quality of life (n = 5), Psychological functioning / distress (n = 4)	30*
Mediators Tested	Psychosocial (n = 18), Affective (n = 8), Cognitive (n = 3), Biological (n = 6), Behavioral (n = 5)	30*

* Mental health outcomes and mediator categories are not mutually exclusive. Several studies examined more than one outcome and/or mediator; therefore, category frequencies may exceed the total number of included studies (n = 30).

For instance, it shows that cross-sectional studies dominated the literature (53%), while randomised controlled trials accounted for around a quarter of the included studies. Similarly, it highlights that habitual physical activity was the most frequently examined exposure, while depression was the most common outcome. The table also shows that psychosocial mediators (such as self-efficacy and coping) were the most frequently studied pathways.

Table 5 groups the mediators into five broad categories: psychosocial, affective, cognitive, biological, and behavioural. It provides examples of mediators within each

category and reports the number (and percentage) of studies examining them. This table reveals that psychosocial mediators were the most frequently investigated (60% of studies), supporting the strong role of factors such as self-efficacy and coping strategies in explaining exercise's mental health benefits.

Table 5. Frequency of Mediator Categories Across Included Studies

Mediator Category	Examples	No. of Studies (%)
Psychosocial	Self-efficacy, coping, self-esteem, body esteem, functionality, self-system	18 (60%)
Affective	Positive affect, negative affect, arousal, daily mood	8 (27%)
Cognitive	Cognitive function, executive function	3 (10%)
Biological	BDNF, cortisol, inflammation, fatigue, fitness	6 (20%)
Behavioral	Sleep, resilience, duration of PA	5 (17%)

Note: Several studies tested more than one mediator category; percentages sum to >100.

Affective mediators (e.g., positive affect, mood) were present in about one-quarter of studies, while cognitive mechanisms (e.g., executive function) were relatively rare. Biological mediators, such as brain-derived neurotrophic factor (BDNF), inflammatory markers, and fatigue, were examined in about one-fifth of studies, while behavioural mediators (such as sleep and resilience) appeared in fewer but still significant analyses. This table underscores the multidimensional nature of mediation pathways.

Table 6 presents the risk-of-bias assessment for the 30 included studies, based on the adapted criteria for mediation research. Studies were categorised as high quality (score of 6-7), acceptable quality (score of 4-5), or low quality (score ≤ 3). The table also provides representative examples of studies in each quality category.

Table 6. Risk of Bias Ratings of Included Studies

Quality Category	Score Range (out of 7)	No. of Studies (%)	Examples of Studies
High Quality	6–7	14 (47%)	Buffart et al. (2014), Adams et al. (2018), Donyaei et al. (2024)
Acceptable Quality	4–5	11 (37%)	Pickett et al. (2012), Chen et al. (2022), Costigan et al. (2019)
Low Quality	≤3	5 (16%)	Feuerhahn et al. (2012), (Foroughi et al. (2023)

Overall, 14 studies (47%) were rated as high quality, 11 (37%) as acceptable, and 5 (16%) as low quality. High-quality studies were typically well-powered randomised controlled trials or longitudinal studies with validated measures and appropriate statistical approaches. In contrast, low-quality studies tended to be small-scale cross-sectional

designs with limited adjustment for confounding variables. This table helps contextualise the strength of the evidence base and informs the interpretation of the findings.

Discussion

This systematic review aimed to elucidate the mechanisms by which exercise and physical activity (PA) benefit mental health, examining 30 empirical studies. The findings reveal a multifaceted network of psychosocial, affective, cognitive, biological and behavioural mechanisms that link PA to mental health outcomes. Importantly, the evidence converges on certain pathways (particularly self-efficacy, affect, sleep, and inflammation) while illuminating under-explored areas (e.g., executive function, resilience). This discussion interprets these results, situates them in the broader literature, and explores their theoretical and practical implications. While the Introduction outlined existing theoretical frameworks and prior evidence, the present Discussion focuses specifically on integrating the current review's findings with this literature to clarify which mediating mechanisms demonstrate the strongest and most consistent empirical support.

Overview: clarifying how exercise improves mental health

Decades of research have established that physical activity (PA) benefits mental health, yet the precise mechanisms by which movement translates into better mood, reduced symptoms, and greater well-being have been harder to pin down (Crichton & Fenesi, 2025; Firth et al., 2020). By restricting inclusion to studies that formally tested mediation, this review offers a clearer map of why PA helps. The cross-study picture that emerges is resolutely multi-mechanistic: psychosocial (e.g., self-efficacy, self/ body-related cognitions), affective (positive/negative affect and arousal), behavioural (especially sleep), biological/physiological (e.g., fitness, fatigue, BDNF, inflammatory markers), and more sparsely cognitive (e.g., executive function) pathways jointly account for PA's mental-health effects. These findings integrate neatly with the broader "lifestyle psychiatry" and mechanisms literature, which argues that exercise likely exerts its benefits via interlocking biopsychosocial processes rather than a single dominant route (Lubans et al., 2008).

A methodological note is important at the outset: the mediators, populations, outcomes, and designs were intentionally diverse. As argued elsewhere, pooling such

heterogeneous mediation effects into a single meta-estimate risks producing a number that is neither clinically interpretable nor epistemically informative (Bero, 2019). Accordingly, we adopted a structured, narrative synthesis that emphasises pattern detection and theory building (MacKinnon & Luecken, 2008). The findings of the present review are further strengthened by recent large-scale syntheses exploring mediating mechanisms between physical activity and mental health. Rhiannon L. White et al. (2024) conducted a best-evidence systematic review of 247 studies and identified strong evidence for psychosocial mediators, including self-efficacy, self-esteem, resilience, and social support, as well as for affective and physiological pathways. These results closely align with the current study's interpretation that improvements in mental health outcomes through exercise are best explained by an integrated biopsychosocial framework rather than by isolated biological or behavioural effects.

Psychosocial pathways: the most consistent signal

Across the included studies, psychosocial mediators provided the most consistent explanatory power. Self-efficacy, long posited as a central lever in behaviour-health links (Bandura, 1977), emerged repeatedly as a key indirect pathway from PA to lower depression/anxiety and higher well-being or quality of life (Aguiñaga et al., 2018; Awick et al., 2017; Chair et al., 2020; Elavsky & McAuley, 2005; Pickett et al., 2012). These findings dovetail with prior mechanism reviews emphasising self-efficacy and related self-beliefs as robust mediators in youth and adults (Lubans et al., 2008; Rhiannon Lee White et al., 2017). Notably, our set also identified global self-esteem/physical self-worth and body esteem as potent mediators, particularly salient in adolescents, older adults, and clinical cohorts where body-related self-perceptions are consequential for mood and functioning (Birch et al., 2016; Chae et al., 2017; Condello et al., 2016; Elavsky & McAuley, 2005).

Two practical implications follow. First, program design matters: PA prescriptions that include mastery experiences, progressive goal-setting, and credible feedback are likely to amplify psychological resources (Bandura, 1978; Deci & Ryan, 1985; Nicholls, 1989). Second, content and context matter: modalities that naturally support competence and favourable body experiences (e.g., graded resistance work, skill-building sessions, low-threat group formats) may potentiate self-efficacy and body esteem gains, thereby improving mental health. This squares with adolescent and

survivorship work showing that when activities fit skill level and foster mastery, downstream mood benefits are larger (Buffart et al., 2014; Costigan et al., 2019).

A recurrent nuance in your dataset is that exercise-specific self-efficacy was sometimes less predictive than global self-efficacy or self-esteem. One interpretation is that specific mastery experiences during PA generalise to broader self-beliefs only when the context sustains autonomy/competence and reduces fear of social evaluation conditions classically emphasised by Self-Determination Theory (Deci & Ryan, 1985). This could explain why some studies found stronger indirect effects via global constructs and why body-image/esteem variables frequently co-mediate with efficacy (Chae et al., 2017; Condello et al., 2016; Elavsky & McAuley, 2005).

Affective mechanisms: proximal changes that accumulate

Affective responses, immediate shifts in positive and negative affect, mood, and arousal, formed another coherent mediation stream. Multiple studies, including trials and diary designs, showed that affect improvements statistically channel the benefits of PA into well-being and reduced distress (Awick et al., 2017; Costigan et al., 2019; Feuerhahn et al., 2012; Foroughi et al., 2023). This is theoretically consonant with work linking structured movement to acute mood elevation (e.g., endorphin hypotheses; monoaminergic signalling) and day-level emotion regulation (Dishman & O'Connor, 2009; Kandola, Ashdown-Franks, Hendrikse, Sabiston, & Stubbs, 2019). Importantly, such short-term affective boosts are not trivial ephemera; repeated exposures appear to accumulate, reinforcing well-being and protecting against symptom escalation (Headey, Kelley, & Wearing, 1993; Watson et al., 1988). Adolescents in PA-intensity studies, for instance, often showed an indirect path from affect to well-being when intensity and enjoyment were aligned (Costigan et al., 2019). For working adults, day-level exercise predicted same-day positive affect, which mediated higher well-being, a signal highly relevant for occupational mental health (Feuerhahn et al., 2012).

Programmatically, this argues for designing interventions that optimise affective valence during and immediately after sessions (e.g., music, preferred modality, scenic routes, supportive climate). Affective tailoring may be particularly important for individuals with low baseline motivation or those early in behaviour change, where positive affect can bootstrap adherence (Lubans et al., 2008; Rhiannon Lee White et al., 2017).

Behavioural and social-behavioural routes: sleep (and friends) matter

A consistent behavioural mediator in your set was sleep. Studies in community and older adult cohorts found that better sleep health or sleep quality partly explained lower depression/anxiety among more active individuals (Barham et al., 2022; Choi et al., 2024). This is a mechanistically plausible exercise that can strengthen circadian timing, increase sleep drive, and improve sleep architecture, thereby regulating mood and stress responsivity (Firth et al., 2020; Kandola et al., 2019). While earlier umbrella reviews judged the sleep pathway as promising but methodologically mixed, the mediation-specific findings here support sleep as a practical, modifiable target to amplify PA's mental health effects (Firth et al., 2020).

Closely related are social-behavioural mechanisms. Several included studies identified social support, connection, or use of PA as a coping strategy as mediators of the PA–mental health link (Chu et al., 2023; Clément et al., 2024). This aligns with a long tradition dating back to early exercise-mood work, suggesting that aspects of social context can amplify post-exercise mood benefits (Doyne, Chambless, & Beutler, 1983; Ransford, 1982), while acknowledging that PA undertaken alone can also be therapeutic (North, McCullagh, & Tran, 1990). Contemporary syntheses emphasise "context matters" the right social climate (supportive, competence-affirming, non-evaluative) can magnify benefits (Rhiannon Lee White et al., 2017). Practitioners should thus steer people toward supportive environments rather than simply "group" per se.

Biological and physiological channels: fitness, fatigue, inflammation, and BDNF

Although fewer in number than psychosocial studies, mediation analyses incorporating biological/physiological variables revealed coherent pathways. In cancer survivorship and chronic disease cohorts, improvements in cardiorespiratory fitness and reductions in fatigue mediated gains in quality of life and mood (Adams et al., 2018; Buffart et al., 2014). In adolescents, inflammatory markers and stress biomarkers partially accounted for the exercise-depression link (Booij et al., 2015). In a randomised trial with women with type 2 diabetes, BDNF increases following combined training mediated reductions in depressive symptoms (Donyaei et al., 2024). Such findings extend neurobiological theorising beyond classic endorphin and monoamine accounts to

neuroplasticity and immunoinflammatory models, providing statistical evidence of indirect effects (Dishman & O'Connor, 2009; Kandola et al., 2019; Paluska & Schwenk, 2000).

Two cautions are appropriate. First, biological mediators were more frequently detected in clinical/older samples, where physiological headroom for change is larger. Second, measurement and timing matter: to detect biological mediation, studies must time assessments to capture change in the mediator prior to or alongside change in outcomes, a design strength more common in trials than cross-sectional work (MacKinnon & Luecken, 2008). Even so, our findings substantiate a biopsychosocial view: biological improvements (fitness, inflammation, neurotrophic support) are not competing with psychosocial routes; they likely cooperate with affective, cognitive, and behavioural mechanisms.

Cognitive pathways: promising but underpowered

Only a handful of included studies examined cognitive mediators, but the signal is suggestive. In college students, executive function mediated the inverse relationship between PA and trait anxiety (Z. Dong et al., 2022). Cognitive control and attentional regulation are plausible levers by which PA reduces worry, rumination, or threat appraisal, especially in populations experiencing cognitive inefficiencies under stress (Lubans et al., 2008). More longitudinal and experimental mediation studies are needed here, ideally pairing validated cognitive tasks with repeated mental-health measures.

Patterns across designs, exposures, and populations

Several cross-cutting patterns clarify for whom and under what conditions particular pathways dominate.

Design quality. RCTs and longitudinal designs more often detected theoretically coherent mediators (Adams et al., 2018; Buffart et al., 2014; Elavsky et al., 2005) than cross-sectional studies, consistent with mediation best practice (MacKinnon & Luecken, 2008). Cross-sectional mediation can be informative but remains more vulnerable to reverse causality and omitted variables.

Exposure type/intensity. Habitual PA commonly activated psychosocial and affective pathways (Costigan et al., 2019; Pickett et al., 2012), whereas structured, higher-intensity interventions in clinical samples more often showed fitness and fatigue

mediation (Adams et al., 2018; Buffart et al., 2014). This suggests a practical heuristic: tailor exposure to the likely active mechanism design youth programs to maximise mastery/enjoyment; design survivorship/chronic-illness programs to progress conditioning safely and reduce fatigue burden.

Population. Adolescents and young adults showed strong mediation via self-related constructs and affect, plausibly reflecting identity development and social-evaluation salience (Chae et al., 2017; Costigan et al., 2019). Older adults and chronic disease cohorts demonstrated physiological and functional mediation (Birch et al., 2016; Buffart et al., 2014), though psychosocial routes remained active (Elavsky et al., 2005). This fits a developmental-contextual model in which mechanism salience shifts with age, health status, and social roles (Lubans et al., 2008; Rhiannon Lee White et al., 2017).

Behavioural ecology. Sleep consistently mediated PA's impact on depression/anxiety in adults and older samples (Barham et al., 2022; Choi et al., 2024). Interventions might therefore schedule activity timing (e.g., morning or early evening) and exposure (light, outdoor activity) to strengthen circadian entrainment and downstream sleep pressure, thereby improving mood.

Reconciling social context debates: it's not "group vs solo," it's support

The included studies echo a long-standing debate over the importance of social interaction in the exercise-mood links. Classic trials showed exercise alone sufficed to improve mood (Doyne et al., 1983; North et al., 1990), but early theorists already suspected that social attention contributed (Ransford, 1982). Contemporary reviews refine the point: context matters, but not all "group" is equal (Vella et al., 2023). In our synthesis, social support and connection often mediated benefits, whereas the mere fact of group participation was not uniformly helpful (Clément et al., 2024). In practice, clinicians should help individuals locate supportive, autonomy-respecting PA environments rather than prescribing group formats indiscriminately (Deci & Ryan, 1985).

Motivation, needs satisfaction, and mastery: clarifying mixed signals

You noted mixed findings for exercise-specific needs satisfaction (autonomy, competence, relatedness). A likely reason is the level of analysis: studies measuring need satisfaction narrowly within a single activity may miss how global need satisfaction

(across life domains) mediates mental health (Deci & Ryan, 1985). Our synthesis suggests that mastery and competence cultivated through optimally challenging tasks and non-comparative climates are reliable levers (Lubans et al., 2008; Nicholls, 1989). Interventions should therefore emphasise task-involving climates, de-emphasise social comparison, and scaffold progressive success to convert PA exposures into durable self-beliefs and mood gains (Lubans et al., 2008; Nicholls, 1989).

Integrating neurobiological theories with lived mechanisms

Narratives about endorphins, monoamines, and more recently neuroplasticity/inflammation have shaped expectations about exercise's antidepressant effects (Dishman & O'Connor, 2009; Kandola et al., 2019; Paluska & Schwenk, 2000). Yet critics note that overly reductionist accounts underplay psychosocial context (Kandola et al., 2019). Our mediation-only synthesis helps reconcile these views: biological routes were detectable (fitness, fatigue, BDNF, inflammation), but psychosocial and affective mediators appeared more consistently across designs and populations. Rather than a hierarchy, the data support a braided model, wherein biological change co-evolves with self-beliefs, affect regulation, and behaviour (sleep), jointly producing mental-health benefits (Lubans et al., 2008). Recent evidence supports the neurobiological plausibility of exercise–mind interactions, as yoga-based interventions have been shown to enhance cortical regulation and emotional stability through autonomic modulation (Choudhary & Choudhary, 2025), reinforcing the present review's emphasis on biopsychosocial mediators linking physical activity and mental health.

Overall Synthesis of Findings

Taken together, the findings indicate that the mental health benefits of physical activity are best understood through a multidimensional framework rather than a single dominant mechanism. Across populations and study designs, psychosocial and affective mediators emerged as the most consistently supported pathways, while biological and cognitive mediators appeared more context-specific, particularly in clinical and experimental settings. Importantly, the relative contribution of each mediator domain varied across population characteristics, physical activity modality, and the outcome assessed, underscoring the need for mechanism-informed intervention design rather than uniform exercise prescriptions.

Public health and clinical implications

At the population level, the evidence endorses PA as a mental health promotion strategy with likely greater marginal benefit among those with baseline symptoms (Firth et al., 2020; Kandola et al., 2019). For practitioners, the take-home is to design for mechanisms:

- Build self-efficacy and mastery: use graded tasks, credible feedback, and autonomy-supportive coaching (Bandura, 1978; Chair et al., 2020; Deci & Ryan, 1985; Pickett et al., 2012).
- Optimise affective experience: prioritise enjoyable, preferred activities and supportive climates to elicit positive affect (Costigan et al., 2019; Feuerhahn et al., 2012; Foroughi et al., 2023).
- Leverage sleep: time activity, and dose to improve sleep health where depression/anxiety is prominent (Barham et al., 2022; Choi et al., 2024).
- Progress conditioning in clinical groups: target fitness and fatigue reduction explicitly in survivorship and chronic disease (Adams et al., 2018; Buffart et al., 2014).
- Curate social context: connect people to *supportive* (not necessarily group) environments that strengthen belonging and coping (Clément et al., 2024).

Crucially, monitor mediators during interventions (e.g., self-efficacy scales, affect diaries, sleep indices, fatigue and fitness markers). Mechanism-aware monitoring allows mid-course adjustment to maximise the indirect effects that matter for a given person (MacKinnon & Luecken, 2008). These mediators also represent modifiable targets for coaches seeking to enhance both athletes' mental well-being and competitive performance.

Methodological reflections and future directions

The field is moving in the right direction; your mediation-only lens shows that many teams now explicitly test mechanisms. Still, several gaps merit attention:

1. Design rigour and timing. More longitudinal and experimental mediation studies are needed, with clear temporal ordering (PA → mediator → outcome) and repeated measures (MacKinnon & Luecken, 2008).

2. Measurement standardisation. Harmonising PA (objective + validated self-report), mediator definitions, and mental-health outcomes would reduce heterogeneity and enable targeted meta-analyses (Bero, 2019; Rhiannon Lee White et al., 2017).
3. Under-studied mediators. Cognitive pathways (executive function) and resilience merit deeper testing across age/clinical strata (Z. Dong et al., 2022; Lubans et al., 2008).
4. Contextual science. Build on the "context matters" work by manipulating features such as autonomy support, natural environments, and social norms to identify which contextual levers amplify specific mediators (Rhiannon L. White et al., 2024).
5. Complex models. Use parallel/serial mediation to model how affect, self-efficacy, sleep, and fitness interact. Several included papers already do this, but more preregistered, adequately powered tests are needed (Baruth et al., 2016; Buffart et al., 2014; Chu et al., 2023).
6. Equity and generalisability. Expand samples beyond WEIRD settings; test mechanisms in low- and middle-income countries, diverse occupations, and across the lifespan (Henrich, Heine, & Norenzayan, 2010)

Strengths of the Review

The primary strength of this review lies in its strict mechanism-focused approach. By including only studies that employed formal mediation analyses, the synthesis moves beyond associative evidence and provides clearer insight into how physical activity influences mental health outcomes. The review integrates evidence across a wide range of populations, study designs, and physical activity modalities, enhancing the external validity and generalizability of the identified mechanisms. Additionally, organising findings into coherent mediator domains enables theory-driven interpretation and facilitates translation into intervention design and applied practice. Together, these features strengthen the review's contribution by advancing a mechanism-informed understanding of the relationship between physical activity and mental health.

Limitations

Several limitations of this review should be acknowledged. First, substantial methodological and clinical heterogeneity was present across the included studies, including variability in populations, physical activity exposures, mediator definitions, outcome measures, and statistical mediation models. This heterogeneity limited direct comparison across studies and precluded quantitative synthesis. Second, a large proportion of the included studies employed cross-sectional designs, which restrict causal inference regarding mediating pathways. Although longitudinal and randomised controlled trials were included, stronger conclusions regarding the temporal ordering of mediators require further experimental research.

Third, no meta-analysis was conducted due to the diversity of mediation approaches and reporting formats, which may limit estimation of the magnitude of indirect effects across studies. Fourth, the review protocol was not preregistered, which may introduce a risk of selection or reporting bias, although systematic procedures were applied throughout study identification, screening, and synthesis. Finally, only English-language, peer-reviewed articles were included, potentially excluding relevant studies published in other languages.

Conclusions

This systematic review synthesised evidence from studies that formally tested mediating mechanisms linking physical activity and exercise to mental health outcomes. The findings demonstrate that the relationship is consistently mediated through multiple domains, most notably psychosocial factors such as self-efficacy and self-esteem, affective responses including positive and negative affect, behavioural pathways such as sleep, and, in specific populations, biological and cognitive mechanisms. The relative contribution of these mediators varies across population characteristics, study designs, and types of physical activity exposure. Overall, the review confirms that the mental health benefits of physical activity are not uniform but are achieved through distinct, context-dependent pathways, highlighting the importance of mechanism-focused research to advance understanding in this field.

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