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Physical activity as a potential protective factor against depressive and anxiety symptoms among children and adolescents: a narrative review

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Abstract

Background. Depressive and anxiety disorders are major public health challenges among children and adolescents. Identifying accessible protective factors is essential for youth mental health promotion. **Aim.** To synthesize evidence (2019–2026) on physical activity (PA) as a protective factor against depression and anxiety in pediatric populations. **Material and methods.** A narrative review was conducted using PubMed/MEDLINE, Scopus, Web of Science, and Google Scholar, covering studies published between 2019 and 2026 on physical activity, exercise, and mental health outcomes in children and adolescents. **Results.** Regular PA was consistently associated with lower depressive and anxiety symptoms. Moderate activity showed the most favorable outcomes, whereas the association between PA volume and mental health appeared non-linear. Team sports were associated with better psychological outcomes than individual sports, and PA interventions were particularly beneficial for psychologically vulnerable youth. Neurobiological mechanisms, including BDNF-related adaptations, remain under investigation. **Conclusions.** PA is an important non-pharmacological strategy for preventing and supporting the management of depressive and anxiety symptoms in youth. Future research should prioritize individualized approaches integrating PA within 24-hour movement frameworks.

Key words: physical activity, exercise, depression, anxiety, mental health, children, adolescents

1. Introduction

Depressive and anxiety disorders are among the most prevalent mental health conditions affecting children and adolescents worldwide and represent a major public health challenge. These conditions negatively affect emotional well-being, academic performance, social relationships, and overall quality of life during critical stages of development. Globally, approximately 13% of individuals aged 10–19 years experience mental health conditions or clinically relevant symptoms, with depressive and anxiety disorders being among the most frequently reported disorders in this population [1, 9]. The increasing burden of internalizing symptoms among young people highlights the need for accessible, effective, and scalable preventive strategies capable of reducing the risk of future mental health problems.

Recent global events have further emphasized the importance of preventive approaches to youth mental health. The COVID-19 pandemic was associated with prolonged school closures, social isolation, and substantial reductions in daily physical activity, accompanied by increases in sedentary behavior among children and adolescents [13]. At the same time, contemporary lifestyle changes have contributed to progressively higher levels of sedentary behavior, which have been associated with less favorable psychological outcomes in pediatric populations [20]. Within the 24-hour movement behavior framework, combinations of insufficient physical activity, prolonged sedentary time, and inadequate sleep have been associated with poorer mental health and educational outcomes, highlighting the importance of considering movement behaviors as an integrated whole rather than in isolation [15, 20].

Although cognitive behavioral therapy (CBT) and pharmacological treatment, particularly selective serotonin reuptake inhibitors (SSRIs), remain central components of the management of depressive and anxiety disorders, their implementation is frequently limited by restricted access to specialized services, challenges related to treatment adherence, and variable treatment response [1, 14]. Consequently, increasing attention has been directed toward preventive strategies that are safe, scalable, and feasible at the population level, particularly interventions that may strengthen psychological resilience before clinically significant symptoms develop.

Physical activity (PA) has emerged as one of the most extensively investigated modifiable lifestyle factors linked to mental health in children and adolescents. Accumulating evidence indicates that regular participation in PA is associated with lower levels of depressive and anxiety symptoms, whereas reduced participation in sport and other forms of physical activity has been linked to a greater likelihood of adverse mental health outcomes among young people [2, 9, 23, 26]. Population-based studies further suggest that adolescents who do not participate in organized sports may have a 10–20% greater likelihood of experiencing mental health problems than their more physically active peers [23, 26]. The potential psychological benefits of PA are thought to result from multiple interacting mechanisms, including exercise-induced neuroplasticity involving brain-derived neurotrophic factor (BDNF), improved emotional regulation, enhanced self-esteem, and greater social connectedness [18].

The potential value of PA may be particularly important for pediatric populations with increased psychological vulnerability. Evidence suggests that PA interventions are associated with improvements in depressive and anxiety symptoms among children and adolescents with overweight or obesity, while also contributing to improved self-esteem and psychological well-being [10]. Similarly, exercise-based interventions have demonstrated beneficial associations with emotional symptoms and executive functioning among adolescents with attention-deficit/hyperactivity disorder (ADHD) [16]. In psychiatric inpatient settings, structured aerobic exercise has also been related to greater reductions in depressive symptoms when implemented alongside standard clinical care [27]. Collectively, these findings suggest that PA may represent a valuable complementary approach across a broad spectrum of pediatric populations.

Beyond physiological adaptations, increasing attention has been directed toward the social context in which physical activity occurs. Conceptual models such as the Mental Health through Sport framework suggest that organized sport participation may promote psychological well-being through social connectedness, peer support, and community engagement, in addition to the direct effects of physical activity itself [3, 24]. Evidence also indicates that psychosocial mechanisms underlying these associations may differ according to individual characteristics, including gender, with factors such as social support and emotional regulation appearing to contribute differently to psychological resilience among male and female adolescents [22].

Recent research has also distinguished between the long-term adaptations associated with regular participation in physical activity and the immediate psychological responses following individual exercise sessions. Ecological momentary assessment studies suggest that even single bouts of physical activity may be associated with short-term improvements in affect, energetic arousal, and executive functioning [19, 30]. At the same time, emerging evidence indicates that the association between PA volume and mental health may not be strictly linear. Dose-response analyses suggest that psychological benefits increase up to moderate levels of activity, whereas additional gains may diminish at very high exercise volumes or intensities [5, 21]. These observations have contributed to growing interest in more individualized approaches to exercise prescription for mental health promotion.

The importance of PA for child and adolescent health is reflected in international recommendations. The World Health Organization (WHO) recommends that children and adolescents accumulate at least 60 minutes of moderate-to-vigorous physical activity (MVPA) daily while minimizing sedentary behavior [29]. Although these recommendations provide an important foundation for general health promotion, uncertainty remains regarding which specific characteristics of physical activity—including its frequency, intensity, time, and type (FITT)—are most consistently associated with favorable mental health outcomes. Recent meta-analyses further suggest that intervention effectiveness may vary according to exercise modality, with structured aerobic and group-based programs frequently demonstrating favorable psychological outcomes [6, 11].

Therefore, this narrative review aims to synthesize and critically discuss recent evidence regarding the role of physical activity as a protective factor against depression and anxiety in children and adolescents. Particular attention is given to the associations between different characteristics of physical activity and mental health outcomes, the potential biological and psychosocial mechanisms underlying these associations, and the implications of current evidence for prevention strategies and clinical practice.

2. Research materials and methods

This narrative review examines the relationship between physical activity (PA) and mental health outcomes in pediatric populations, including typically developing children and adolescents, at-risk groups, and clinical cohorts with diagnosed depressive or anxiety

disorders. Literature published between 2019 and 2026 was identified through a targeted search of the PubMed/MEDLINE, Scopus, Web of Science, and Google Scholar databases. The search strategy employed combinations of the following keywords: physical activity, exercise, sport, depression, anxiety, mental health, children, adolescents, youth, prevention, and psychological well-being. Reference lists of relevant systematic reviews and meta-analyses were also screened to identify additional eligible publications. Although the primary focus was on children and adolescents (<19 years), studies including broader age ranges or longitudinal follow-up into adulthood were retained when participants had been recruited during childhood or adolescence or when the reported findings primarily reflected pediatric cohorts.

Eligible study designs included randomized controlled trials (RCTs), longitudinal and observational studies, systematic reviews, and meta-analyses. Priority was given to recent high-quality systematic reviews, meta-analyses, and longitudinal cohort studies utilizing validated assessment instruments. The World Health Organization (WHO) Physical Activity Guidelines were additionally consulted to support interpretation of the available evidence and to provide a reference framework for discussing physical activity recommendations. Studies focusing exclusively on adult populations, animal models, conference abstracts, editorials, and non-peer-reviewed publications were excluded.

Across the included studies, mental health outcomes were assessed using validated self-report and clinician-administered instruments, including the Children's Depression Inventory (CDI), the Screen for Child Anxiety Related Emotional Disorders (SCARED), the Hospital Anxiety and Depression Scale (HADS), and the Clinical Interview Schedule–Revised (CIS-R). Physical activity was assessed using both self-reported questionnaires and objective measures, most commonly wearable accelerometry, allowing quantification of activity volume, intensity, and sedentary behavior.

The final narrative synthesis incorporated 30 publications. As this study was designed as a narrative review rather than a systematic review, no formal risk-of-bias assessment or methodological quality scoring of individual studies was performed. Instead, emphasis was placed on recent peer-reviewed evidence, particularly studies employing robust methodological approaches. Because substantial heterogeneity existed across study populations, physical activity interventions, outcome measures, and methodological

approaches, quantitative pooling of results was not considered appropriate. Instead, evidence was synthesized narratively, with findings organized according to major thematic areas identified across the literature. To facilitate comparison between studies, the characteristics of physical activity interventions were interpreted using the Frequency, Intensity, Time, and Type (FITT) framework.

3. Research results

3.1. General Associations Between Physical Activity and Mental Health

Across the reviewed literature, higher levels of physical activity (PA) were consistently associated with more favorable mental health outcomes among children and adolescents. Evidence from umbrella reviews, systematic reviews, meta-analyses, observational studies, and intervention trials demonstrated associations between regular PA participation and lower depressive and anxiety symptom severity across both general pediatric populations and groups with increased psychological vulnerability [1, 9, 12, 14].

Singh et al. [1], in an umbrella review and meta-meta-analysis evaluating PA interventions among children and adolescents, reported significant improvements in depressive and anxiety outcomes following PA participation. Although the magnitude of effects varied according to exercise modality, intensity, duration, participant characteristics, and methodological quality of the included reviews, beneficial associations were consistently observed across diverse pediatric populations.

Similarly, Recchia et al. [8], in a meta-analysis including 21 randomized and quasi-experimental studies involving 2,441 participants, demonstrated a statistically significant reduction in depressive symptoms following PA interventions compared with control conditions (Hedges' $g = -0.29$; 95% CI: −0.49 to −0.09; $p = 0.004$). These findings suggest that structured PA interventions can contribute to statistically significant, though modest, improvements in depressive symptoms among children and adolescents.

Evidence derived from objectively measured movement behaviors further supports these findings. Wang et al. [9], in a systematic review and meta-analysis of accelerometer-based studies, reported that higher levels of objectively measured PA were associated with lower depressive and anxiety symptom severity. The use of accelerometry strengthened the

available evidence by reducing recall bias commonly associated with self-reported PA assessment and providing more accurate estimates of activity volume, intensity, and sedentary behavior.

Beyond reductions in depressive and anxiety symptoms, PA participation was also associated with broader indicators of psychological functioning. Fu et al. [12] reported positive associations between regular PA and psychological well-being, emotional functioning, and self-esteem among typically developing children and adolescents. Similarly, Wade et al. [24] highlighted associations between organized sport participation and improved social functioning, interpersonal relationships, and overall psychological well-being. Pascoe et al. [26] likewise identified PA as an important component of youth mental health promotion strategies, with beneficial associations reported for mood, resilience, and psychological well-being.

Collectively, the reviewed evidence consistently indicates that regular PA is linked to more favorable mental health outcomes across diverse pediatric populations. While the magnitude of these associations varies according to study design, participant characteristics, and intervention parameters, the overall direction of evidence supports PA as an important protective factor against depressive and anxiety symptoms during childhood and adolescence.

3.2. Exercise Type, Sport Context, and Psychosocial Environment

The reviewed evidence indicated that psychological outcomes associated with PA differed according to the context and organization of participation. Organized team sports were more frequently correlated with favorable mental health outcomes compared with individual sports or non-participation, particularly regarding depressive and anxiety symptoms [3, 23].

Pluhar et al. [23] examined differences in mental health outcomes between youth participating in team and individual sports in a cross-sectional study involving 756 youth athletes. Participants engaged exclusively in individual sports demonstrated a higher prevalence of clinically relevant anxiety or depressive symptoms compared with team-sport athletes (13% vs. 7%; $p < 0.01$). Differences between sport contexts were discussed in relation to motivational environment, competitive structure, and opportunities for social interaction.

Longitudinal evidence was provided by Bengtsson et al. [3], who synthesized data from more than 50,000 participants and evaluated associations between organized sport participation during childhood and adolescence and subsequent health-related outcomes. The review identified associations between organized sport participation and more favorable long-term psychological outcomes, with team-based participation demonstrating particularly consistent relationships with positive mental health indicators.

Wade et al. [24], in an updated Mental Health through Sport conceptual model, examined pathways connecting sport participation with psychological and social outcomes. The model identified social connectedness, interpersonal relationships, and community engagement as relevant components associated with sport participation and mental health outcomes.

Differences between team and individual sports were further examined by Wei et al. [22], who investigated mechanisms linked to psychological resilience among adolescent athletes. The authors reported that emotion regulation, perceived social support, and self-efficacy contributed to resilience, with differences according to sport context. Social support showed a particularly prominent association among team sport participants, whereas self-efficacy demonstrated a comparatively stronger relationship among individual sport participants.

Importantly, participation in individual sports was not uniformly associated with unfavorable psychological outcomes. Individual disciplines were also correlated with development of self-efficacy, competence, and achievement-related skills. Differences between sport types appeared to be related to variations in social environment, motivational characteristics, and competitive demands rather than to the activity type alone [19, 22, 23].

3.3. Neurobiological and Psychological Mechanisms Associated with Physical Activity

The reviewed literature indicates that the relationship between PA and mental health outcomes involves multiple biological and psychological processes. Among the biological mechanisms investigated, exercise-induced neuroplasticity, particularly involving brain-derived neurotrophic factor (BDNF), represents one of the most frequently examined pathways potentially involved in psychological and cognitive outcomes in young populations.

Rico-González et al. [18] conducted a systematic review of randomized controlled trials evaluating the effects of exercise interventions on circulating BDNF concentrations in

adolescents. The review included eight high-quality trials investigating different exercise modalities and intervention protocols. The findings demonstrated substantial heterogeneity: four studies reported statistically significant increases in circulating BDNF concentrations following exercise interventions, whereas four studies did not identify significant changes. Positive findings were more frequently observed in interventions involving vigorous-intensity exercise and programs lasting at least six weeks. Differences between studies were reported according to developmental stage, metabolic characteristics, exercise modality, intervention duration, and methodological approach.

In addition to long-term biological adaptations, studies have examined immediate psychological responses following individual episodes of PA. Bourke et al. [30] conducted a systematic review using ecological momentary assessment (EMA) approaches to evaluate within-person associations between PA and affective states in children and adolescents. The review demonstrated associations between individual episodes of PA and short-term increases in positive affect and energetic arousal.

The relationship between habitual sport participation, acute exercise exposure, and psychological functioning was also investigated by Pasquerella et al. [19]. Their study examined associations between sport participation, acute exercise responses, mental health indicators, and executive functioning in adolescents. The authors reported relationships between PA engagement and measures of psychological functioning, including executive functioning outcomes.

Several studies also reported associations between PA participation and psychological domains beyond depressive and anxiety symptoms. Fu et al. [12] identified relationships between PA and improved psychological well-being, self-esteem, and emotional functioning among typically developing children and adolescents. Similarly, Simpson et al. [14] reported associations between PA interventions and improvements in mental health-related outcomes among children and adolescents with increased psychological vulnerability, although effect magnitude varied depending on participant characteristics and intervention design.

Overall, the available evidence suggests that the beneficial association between PA and mental health is likely mediated through multiple interacting biological, psychological, and social mechanisms rather than a single physiological pathway. However, findings regarding

specific biological markers, particularly exercise-related changes in BDNF concentrations, remain heterogeneous across studies.

3.4. Dose-Response Characteristics and FITT Parameters of Physical Activity

Beyond the overall beneficial association between PA and mental health, several studies investigated whether specific exercise prescriptions produce different psychological outcomes. The relationship between PA characteristics and mental health outcomes has been investigated using the Frequency, Intensity, Time, and Type (FITT) framework. Recent meta-analyses and dose-response studies have examined whether differences in exercise prescription correspond to variations in depressive and anxiety symptom outcomes.

Exercise intensity represented one of the most frequently examined variables. Song et al. [4], Li et al. [6], and Li et al. [11] reported that aerobic exercise interventions performed at moderate-to-high intensity were associated with reductions in depressive and anxiety symptoms among children and adolescents. Across these analyses, anxiety symptoms demonstrated particularly favorable associations with higher-intensity aerobic exercise, whereas depressive symptoms improved across a broader range of moderate-to-high intensity interventions. Reported intensity ranges varied between studies depending on the measurement approach, including approximately 60–89% of maximal aerobic capacity for anxiety outcomes and approximately 40–89% for depressive symptoms [4, 6, 7, 11].

The influence of total exercise volume was examined by Du et al. [5] in a systematic review and Bayesian dose-response meta-analysis of aerobic exercise interventions for adolescent depression. The authors identified an association between increasing weekly PA volume and greater reductions in depressive symptoms up to approximately 740 MET-min/week. Beyond this level, additional increases in exercise volume were linked to limited further improvement. Similar non-linear patterns were reported by Zhang et al. [21], who investigated prospective associations between PA duration and mental health outcomes in adolescents.

Intervention duration and weekly frequency were also associated with differences in observed outcomes. Song et al. [4], Li et al. [6], and Li et al. [11] reported that intervention characteristics such as session duration and training frequency influenced the magnitude of psychological effects. Sessions lasting approximately 45–50 minutes were associated with greater improvements in depressive symptoms, whereas longer sessions of approximately 60–

75 minutes demonstrated favorable associations with anxiety outcomes. Interventions performed approximately three times per week were frequently linked to reductions in depressive and anxiety symptoms across meta-analytic evidence [7, 11].

The relationship between exercise exposure and psychological outcomes was further examined by Chen et al. [7], who investigated precision exercise strategies for adolescent depression. Their findings indicated that the association between exercise dose and psychological outcomes was non-linear, with moderate exercise exposure demonstrating substantial symptom improvement compared with both lower and higher exposure levels.

Gu [25] additionally examined whether the type and context of PA influenced associations with depressive symptoms. Using data from the China Family Panel Studies, the study reported differences between recreational and obligatory forms of activity, with recreational PA demonstrating more favorable associations with depressive symptoms compared with certain forms of obligatory non-recreational activity.

Collectively, the reviewed studies indicate that multiple characteristics of PA—including intensity, volume, duration, frequency, type, and activity context, consistent with the FITT framework—are associated with variability in psychological outcomes among children and adolescents.

3.5. Effects of Physical Activity in Vulnerable and Clinical Pediatric Populations

PA interventions have been investigated in several pediatric populations characterized by increased psychological vulnerability, including adolescents with psychiatric disorders, neurodevelopmental conditions, obesity, and elevated depressive or anxiety symptoms. Across these groups, studies generally reported associations between structured PA interventions and improvements in psychological outcomes, although effect magnitude varied according to population characteristics, baseline symptoms, and intervention protocols.

The relationship between PA and psychological outcomes was also examined during periods of increased environmental stress. Zhong et al. [13] reviewed studies conducted during the COVID-19 pandemic and reported associations between maintaining PA participation during school closures and lower levels of emotional distress among children and adolescents.

Among adolescents receiving psychiatric inpatient treatment, Philippot et al. [27] investigated structured physical exercise as an adjunctive intervention in a randomized controlled trial. Participants completing a six-week group-based aerobic exercise program demonstrated a greater reduction in depressive symptoms compared with participants receiving a social relaxation intervention. The exercise group showed a mean reduction of approximately 3.8 points on the Hospital Anxiety and Depression Scale–Depression subscale (HADS-D). No statistically significant between-group difference was observed for anxiety symptoms.

Physical activity interventions have also been examined among adolescents with ADHD. Liu et al. [16] conducted a randomized controlled trial evaluating the effects of a 12-week aerobic exercise intervention. The intervention was associated with reductions in depressive symptoms, anxiety symptoms, and stress levels, together with improvements in inhibitory control. Improvements in depressive symptoms, anxiety, stress, and inhibitory control were maintained at three-month follow-up, whereas improvements in resilience were not sustained.

Children and adolescents with overweight or obesity represent another extensively investigated population. Men et al. [10] conducted a systematic review and meta-analysis including 19 randomized controlled trials involving 1,795 participants. The authors reported that PA interventions were related to reductions in depressive and anxiety symptoms and improvements in self-esteem and self-worth outcomes. The magnitude of effects differed according to participant characteristics, including age, obesity severity, and race.

School-based PA interventions have been evaluated as scalable approaches for addressing adolescent mental health. Da Silva et al. [17] conducted a cluster randomized controlled trial among Brazilian adolescents. Although no significant differences between intervention and control groups were observed in the overall sample, participants presenting with moderate-to-severe depressive or anxiety symptoms at baseline demonstrated significant reductions in both symptom domains following the intervention.

Collectively, these findings indicate that although PA interventions appear beneficial across several vulnerable pediatric populations, the magnitude of observed effects varies according to baseline clinical status, intervention characteristics, and participant-specific factors.

3.6. Longitudinal Evidence and Integrated Movement Behaviors

Longitudinal studies provide important evidence regarding associations between movement patterns during childhood and adolescence and subsequent mental health outcomes. The reviewed cohort studies indicate that changes in PA, sedentary behavior, and other movement-related behaviors throughout adolescence are associated with later psychological outcomes.

Kandola et al. [2] investigated objectively measured PA and sedentary behavior during adolescence using prospective data from the Avon Longitudinal Study of Parents and Children (ALSPAC) cohort. Participants underwent accelerometer assessment at approximately 12, 14, and 16 years of age, while depressive symptoms were assessed at age 18 using the Clinical Interview Schedule–Revised (CIS-R). The study demonstrated a progressive decline in total PA during adolescence accompanied by increasing sedentary behavior. Higher sedentary time across adolescence was associated with higher depressive symptom scores at age 18. Conversely, higher levels of light-intensity PA and greater overall activity during earlier adolescence were correlated with more favorable depressive symptom outcomes.

Bengtsson et al. [3] examined longitudinal associations between organized sport participation during childhood and adolescence and subsequent health-related outcomes. Their systematic review and meta-analysis, including data from more than 50,000 participants, reported associations between organized sport participation and favorable long-term psychological outcomes. Associations were observed across different sport contexts, with team-based participation demonstrating particularly consistent relationships with positive mental health indicators.

The association between activity dose and future mental health outcomes was further examined by Zhang et al. [21]. In a prospective cohort study, moderate-intensity PA of approximately 30–59 minutes per day and vigorous-intensity PA of up to approximately 29 minutes per day were associated with the lowest risk of subsequent mental health problems. Longer durations of activity were not correlated with additional proportional improvements.

Sedentary behavior represented an additional component of movement patterns associated with mental health outcomes. Lu et al. [20] conducted a systematic review and dose-response meta-analysis based on objectively measured movement behaviors and reported a non-linear

association between sedentary time and depressive symptoms. Higher levels of sedentary behavior were related to increased depressive symptom severity, with greater risk observed at higher levels of daily sedentary time, particularly beyond approximately 2–4 hours per day.

Movement behaviors have also been examined within broader 24-hour activity frameworks incorporating PA, sedentary behavior, and sleep. Wilhite et al. [15] conducted a systematic review evaluating combinations of these movement domains in relation to psychological, physical, and educational outcomes among children and adolescents. The review reported that meeting recommendations across multiple movement behavior domains was associated with more favorable outcomes compared with meeting fewer or none of the recommendations.

Together, the longitudinal evidence supports the view that physical activity, sedentary behavior, and sleep should be considered as interrelated components of daily movement behaviors influencing mental health trajectories across childhood and adolescence.

4. Discussion

4.1. Interpreting the Relationship Between PA Dose and Mental Health

The findings synthesized in this narrative review indicate that physical activity (PA) represents an important non-pharmacological strategy that is consistently associated with more favorable mental health outcomes among children and adolescents. Across umbrella reviews, meta-analyses, randomized controlled trials, and longitudinal cohort studies, greater engagement in PA was generally correlated with lower depressive and anxiety symptom severity [1, 8, 14, 17]. However, the accumulated evidence suggests that the relationship between PA and youth mental health is not explained by activity volume alone and does not follow a simple linear dose-response pattern.

Although increasing levels of PA are generally associated with improvements in psychological outcomes, recent dose-response analyses suggest the presence of a plateau beyond which additional activity provides limited additional benefit [5, 7, 21]. Du et al. [5] identified a threshold of approximately 740 MET-min/week, after which further increases in activity volume were associated with progressively smaller improvements in depressive symptoms. These findings highlight the importance of considering the qualitative characteristics of PA and applying the FITT framework to better understand how frequency,

intensity, duration, and type of activity may influence psychological outcomes rather than focusing exclusively on maximizing exercise volume.

Likewise, the reviewed evidence suggests that sedentary behavior should not be viewed simply as the absence of physical activity. Dose-response analyses indicate that prolonged sedentary time is independently linked to poorer mental health outcomes, reinforcing the importance of reducing sedentary behavior alongside increasing PA [20]. Moreover, the reviewed evidence suggests that the context in which PA is performed also matters. Some evidence suggests that recreational and voluntarily chosen activities may be associated with more favorable psychological outcomes than obligatory forms of physical exertion [25], indicating that autonomy may influence the mental health benefits of exercise [25]. Future prescription guidelines may benefit from ongoing methodological efforts to formally quantify these dose-response relationships, including a registered protocol for a Bayesian dose-response network meta-analysis addressing optimal exercise prescription for depression and anxiety in children and adolescents [28].

4.2. Contextual Determinants of Sport Participation

The psychological impact of PA appears to depend substantially on the context in which activity occurs. Organized sport participation, particularly within team environments, has been associated with more favorable mental health outcomes [3, 23, 24]. The available evidence suggests that these associations may arise not only from physiological adaptations related to exercise but also from social mechanisms, including peer support, belonging, and interpersonal connectedness. The Mental Health through Sport model proposed by Wade et al. [24] emphasizes that sport-related psychological benefits emerge through broader social experiences created within organized environments rather than through physical activity exposure alone.

However, individual disciplines should not be considered inherently detrimental. Participation in individual sports may contribute to autonomy, self-efficacy, and personal competence [19, 22]. The less favorable outcomes occasionally observed among individual-sport populations may be related to contextual factors, including increased performance pressure, competitive environment, or reduced opportunities for social support, rather than the nature of the activity itself [22, 23]. Therefore, future approaches should focus on optimizing motivational and

social environments across different sporting contexts rather than prioritizing one type of participation exclusively.

4.3. Neurobiological and Affective Mechanisms

The mechanisms underlying the association between PA and mental health are multifactorial and involve interacting biological, psychological, and social processes. Neurobiological pathways involving exercise-induced neuroplasticity, particularly brain-derived neurotrophic factor (BDNF), have received considerable attention. However, findings regarding changes in peripheral BDNF concentrations among adolescents remain inconsistent, suggesting that BDNF represents one component of a broader biological network rather than a single explanatory marker of psychological improvement [18].

Complementing these long-term adaptations, acute psychological responses captured through ecological momentary assessment demonstrate that individual episodes of PA are associated with rapid improvements in affective states, including increased positive affect and energetic arousal [30]. Therefore, the mental health effects of PA likely reflect interactions between immediate affective changes, cognitive processes, and cumulative physiological adaptations occurring over repeated engagement in physical activity [19, 30]. Improvements in executive functioning reported in several studies may additionally contribute to better emotional regulation and psychological functioning [19].

4.4. Clinical Utility and Targeted Interventions

The reviewed evidence indicates that PA interventions may be particularly relevant for pediatric populations with elevated psychological vulnerability. Studies involving adolescents with ADHD, obesity, depressive or anxiety symptoms, and those receiving psychiatric inpatient treatment demonstrate associations between structured exercise programs and improvements in clinical symptoms and functional outcomes [10, 16, 27].

Importantly, baseline symptom severity appears to influence intervention responsiveness. Findings from school-based interventions suggest that adolescents presenting with higher initial levels of depressive or anxiety symptoms may derive greater benefit than those without substantial psychological difficulties at baseline [17]. These observations emphasize the importance of identifying populations most likely to benefit from targeted PA interventions

adapted to individual clinical characteristics rather than applying identical approaches across all youth populations. Evidence synthesized from studies conducted during the COVID-19 pandemic additionally suggests that maintaining regular PA may help buffer psychological distress during periods of social restriction and reduced daily movement opportunities [13].

4.5. Limitations and Future Research Directions

Despite consistent associations between PA and mental health outcomes, several limitations should be considered. First, although longitudinal studies provide important information regarding temporal relationships, residual confounding and bidirectional associations remain possible. An important consideration is that the relationship between PA and mental health may be reciprocal: while reduced physical activity may contribute to worsening psychological outcomes, emerging depressive or anxiety symptoms may simultaneously decrease motivation and the ability to engage in regular physical activity. Adolescents with better baseline psychological functioning may therefore be more likely to initiate and maintain regular PA participation, particularly organized sport involvement [2, 3].

Second, substantial heterogeneity exists across studies regarding PA measurement methods, intervention protocols, participant characteristics, and mental health assessment tools. Although the increasing use of accelerometry has improved measurement precision, many studies continue to rely partly on self-reported activity measures, limiting direct comparisons between investigations [2, 9, 20]. Moreover, considerable variability in intervention characteristics, including exercise modality, supervision, adherence, and outcome measures, further complicates direct comparisons across studies and limits the development of universally applicable exercise recommendations.

Furthermore, many intervention studies involve relatively short follow-up periods, creating uncertainty regarding the long-term sustainability of psychological improvements after structured programs conclude [8]. Future research should prioritize longer-term follow-up designs, standardized assessment protocols, and methodological approaches capable of better clarifying causal mechanisms. Additional attention should also be directed toward demographic, developmental, and socioeconomic factors that may influence both participation patterns and intervention effectiveness.

Finally, future research should increasingly investigate how PA interventions can be effectively integrated into school and organized sport environments to support sustainable mental health promotion among children and adolescents.

4.6. Implications for Practice and Integrated Movement Frameworks The current evidence supports a transition from purely quantity-focused approaches toward a more individualized model of PA promotion that considers enjoyment, autonomy, social support, and long-term sustainability. Although achieving recommended levels of physical activity remains an important public health objective, psychological outcomes appear to depend not only on the amount of activity performed but also on the quality and context of participation.

Finally, PA should be considered within the broader framework of daily movement behaviors. Evidence from the 24-hour movement framework indicates that physical activity, sedentary behavior, and sleep represent interconnected components influencing youth health outcomes [15]. Integrating PA promotion with strategies aimed at reducing excessive sedentary time and supporting adequate sleep may therefore provide a more comprehensive approach to improving psychological well-being among children and adolescents. Given the multifactorial nature of youth mental health, integrating physical activity promotion with established psychological and educational support strategies may represent a promising approach. Such an integrated approach, rather than isolated interventions, may better address the complex interplay between physical health, psychological well-being, and social environment.

5. Conclusions

Physical activity represents an important and accessible component of strategies aimed at promoting mental health among children and adolescents. Evidence from umbrella reviews, meta-analyses, randomized controlled trials, accelerometer-based studies, and longitudinal cohorts indicates that regular participation in physical activity is consistently associated with lower depressive and anxiety symptom severity across both general pediatric populations and groups with increased psychological vulnerability [1, 2, 8, 9, 10, 16, 27].

Current evidence suggests that the relationship between physical activity and mental health is influenced not only by the total amount of exercise performed but also by its characteristics and context. Moderate and sustainable levels of activity are frequently associated with the

most favorable psychological outcomes, emphasizing the importance of considering frequency, intensity, duration, type, enjoyment, and individual preferences when designing interventions [5, 7, 21]. Strategies promoting excessive exercise volume without consideration of adherence and personal motivation may therefore be less effective than approaches supporting long-term engagement in enjoyable and meaningful movement behaviors.

The psychosocial environment surrounding physical activity also appears to contribute substantially to psychological outcomes. Team-based activities may provide additional benefits through social connectedness, peer support, and a sense of belonging, whereas individual sports may promote self-efficacy and competence when implemented within supportive motivational environments [3, 19, 22, 24].

The association between physical activity and youth mental health is likely mediated by interacting biological, psychological, and social mechanisms. Although exercise-induced neuroplasticity and BDNF-related adaptations represent important areas of investigation, current evidence indicates that no single pathway fully explains the observed benefits of physical activity [18]. Immediate improvements in affective state and cognitive functioning may complement longer-term adaptations resulting from regular participation [19, 30].

Future research should prioritize individualized, evidence-based approaches to physical activity promotion, longer follow-up periods, and improved clarification of causal mechanisms. Integrating physical activity promotion with reductions in sedentary behavior and optimization of sleep within the 24-hour movement framework may provide a comprehensive strategy for supporting mental health throughout childhood and adolescence [15]. Despite remaining uncertainties related to intervention characteristics and individual variability, physical activity should be considered a valuable and scalable component of preventive and supportive approaches targeting depressive and anxiety symptoms in young populations.

Declarations

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