Health Problems of Civilization
eISSN: 2354-0265, ISSN: 2353-6942

REVIEW PAPER

Psychological strength as a mediator of the relationship between physical activity and depressive symptoms in young people: a literature review

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Michalski N, Chmielarska A. Psychological strength as a mediator of the relationship between physical activity and depressive symptoms in young people: a literature review. Health Prob Civil. https://doi.org/10.29316/hpc/221195

Tables: 1
Figures: 0
References: 37
Submitted: 2026 March 19
Accepted: 2026 Apr 28

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Abstract

The aim of this study was to review literature and synthesize data published between 2023 and 2026 on the relationship between physical activity, psychological strength, and depressive symptoms in young people, with particular emphasis on the mediating role of psychological strength. A literature search was conducted in the Scopus, Web of Science, PubMed, PsycINFO, SPORTDiscus, ScienceDirect, and SpringerLink databases. The analysis included empirical cross-sectional, longitudinal, and interventional studies, as well as systematic reviews and meta-analyses examining the relationship between physical activity, constructs related to psychological strength, including resilience, and depressive symptoms. The results indicate a consistent inverse relationship between physical activity levels and the severity of depressive symptoms in young people. Longitudinal studies suggest a possible directional relationship, while interventional studies indicate a small to moderate antidepressant effect of physical exercise. Mediation analyses show that resilience may partially mediate the relationship between physical activity and mental health outcomes, accounting for a significant portion of the total effect in this age group. These results suggest that resilience is an important and potentially modifiable protective factor against depressive symptoms in young people and may be one of the important mechanisms through which physical activity supports mental health and prevention of depression.

Keywords: psychological strength, mediation, physical activity, depression, youth

Introduction

Depression is one of the most serious public health problems among young people, and its prevalence is steadily increasing worldwide. Adolescence and early adulthood are particularly vulnerable stages of development, characterized by intense biological, cognitive, emotional, and social changes that may increase susceptibility to depressive symptoms. Depression is associated with reduced quality of life, impaired academic, and interpersonal functioning, increased risky behaviors, as well as an increased risk of self-harm and suicide [1-3]. In response to the growing burden of depressive symptoms among young people, increasing attention to research is being devoted to identifying modifiable protective factors that may reduce the risk of developing depression or alleviate its severity [1-3]. Among these factors, physical activity is identified as one of the best-documented behavioral resources supporting mental health [4-6]. Numerous studies show that regular physical activity is associated with

improved mood, reduced symptoms of depression and anxiety, and improved overall psychological well-being in young people [5-8]. Furthermore, meta-analyses suggest that aerobic exercise can significantly reduce depressive symptoms in young people, confirming its importance as a valuable, non-pharmacological strategy for promoting mental health and preventing depressive disorders [6-11].

Despite growing evidence confirming the beneficial effects of physical activity on the mental health of young people, the mechanisms underlying this relationship remain to be sufficiently explained [9,10]. Current research indicates that the relationship between physical activity and mental health is complex and likely involves the interaction of multiple neurobiological, psychosocial, and behavioral pathways [4,5,10]. In recent years, the role of internal psychological resources as potential mediating mechanisms in this relationship has attracted particular attention [10,12-15].

For the purposes of this review, psychological strength is understood as a broad set of protective psychological resources that promote adaptive functioning under conditions of stress and developmental demands. In the context of the available literature, this construct primarily encompasses resilience, self-efficacy, coping resources, and emotional self-regulation, which may promote more favorable mental health outcomes in young people [10,12-15]. This approach is supported by research findings indicating that resilience and self-efficacy may mediate the relationship between physical activity and well-being, while resilience-related constructs may also mediate the relationship between physical activity and broader psychosocial outcomes in the young population [12-15]. In this approach, psychological strength can be considered a potential mediator explaining how physical activity may contribute to improved mental health and potentially reduce the severity of depressive symptoms in young people [10,12,13].

Analyzing such mediation pathways has significant cognitive and practical implications, as it allows for a better understanding of the mechanisms responsible for the psychological benefits of physical activity and for identifying those elements of preventive and therapeutic interventions that are worth strengthening to increase their effectiveness [10,12].

The relationship between physical activity, psychological strength, and depressive symptoms can be viewed within the framework of the biopsychosocial model, which posits that mental health is the result of a dynamic interaction of biological, psychological, and environmental factors [4,5]. A more precise understanding of these mechanisms can provide an

important foundation for developing accessible, developmentally appropriate, and evidence-based strategies for supporting the mental health of young people and preventing depression.

Therefore, the aim of this literature review is to analyze the current state of knowledge regarding the role of psychological strength as a potential mediator of the relationship between physical activity and depressive symptoms in young people. A further aim of this study is to identify the factors of psychological strength that appear to be most important in this relationship and to organize the available evidence regarding the psychological mechanisms through which physical activity may support the mental health of young people.

Aim of the work

The aim of the article is to assess the current state of knowledge regarding the role of psychological strength as a potential mediating mechanism in the relationship between physical activity and depressive symptoms in young people. An additional goal is to identify the factors of psychological strength most frequently identified in literature as key components of this relationship.

Methods

This work is a narrative literature review. The analysis encompassed scientific publications from 2023-2026, including empirical studies and review articles on the relationship between physical activity, depressive symptoms, psychological well-being, and protective psychological resources in young people. The WHO definition of "young people" as individuals aged 10-24 years, encompassing adolescents (10-19 years) and youth (15-24 years), was adopted. A literature search was conducted in Scopus, Web of Science, PubMed, PsycINFO, SPORTDiscus, ScienceDirect, and SpringerLink. Cross-sectional, longitudinal, and interventional studies were included if they assessed the relationship between physical activity, psychological strength, and depressive symptoms. Systematic reviews and meta-analyses relevant to the interpretation of mediating mechanisms were also included. Publications that were not peer-reviewed and those that did not meet the thematic relevance criteria were excluded from the analysis. Due to the narrative nature of the study, the full PRISMA 2020 procedure was not followed; the literature search and selection process was conducted in a structured and transparent manner.

Literature review results

Depression in young people, physical activity and the need to analyze mediating mechanisms

Depressive disorders and symptoms in young people constitute one of the most serious public health challenges and are the leading cause of years lived with disability. A significant proportion of mental health problems begin during adolescence, and many cases remain undiagnosed and untreated [1,2]. Consequences of depressive symptoms include impaired school functioning, difficulties in peer relationships, an increased risk of self-destructive behavior, and an increased likelihood of recurrent depressive episodes in adulthood [1,3]. Early onset of symptoms is associated with a higher risk of chronicity and psychosocial burden later in life. Concurrently, low levels of physical activity are observed globally among young people. Analyses have shown that the vast majority of young people do not meet the recommendations for at least 60 minutes of moderate-to-vigorous physical activity daily [16]. The co-occurrence of depression and hypokinesia indicates a potential area for preventive intervention. Empirical evidence indicates that physical activity is associated with a reduction in depressive symptoms in children and young people. Meta-analyses of randomized controlled trials confirm the significant effect of exercise interventions on reducing the severity of depressive symptoms [6-8,17,18].

Physical activity consistently correlates with improved mental health indicators but highlights the methodological heterogeneity of the studies [6,7,17]. Longitudinal studies provide additional evidence for a directional relationship between physical activity and mental health. Higher levels of activity are associated with lower levels of depressive symptoms over time, although a possible bidirectional relationship has also been demonstrated – increased depressive symptoms may lead to a decrease in physical activity [8,15,19,20].

The social context of activity appears to be particularly important. Participation in organized sports, especially team sports, is associated with more favorable mental health trajectories and improved psychosocial well-being [21-25]. These results suggest that the physical activity effect may be partially related to social and psychological mechanisms.

Despite the growing evidence supporting the beneficial effects of physical activity on young people mental health, the mere finding of a correlation does not explain the mechanism of this effect. The importance of psychological mediators has been emphasized as explaining the observed effect [10-15].

One of the most promising constructs is resilience, defined as the ability to adaptively cope with stress and adversity. Resilience is associated with reduced depressive symptoms and better psychosocial functioning [21,26]. Mediational studies suggest that physical activity may influence mental health by increasing resilience. A longitudinal study demonstrated that resilience mediates the relationship between physical activity and social anxiety in young people [14,15]. Furthermore, other potential mediators have been identified, such as emotion regulation, self-esteem, and sleep quality. This suggests that the impact of physical activity on depressive symptoms may be multifaceted, encompassing both psychological and biological processes; therefore, there is a need to analyze the mediating mechanisms [24,27-29].

Evidence of the relationship between physical activity and depression, physical activity-resilience relationship

The strongest evidence for the association between physical activity and depressive symptoms in young people comes from systematic reviews and meta-analyses of intervention studies. These studies demonstrate significant reductions in depressive symptoms following exercise interventions, with moderate effect sizes. They document a beneficial effect of exercise on depressive symptoms in young people, but with notable heterogeneity in the results. However, the effectiveness of the intervention may depend on the type of activity, with aerobic exercise and mixed programs appearing to provide the greatest benefits [6,7,17,18].

The positive impact of exercise interventions on depression, anxiety, and self-esteem has been confirmed, and physical activity may therefore serve as a supportive intervention in the treatment of depression in young people. While physical activity is associated with improved mental health outcomes in the population of young people, the authors emphasize methodological limitations, including small sample sizes and short follow-up periods.

Experimental evidence indicates a significant, albeit moderate, effect on reducing depressive symptoms with physical activity. The heterogeneity of the effects suggests the role of moderating factors. Longitudinal studies provide important information regarding the directionality of the relationship [8,15,19,20]. Higher physical activity levels have been shown to be associated with lower levels of depressive symptoms over time, indicating a positive relationship between physical activity and emotional well-being. A bidirectional relationship has been observed: increased depressive symptoms may lead to a reduction in physical activity.

This suggests that some of the observed effects may result from the mechanism of secondary withdrawal from activity in the course of depression [8].

High population exposure to hypokinesia reinforces the potential protective effects of physical activity. Participation in organized sports is associated with more favorable mental health trajectories [21-25]. The psychosocial benefits of participation in sports include an increased sense of belonging and social support. Studies of school-based exercise interventions suggest that the educational environment provides an effective platform for implementing programs that support mental health through physical activity [22].

The effect of physical activity on depressive symptoms is not limited to physiological mechanisms; social and psychological factors are also important. A positive relationship between physical activity levels and resilience has been demonstrated in the population of young people, and a model has been proposed in which physical activity enhances psychological resources, including emotion regulation competencies and a sense of agency – components of resilience [13,21,26].

Mediation analyses indicate that resilience partially mediates the relationship between physical activity and mental health indicators, with meta-analytic structural equation models suggesting an indirect contribution of resilience of approximately one-third of the total effect [13]. Higher levels of resilience are associated with better mental health outcomes over time. Resilience may partially mediate the relationship between lifestyle and depressive symptoms. The most direct evidence of mediation comes from a multi-wave study that demonstrated that resilience mediates the relationship between physical activity and social anxiety [14,15]. Although this study examined a different clinical outcome, this model has high translational value for depression research.

Mediating mechanisms are also emphasized, including emotion regulation, self-esteem, sleep as a sequential mediator, family context as a moderator, and experiences of emotional abuse. This demonstrates a potentially multi-pathway model of the impact of physical activity on mental health, and these mechanisms are likely to be multi-level: biological, psychological and social [9-12,23,24,27-32], as shown in Table 1.

Table 1. Summary of evidence on associations between physical activity, psychological strength, and depressive symptoms in young people

Association domain	Study design	Key references	Core findings	Overall strength of evidence*
Physical activity → depressive symptoms	Umbrella review, systematic reviews and meta-analyses of interventions and RCTs	[7,11,17,18]	Physical activity is associated with lower depressive symptoms in young people. Effects are generally small to moderate, with aerobic and mixed exercise showing the most consistent benefits.	High
Temporal directionality	Prospective cohort studies, meta-analysis of prospective studies	[8,19,20,36]	Higher physical activity predicts lower later depressive symptoms or psychiatric risk, although effect sizes vary across studies.	Moderate-high
Population exposure	Global surveillance, epidemiological reports	[2,3,16]	Physical inactivity is common among young people, while depressive symptoms remain highly prevalent, underscoring the public health relevance of the issue.	High (descriptive epidemiological evidence)
Organized sport participation	Systematic review and meta-analysis, qualitative systematic review	[23-25]	Sport participation is generally linked to better mental health outcomes, likely through social support, peer integration, and self-regulatory mechanisms.	Moderate
School-based interventions	Cluster randomized controlled trial, school-based intervention evidence	[22]	School-based physical activity programs may improve mental health in young people, but long-term evidence remains limited.	Moderate
Physical activity → resilience / psychological strength-related resources	Meta-analytic structural equation modeling, mechanism-focused studies	[12,13,24,26]	Physical activity is positively related to resilience, self-efficacy, and other protective psychological resources.	Moderate
Resilience → mental health	Longitudinal studies, mechanism-focused analyses	[14,15,21,26,33]	Higher resilience is associated with more favorable psychosocial and mental health outcomes over time.	Moderate-high
Resilience as mediator	Meta-analytic structural equation modeling, longitudinal multi-wave studies	[12-15,31]	Resilience partially mediates the association between physical activity and mental health-related outcomes, although direct evidence for	Moderate

			depressive symptoms alone is more limited.	
Additional mediators / moderators	Mediation and moderation studies, secondary analyses	[9,24,30,31,35]	Sleep, emotion regulation, family context, executive function, and social support appear to shape this association through multiple pathways.	Low-moderate
Biological mechanisms	Reviews, biomarker analyses, mechanism studies	[5,26-29,32,34]	Biological plausibility is supported by findings related to inflammation, stress reactivity, neuroplasticity, and BDNF-related pathways.	Moderate

Notes: * The assessment of the strength of evidence was descriptive in nature and was based on study design, consistency of findings, number of sources, and the extent to which directionality or causality of the examined relationships could be inferred.

Other mediators in the physical activity-depression relationship and biological and neuropsychological mechanisms

Resilience is a promising mediator in the relationship between physical activity and depressive symptoms in young people, but alternative and complementary mediating pathways exist. Understanding their significance allows for the construction of a more comprehensive, multi-pathway model of influence, incorporating both psychological and biological mechanisms. These mechanisms may involve improved cognitive control, reduced stress reactivity, and enhanced executive functions.

Physical activity may reduce rumination and negative emotional processing – processes considered key in the pathogenesis of depression. In this context, improved emotion regulation constitutes a direct pathway between physical activity and the reduction of depressive symptoms. Exercise interventions may contribute to improving young people's ability to adaptively manage emotions and regulate emotions, which mediate the relationship between physical activity and mental health indicators, including depressive symptoms [23,24,33].

Self-esteem plays a mediating role between physical activity and depressive symptoms in young people. Participation in physical activity – especially organized physical activity – can enhance a sense of agency, competence, and a positive self-image. From the perspective of self-determination theory, an increased sense of competence and autonomy can lead to improved mental well-being, which partially explains the protective effect of physical activity [9,23,24].

Sleep disorders are both a risk factor and a symptom of depression; therefore, improving sleep parameters may constitute an important mediating pathway. Empirical studies and mediation analyses analyze these pathways in the form of a mediation model, in which physical activity influences sleep quality and duration, and sleep, in turn, mediates the relationship with depressive symptoms. This model indicates the possibility of sequential mediation and emphasizes the complexity of the mechanisms of influence and the need to analyze multi-stage models [10-12,30,31]. The model assumes sequential mediation, in which physical activity improves sleep quality and duration, which promotes increased psychological resources (resilience, emotion regulation), ultimately leading to a reduction in depressive symptoms. The model incorporates biological, cognitive, and emotional mechanisms.

The impact of physical activity on mental well-being may also be moderated by the family context (e.g. parental absence) [31]. The multilevel model of the impact of physical activity on the mental health of young people includes emotional, cognitive, and social mechanisms. The effect of physical activity on depression may be parallel (several mediators simultaneously) or sequential (e.g. physical activity → sleep → emotion regulation → depression), which explains the heterogeneity of effects observed in intervention studies [10-12].

Understanding psychological mediators requires contextualizing them within the biological mechanisms that may underlie the observed effects. Physical activity influences brain structure and function during adolescence, improves neural plasticity and cognitive function, and significantly modulates neuroplasticity in the context of depression [4,29,33,34]. Executive functions play a key role in emotion regulation and cognitive control, and their improvement may indirectly enhance resilience and reduce susceptibility to depressive symptoms. Physical activity interventions in young people improve key components of executive function, such as inhibitory control, working memory, and cognitive flexibility, and both chronic and occasional physical activity has a positive impact on executive function and the mental health of young people [4,25,35]. Physical activity may modulate stress reactivity by influencing the hypothalamic-pituitary-adrenal (HPA) axis.

Reducing excessive stress reactivity may limit the development of depressive and anxiety symptoms. Resilience can be considered a psychological manifestation of biological adaptation to stress [4,33]. Proinflammatory cytokines and stress hormones have been implicated in the pathogenesis of depression in young people. Physical activity reduces the level of inflammatory markers, potentially reducing the risk of affective disorders.

These mechanisms may constitute the biological basis of the psychological changes observed in mediation studies [27,28,32]. Therefore, the relationship between physical activity and depressive symptoms in young people is multifaceted; in addition to resilience, important mediators include emotion regulation, self-esteem, and sleep, while biological mechanisms – including neuroplasticity, HPA axis modulation, and inflammatory processes – may underlie the observed psychological changes [23,24,27-31,33].

Moderators, contextual factors, and mediation research methodology in the analysis of the physical activity-depression relationship

The relationship between physical activity and depressive symptoms in young people is not uniform. The heterogeneity of the effects suggests the existence of moderating factors that may amplify or attenuate the effect of physical activity on mental health [6,7,17,18].

Gender and developmental age

Studies demonstrate a general protective effect of physical activity, but there are indications that the strength of this effect may vary depending on gender and developmental stage. Late adolescence is associated with a higher incidence of depression, especially among females, which may influence differences in response to exercise interventions. Biological (hormonal) and psychosocial (social pressure, body image) differences may modify mediating mechanisms such as self-esteem and emotion regulation.

Globally, low levels of physical activity are observed among young people. Analyses have shown that the vast majority of young people do not meet the recommendations for at least 60 minutes of moderate-to-vigorous physical activity daily, which is a significant risk factor not only for metabolic disorders but also for deterioration of mental health in young people [16,31].

Family and environmental context

The relationship between physical activity and psychological well-being may be moderated by parental absence. In conditions of limited family support, physical activity may serve a compensatory function, enhancing psychosocial resources. Physical activity may attenuate the negative impact of emotional abuse on depressive symptoms through mediation

by social anxiety. This suggests a moderated mediation model, in which the indirect effect depends on the level of exposure to stressors [1,3,10-12,14,15].

Type of activity: team sport vs. individual sport

Participation in organized sports, especially team sports, is associated with more favorable mental health trajectories. The importance of the social aspects of sport – affiliation, peer support, and integration – should also be emphasized [23-25]. The type of activity may moderate the effect size through differences in social and emotional components. Individual activity may operate primarily through biological and regulatory mechanisms, while team activity may act by strengthening social support and group identity [4,23,24].

Sedentary behaviors are independently associated with poorer mental health indicators. In analytical models, the lack of control for time spent sitting may lead to an overestimation of the effects of physical activity, while sleep may be a mediator and a modifier of the physical activity-depression relationship [30,31].

The relationship between physical activity and depression is bidirectional. This means that depression may reduce levels of physical activity, complicating the interpretation of effects and highlighting the need for longitudinal designs [8,15,19,20]. Identifying mediators in the physical activity-depression relationship requires a rigorous methodological approach. Mediation analysis is not synonymous with causal inference [10-12]. In the context of research on the relationship between physical activity and depression, this implies the need to measure physical activity prior to assessing the mediator, and the mediator prior to evaluating depressive symptoms, while controlling for factors such as socioeconomic status, gender, sleep, and stress.

Cross-sectional designs have limited value for mediation analysis [10-12]. Many studies on physical activity and mental health are cross-sectional, which makes it difficult to determine the direction of the relationship. Multi-wave studies are an example of a more methodologically appropriate approach, enabling the analysis of dynamic changes over time [16,17]. A common limitation is the reliance on self-reported measures of physical activity, which are prone to recall bias and social desirability effects [6,7]. Psychological resilience is operationalized in various ways – as a trait, a process, or an outcome of adaptation. The lack of standardized instruments hinders comparability of results and the interpretation of mediation effects.

Discussion of the review results

The aim of this study was to analyze the current state of knowledge regarding the relationship between physical activity, psychological strength, and depressive symptoms in young people, with particular emphasis on the role of psychological strength as a potential mediating mechanism in this relationship. Overall, available evidence suggests both a direct association between physical activity and lower depressive symptoms and an indirect pathway involving protective psychological resources, particularly resilience and related constructs [7,8,11,13-15,17-20,36].

The most robust evidence identified in this review concerns the direct association between physical activity and depressive symptoms. Recent meta-analyses indicate that exercise interventions are associated with small to moderate reductions in depressive symptoms in young people, with the most consistent benefits observed in aerobic and mixed exercise programs [7,11,17,18]. Prospective studies also suggest that higher levels of physical activity predict lower subsequent depressive symptoms or reduced psychiatric risk, although the magnitude of these associations varies across studies, and partial bidirectionality cannot be ruled out [8,19,20,36]. At the same time, literature suggests that the health benefits of physical activity cannot be explained solely by a direct effect. Therefore, increased attention has been paid to mediating mechanisms that may explain how physical activity contributes to better psychological outcomes [9,10,12,13,26].

In this context, psychological strength, conceptualized primarily in terms of resilience and related protective resources, appears to be a theoretically consistent and empirically plausible mediator. Available research indicates that physical activity can enhance adaptive resources such as resilience, self-efficacy, coping skills, and emotion regulation, thereby supporting more favorable mental health outcomes [12-15,24,26]. Reviewed mediation studies suggest that resilience may partially mediate the relationship between physical activity and mental health outcomes [12-15,31]. However, current evidence is stronger for broader outcomes such as well-being, social anxiety, and psychosocial adjustment than for depressive symptoms specifically [12-15]. Therefore, resilience should be considered a promising, though not yet definitive, mediator of the association between physical activity and depressive symptoms in young people.

An additional important observation is that resilience is unlikely to be the sole explanatory mechanism. Literature suggests a broader network of complementary mediators

and moderators, including self-efficacy, self-esteem, sleep, emotion regulation, and family or social context [9,24,30,31]. This suggests that psychological resilience should be understood as an umbrella construct encompassing several interrelated protective resources rather than as a single isolated factor. From a biopsychosocial perspective, the reviewed evidence also supports the biological plausibility of these associations.

Physical activity has been linked to neuroplasticity, modulation of stress reactivity, inflammatory processes, and BDNF-related pathways, which may contribute to improved emotional functioning and adaptability [4,5,26-29,32-34]. However, literature still lacks sufficiently integrated multilevel studies integrating biological and psychological mediators within a single model of depression in young people. These findings may have practical implications. If psychological strength is at least partially modifiable by physical activity, preventive strategies targeting depression in young people may benefit from combining exercise with interventions explicitly aimed at enhancing resilience, self-efficacy, coping skills, and emotion regulation. This approach may be particularly relevant during adolescence, a period of development characterized by increased sensitivity to stress and greater susceptibility to depressive symptoms [7,12-15].

Limitations of the current evidence base should be acknowledged. First, the number of longitudinal studies using formal mediation analysis remains limited. Second, many of the available studies are cross-sectional, limiting conclusions regarding temporal order and causality. Third, significant heterogeneity exists in the operationalization of resilience and related constructs, as well as in the methods used to assess physical activity and mental health outcomes [9,12-15]. Therefore, the mediating role of psychological strength should currently be considered plausible and promising rather than definitively established.

In summary, available evidence suggests that physical activity is associated with lower depressive symptoms and better mental health outcomes in young people, while psychological strength, particularly resilience and related protective resources, may partially explain this association. Currently, the strongest findings relate to the direct effect of physical activity on depressive symptoms, while the evidence for mediation, although supportive, remains less clear. Future research should prioritize longitudinal and intervention-based studies with formal mediation tests, standardized measures, and multilevel models integrating psychological and biological pathways [8,9,12-15,26].

Practical implications

Physical activity may be an important element of preventive and supportive strategies for the treatment of depression in young people [6,7]. However, interpreting its role solely as a "protective factor" is insufficient. Considering psychological mediators and biological mechanisms allows for more precise intervention design. If emotion regulation is a significant mediator of the physical activity-depression relationship, exercise programs should be designed to support the development of emotional competencies, which means incorporating mindfulness elements into training, emphasizing stress-coping strategies, and reflecting on emotions accompanying physical activity. This approach increases the likelihood that the intervention's effect will not be limited to improved physical fitness but will also encompass adaptive emotional processing [9,23,24,33].

Research findings pointing to the role of self-esteem as a mediator suggest that interventions should enhance a sense of agency and competence; in practice, this means: adapting the level of exercise difficulty to participants' abilities, avoiding excessive competition in high-anxiety populations, and promoting experiences of success and progress. Programs based on self-determination theory, which enhance autonomy and competence, may produce more lasting psychological effects. If physical activity affects depression by improving sleep quality, interventions should include: sleep hygiene education, appropriate scheduling of training sessions (avoiding intense sessions late in the evening), and monitoring of the circadian rhythm [30,31]. This approach promotes synergistic biological and psychological effects.

School is a key environment for implementing exercise programs. According to the UNESCO recommendations on education for health and well-being, the school environment should integrate mental health promotion with physical activity [37]. School interventions have the potential to improve the mental health of young people [1,22]. The high level of insufficient physical activity in the population of young people [16] justifies the need for systemic solutions, such as increasing the number of hours of physical education, integrating physical activity with mental health promotion programs, and creating safe spaces for activity in schools. Including a social component (team sports) can further enhance the effect by improving integration and peer support [23-25].

Considering moderators such as gender, family context, and exposure to stressors [10-12,31] suggests the need to personalize interventions. In populations with high levels of psychosocial burden, physical activity may serve a compensatory function. In clinical groups,

exercise programs should be integrated with psychological and pharmacological therapy, in accordance with the recommendations for the treatment of depression in young people.

Evidence demonstrating the impact of physical activity on neuroplasticity [29,34], executive function, and stress reactivity suggests that exercise interventions may act through neurobiological mechanisms that enhance the ability to regulate emotions and adapt to stress [33,35]. In practice, this means that:

- regularity and moderate intensity of activity may be more important than short-term, intense programs;
- programs should be long-term to consolidate neuroadaptive changes.

From a population perspective, physical activity is a low-cost and scalable intervention. The high prevalence of hypokinesia [16] and the significant burden of depression [1,2,3] justify considering physical activity as a primary prevention strategy.

Key actions include:

- policies promoting active transportation (walking, cycling),
- programs supporting access to sports for young people with lower socioeconomic status,
- integrating physical activity promotion with mental health programs.

Conclusions

Available evidence indicates that physical activity is a significant and potentially modifiable protective factor for depressive symptoms in young people. Meta-analyses of randomized controlled trials and longitudinal studies suggest a small to moderate and relatively consistent effect of physical activity on reducing depressive symptoms. However, this relationship may be partially bidirectional, requiring caution in causal interpretation. Psychological strength, particularly resilience, appears to be a theoretically consistent and empirically plausible mediator of this association. Available analyses suggest partial mediation, indicating that physical activity retains a significant direct effect, while part of its effect on mental health may be explained by strengthening young adults' adaptive resources. In addition to resilience, emotion regulation, self-esteem, and sleep also contribute to this association, suggesting that the relationship between physical activity and depression involves multiple pathways. Biological mechanisms, including neuroplasticity, modulation of stress reactivity, and inflammatory processes, may partially underlie the observed psychological changes, consistent with the biopsychosocial model. Despite these promising findings, evidence for

mediation remains methodologically limited. The predominance of cross-sectional studies and the limited number of longitudinal and experimental designs with formal mediation testing limit the ability to draw clear causal conclusions. Additional challenges arise from the heterogeneity of operationalizations of resilience and the variability of methods for assessing physical activity. Future research should incorporate rigorous longitudinal and intervention designs with formal mediation analysis, appropriate time-based measurement, integration of psychological and biological indicators, and moderate mediation models that incorporate contextual factors. Physical activity, understood not only as a somatic stimulus but also as a way to strengthen young adults' adaptive resources, may be an important element of multilevel strategies for preventing and supporting the treatment of depression in young people.

Disclosures and acknowledgements

The authors declare no conflicts of interest with respect to the research, authorship, and/or publication of this article.

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

In preparing this work, the authors used ChatGPT (OpenAI) for the purpose of improving the English translation and language clarity. After using this tool, the authors have reviewed and edited the content as needed and accept full responsibility for the substantive content of the publication.

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