QUALITY IN SPORT
eISSN 2450-3118 · Open Access · Peer-reviewed
apcz.umk.pl/QS Nicolaus Copernicus University in Toruń

SZATKOWSKI, Michał, KRYSZPIN, Paulina, KANIA-BONICKA, Zofia, KRAJEWSKA, Natasza and MICHNIAK, Wiktor. Physical Activity and Sleep Quality in Adolescents and Young Adults: A Comprehensive Literature Review. Quality in Sport. 2026;56:72495. https://doi.org/10.12775/QS.2026.56.72495

ARTICLE TIMELINE
Received: 24.05.2026 Revised: 26.05.2026
Accepted: 26.05.2026 Published: 30.05.2026

INDEXING & EVALUATION
MEiN points: 20 Unique ID: 201398
Disciplines: Economics & Finance; Management & Quality Sciences

The journal has been awarded 20 points in the parametric evaluation by the Polish Ministry of Higher Education and Science (Annex to the announcement of 05.01.2024, No. 32553). Unique Journal Identifier: 201398. Scientific disciplines: Economics and Finance (Social Sciences); Management and Quality Sciences (Social Sciences).

Punkty Ministerialne z 2019 – aktualny rok 20 punktów. Załącznik do komunikatu Ministra Szkolnictwa Wyższego i Nauki z dnia 05.01.2024 Lp. 32553. Posiada Unikatowy Identyfikator Czasopisma: 201398. Przypisane dyscypliny naukowe: Ekonomia i finanse (Dziedzina nauk społecznych); Nauki o zarządzaniu i jakości (Dziedzina nauk społecznych).

Physical Activity and Sleep Quality in Adolescents and Young Adults: A Comprehensive Literature Review

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Abstract

Background. Sleep disturbances represent an escalating public health crisis among adolescents and young adults undergoing intensive neurobiological and social transitions. Modern 24-hour movement guidelines emphasize physical activity (PA) to counteract sedentary patterns and excessive digital engagement.

Aim. This review synthesizes empirical evidence regarding the relationship between PA and sleep quality in populations aged 10–25, exploring physiological impacts, psychological mediators, and lifestyle constraints.

Material and methods. A comprehensive search across PubMed, Web of Science, Cochrane, Embase, and Google Scholar identified 23 primary peer-reviewed studies (RCTs, longitudinal, cross-sectional, and systematic reviews). Eligible studies paired quantifiable PA metrics with validated sleep tools like the Pittsburgh Sleep Quality Index (PSQI) or actigraphy.

Results. Regular moderate-to-vigorous PA directly optimizes subjective sleep quality and objective sleep architecture, yielding a substantial intervention effect (SMD = -2.10). PA also operates through indirect pathways by alleviating academic stress and pre-sleep rumination. However, these benefits are heavily constrained by lifestyle factors; high recreational screen time (>2 hours/day) and poor nutrition significantly erode exercise's sleep-protective effects. Methodologically, a dichotomy exists between subjective scales prone to recall bias and objective actigraphy, which captures sex-specific sleep fragmentation.

Conclusions. PA functions as an effective, non-pharmacological stabilizer of sleep profiles by regulating physiological mechanisms and modulating cognitive-behavioral vulnerabilities. Future research must prioritize longitudinal designs pairing subjective metrics with high-resolution wearable actigraphy to establish precise, age-specific dose-response recommendations.

Keywords: Physical activity, Exercise, Sleep quality, Sleep architecture, Adolescents, Young adults, College students, Perceived stress, Cognitive hyperarousal, Screen time

1. Introduction

The developmental transitions of adolescence (ages 10–19) and young adulthood (ages 18–25) are characterized by profound neurobiological changes, psychological maturation, and shifting social frameworks. Among the most pervasive yet frequently neglected challenges during these life stages is the widespread decline in sleep health. Biological shifts, including a delayed circadian phase preference and an altered homeostatic sleep drive, systematically push bedtime preferences later into the night. When these biological predispositions collide with rigid societal structures—such as early high school start times and demanding university schedules—the result is widespread "social jetlag," truncated sleep duration, and diminished sleep quality.

Chronic sleep deprivation is not merely an inconvenience; it is deeply implicated in elevated morbidity and mortality risks within the general population, correlating with cardiovascular disease, metabolic syndrome, and severe psychological distress (Grandner et al., 2017). Within higher education environments, this issue is particularly acute. Estimates indicate that over 60%

of university students routinely experience poor sleep quality, which directly impairs cognitive performance, executive functioning, and emotional regulation (Lund et al., 2010).

To combat this public health trajectory, international health frameworks have increasingly pivoted toward holistic "24-hour movement guidelines." This paradigm recognizes that sleep health cannot be understood in a vacuum; instead, it is deeply codependent on an individual's balance of physical activity, sedentary time, and light exposure throughout the day (Chaput et al., 2020). Physical activity (PA) has emerged as a premier non-pharmacological strategy capable of regulating sleep parameters due to its accessibility and low cost. However, the interactions between exercise, modern digital environments, and psychological stressors in young populations are complex and highly individualized. This review synthesizes current empirical literature to provide a structured overview of how physical activity shapes sleep profiles in adolescents and young adults, exploring direct physiological impacts, underlying behavioral mechanisms, and contextual constraints.

2. Methodology

To establish a robust empirical foundation for this review, a systematic search strategy was designed to isolate high-quality, peer-reviewed literature detailing the intersections of movement behaviors and sleep parameters in younger demographics.

Database Search Strategy

Primary source collection was conducted across principal academic databases, including PubMed, Web of Science, the Cochrane Central Register of Controlled Trials, Embase, and Google Scholar. Search syntaxes integrated boolean strings combining keywords:

("physical activity" OR "exercise" OR "sports") ***AND*** ("sleep quality" OR "sleep duration" OR "insomnia" OR "actigraphy") ***AND*** ("adolescents" OR "young adults" OR "college students" OR "undergraduates")

2.1 Selection & Inclusion Criteria

Articles were restricted to those published or indexed in peer-reviewed journals. Investigations were systematically filtered based on the following targeted benchmarks:

- **Target Population:** Samples composed explicitly of adolescents (10–19 years) or young adults/college students (18–25 years).
- **Study Designs:** Randomized controlled trials (RCTs), prospective cohort studies, cross-sectional analyses, systematic reviews, and meta-analyses.
- **Variables Measured:** Quantifiable levels of physical exertion (frequency, intensity, or duration) paired with validated metrics of sleep, such as the Pittsburgh Sleep Quality Index (PSQI) or wrist-worn actigraphy sensors.

Through iterative filtering and removal of duplicates, exactly 23 distinct reference sources were isolated to form the empirical baseline of this review, ensuring representation across direct exercise interventions, psychological mediator models, and multi-behavioral lifestyle paradigms

3. Direct Effects of Physical Activity on Sleep Quality and Architecture

3.1 Meta-Analytic and Longitudinal Evidence

An extensive body of empirical research supports the premise that structured physical engagement functions as an effective stabilizer of sleep profiles. In an extensive meta-analysis evaluating eight randomized controlled trials involving adolescent cohorts, exercise interventions demonstrated a profound capability to improve global sleep profiles, yielding a substantial overall standardized mean difference ***(SMD = -2.10)*** across varying training configurations (Yan & Chen, 2025). This intervention data aligns with broader systemic literature showing that routine exercise alters human immune function, accelerates nervous system recovery, balances core temperature regulation, and synchronizes circadian rhythms, all of which directly facilitate sleep initiation and maintenance (Yan & Chen, 2025).

Furthermore, longitudinal analyses confirm that short-term and extended exercise regimens exert a bidirectional, mutually reinforcing positive impact on overall physical well-being and daily sleep performance (Dolezal et al., 2017). When individuals maintain sufficient baseline physical activity, they report a marked reduction in nighttime awakenings and an increase in perceived daytime alertness, creating a sustainable loop of physical health and sleep optimization.

3.2 The Nuance of Intensity and Timing

However, the specific characteristics of the physical activity—such as its intensity and timing—dictate its eventual efficacy. Structured evaluations show that while active individuals display superior sleep architectures compared to sedentary controls, moderate-intensity exercise tends to yield more uniform improvements in subjective sleep perception than high-intensity alternatives (Wang & Boros, 2019). Engaging in highly vigorous training immediately before bedtime can induce acute autonomic hyperarousal, elevate core body temperatures, and raise cortisol levels, thereby prolonging sleep-onset latency and disrupting total sleep time (Wang & Boros, 2019).

When structured appropriately, physical activity acts as a crucial buffer against sleep disturbances. For example, a 12-week controlled physical activity program conducted among female university students (aged 18–24) resulted in a major decrease in subjective sleep problems, with average global PSQI scores dropping significantly from an baseline of $\boldsymbol{9.1 \pm 1.7}$ down to $\boldsymbol{4.8 \pm 2.0}$ by the study's conclusion (Hurdiel et al., 2017). Similar preventative outcomes have been documented in broader systematic reviews, which conclude that consistent physical activity during adolescence decreases sleep fragmentation and increases deep, slow-wave sleep stages (Lang et al., 2016).

4. Psychological and Behavioral Mediating Mechanisms

The pathways connecting physical activity to enhanced sleep quality are rarely completely direct; instead, they operate through a network of behavioral self-regulation and psychological mediation.

> **Theoretical Framework:** Exercise does not merely tire the body; it restructures the individual's cognitive and behavioral choices throughout their waking hours, neutralizing stressors that would otherwise disrupt the sleep cycle.

4.1 Behavioral Cascades and Screen Dependency

In the modern digital environment, physical activity serves as an active behavioral disruptor of sedentary habits. Structural equation modeling reveals that physical exercise has a strong positive relationship with individual self-control $\boldsymbol{(r = 0.45)}$, creating a dual-mediating cascade

(Yin et al., 2024). By strengthening neurological prefrontal self-regulation, consistent physical activity empowers young adults to resist compulsive smartphone over-use and late-night screen scrolling (Yin et al., 2024). This reduction in screen dependency prevents blue-light-induced suppression of nocturnal melatonin synthesis, minimizing subsequent sleep onset delays.

4.2 Psychological Stress Mitigation

Psychologically, physical activity functions as a highly effective tool for cognitive defusion and emotional regulation. University environments place heavy academic demands on young adults, frequently triggering sleep-disrupting psychological distress. In these populations, physical exercise serves to lower perceived environmental stress and break cycles of ruminative thinking (Liu et al., 2025). By interrupting persistent negative thought loops and lowering somatic anxiety, physical activity dampens the pre-sleep cognitive hyperarousal that routinely compromises sleep efficiency and exacerbates insomnia symptoms (Liu et al., 2025). This psychological stabilization directly reinforces emotional well-being. Indeed, cross-sectional tracking confirms that regular physical activity improves daily mood state, elevates overall life satisfaction, and decreases self-reported daytime sleepiness in student cohorts (Lin et al., 2020; Kosendiak et al., 2022).

5. Synthesis of Key Empirical Studies

The following matrix synthesizes a selection of the core empirical papers included in this review, outlining their specific methodological approaches and primary findings regarding physical activity and sleep outcomes:

Author (Year)	Study Design	Sample Size & Characteristics	Measurement Modalities	Primary Outcomes & Findings

Hurdiel et al. (2017)	Interventional (12-Week Program)	Female University Students (Ages 18–24)	PSQI, Sleep Diaries	Observed an unprecedented drop in global PSQI scores from ***9.1*** $\pm$***1.7*** to ***4.8***$\pm$***2.0***, confirming the efficacy of structured fitness programs.
Xu et al. (2019)	Cross-Sectional Analysis (NHANES)	452 US Older Adolescents (Ages 16–19)	Self-report questionnaires, lifestyle logs	Determined that combining high PA with low screen time (2 h/day) reduced the odds of poor sleep quality by 73%.
Yin et al. (2024)	Mediational / Structural Equation Model	Undergraduate University Students	IPAQ (Short Form), PSQI, Smartphone Addiction Scale	Proved that physical activity enhances baseline self-control, which indirectly minimizes smartphone addiction to rescue sleep quality.

Liu et al. (2025)	Path Analysis / Modeling	Chinese Higher Education Cohort	Perceived Stress Scale, Ruminative Thinking Scale, PSQI	Isolated a significant indirect path where physical exercise decreases perceived academic stress, dampening rumination to optimize sleep efficiency.
Yan & Chen (2025)	Systematic Review & Meta-Analysis	710 Adolescents across 8 Randomized Trials	Combined subjective/objective sleep metrics	Yielded a profound overall intervention effect ***(SMD = -2.10)***, solidifying PA as a primary non-pharmacological sleep aid.
Al-Rasheed (2026)	Comparative Cross-Sectional	Saudi Arabian Adolescents	Multi-axial Wrist Actigraphy, PSQI, Biodex Balance System	Revealed that actigraphy-verified poor sleepers exhibited significantly lower daily step counts and elevated sedentary duration.

6. Confounding Constraints: Screen Time, Dietary Choices, and Macro Contexts

The real-world benefits of an active lifestyle on sleep quality are often limited by broader lifestyle behaviors, including dietary choices, recreational screen habits, and wider environmental stressors.

6.1 The Screen-Time and Dietary Nexus

Epidemiological data indicates that physical activity should not be analyzed in isolation, but rather as part of an integrated lifestyle profile. Scoping reviews indicate that matching adequate weekly physical activity with structured, high-quality nutritional habits—such as eating regular meals and consuming plenty of fruits and vegetables—exers a cumulative, positive influence on both sleep duration and sleep efficiency (Cruz et al., 2024). Conversely, combining physical inactivity with the regular intake of ultra-processed foods, high saturated fat, and excessive simple sugars correlates with abbreviated sleep cycles and heightened insomnia severity (Cruz et al., 2024).

Furthermore, excessive screen time can undermine the benefits of physical activity. In cross-sectional cohorts of older adolescents (ages 16–19), those who successfully combined recommended physical activity levels with low recreational screen time (2 hours/day) showed a 73% reduction in their odds of experiencing poor sleep (Xu et al., 2019). However, these protective benefits can display significant gender divergence; for instance, male adolescents frequently show more distinct protective gains when meeting physical activity and screen guidelines simultaneously compared to female peers (Xu et al., 2019). Additionally, adolescents who combine low baseline physical activity with high sedentary screen time and an elevated body mass index face the highest risk for severe sleep restriction (De Souza et al., 2021). These multi-behavioral interactions are further supported by international research confirming that high vigorous activity levels are associated with longer sleep durations, provided screen-based sedentariness is kept in check (Antczak et al., 2020).

6.2 Macro Contextual Disruptions

Societal crises can also drastically disrupt these lifestyle interactions. During the global COVID-19 pandemic, sudden lockdowns and widespread closures of fitness facilities fundamentally altered adolescent movement routines (Birmingham et al., 2021). The resulting

changes in daily schedules caused sharp declines in adolescent physical activity, which were accompanied by a substantial increase in sedentary lifestyles and irregular sleep patterns (Andrade, 2026).

Among university healthcare students tracked during the pandemic, approximately 73.1% reported poor sleep quality, an effect heavily correlated with a 12.7% rate of total physical inactivity and an escalation in late-night smartphone usage (Saygılı Düzova, 2025). Similar multi-behavioral tracking among medical and nursing undergraduates reveals that higher screen time combined with physical inactivity significantly worsens daytime fatigue and negative mood states, though the direct impact of screen time on absolute sleep indices can vary based on academic stress levels (AlKhenaizi, 2025).

7. Methodological Dichotomy: Subjective Questionnaires vs. Objective Devices

A critical challenge in interpreting the current literature stems from the distinct measurement modalities used to assess physical activity and sleep. The majority of large-scale epidemiological studies rely heavily on self-report questionnaires, such as the PSQI or the International Physical Activity Questionnaire (IPAQ). While these tools offer valuable insights into an individual's subjective experience of sleep quality and daytime dysfunction, they remain susceptible to recall bias and social desirability distortions.

To overcome these limitations, contemporary research increasingly pairs subjective scales with objective tracking technologies, such as multi-axial wrist actigraphy. Comparative studies using ActiGraph devices demonstrate that adolescents experiencing poor sleep (global PSQI > 5) show significantly lower total step counts, fewer daily activity sequences, and a higher proportion of overall sedentary time compared to normally sleeping peers (Al-Rasheed, 2026). Interestingly, objective actigraphy data reveals that while poor sleep quality profoundly impairs daytime postural stability and physical activity levels, it does not necessarily reduce acute isometric muscle strength (Al-Rasheed, 2026).

Furthermore, cluster analyses combining actigraphy data with the PSQI reveal distinct, sex-specific sleep profiles among young populations (Jiménez-Vaquero, 2025). For instance, men and women demonstrate varying degrees of sleep fragmentation, wake after sleep onset (WASO), and sleep efficiency, which influences how physical exercise alters their sleep architecture (Jiménez-Vaquero, 2025). These findings emphasize that relying solely on global

subjective scores can obscure specific micro-structural sleep impairments. This limitation is highlighted by multivariate regression models where weak initial correlations between physical activity and self-reported sleep quality can lose statistical significance once adjusted for sex, baseline health status, and academic pressures (Andrade, 2026).

8. Conclusion and Future Research Directions

In summary, the literature establishes a clear, multi-layered relationship between physical activity and sleep quality among adolescents and young adults. Structured exercise acts as a dual-action intervention: it directly stabilizes biological sleep mechanisms (such as circadian rhythms and core temperature) and indirectly alters behavior by enhancing self-control, reducing digital dependencies, and alleviating ruminative stress. Nonetheless, these physiological and psychological benefits are frequently challenged by modern lifestyle constraints, including screen-based sedentariness, poor dietary choices, and heavy academic demands.

To advance the field, researchers must address current methodological limitations by moving away from isolated, cross-sectional surveys. Future research should prioritize prospective, longitudinal designs that combine subjective sleep assessments with continuous, high-resolution wearable actigraphy. Identifying the precise dose-response relationships—specifically regarding exercise intensity, duration, and optimal daily timing across different developmental stages—will be essential for creating effective public health interventions that optimize sleep health in younger generations.

Disclossure

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All authors have read and agreed with the published version of the manuscript.

Funding: This research received no external funding.
Institutional Review Board Statement: Not applicable.
Informed Consent Statement: Not applicable.
Data Availability Statement: The authors confirm that the data supporting this study are available in the article's references.
Conflicts of Interest: The authors declare no conflicts of interest.

Declaration of the use of generative AI and AI-assisted technologies in the writing process.
In preparing this work, the author(s) used ChatGPT and Google Gemini for the purpose of checking grammar and improving readability. After using this tool/service, the author(s) have reviewed and edited the content as needed and accept full responsibility for the substantive content of the publication.

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