
Physical Activity, Sleep Quality, And Gadget Use As Risk Factors For Anemia In Adolescent Girls: A Systematic Literature Review

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Abstract

Anemia among adolescent girls remains a significant public health problem because it can adversely affect growth, learning capacity, productivity, and future reproductive health. In addition to nutritional factors, modern lifestyle changes—including physical activity, sleep quality, and gadget use—are increasingly recognized as potential contributors to anemia risk. This study aimed to synthesize scientific evidence regarding the association of physical activity, sleep quality, and gadget use with anemia among adolescent girls. This study aimed to analyze and synthesize scientific evidence regarding the association of physical activity, sleep quality, and gadget use with anemia among adolescent girls and to identify the underlying mechanisms linking these factors to anemia. This study employed a Systematic Literature Review (SLR) following the PRISMA 2020 guidelines. Literature searches were conducted in the PubMed, Scopus, ScienceDirect, ProQuest, Google Scholar, and Garuda databases for articles published between 2020 and 2025. Studies were selected based on predefined inclusion and exclusion criteria, assessed for methodological quality, and analyzed using narrative synthesis and thematic analysis. A total of 25 articles met the eligibility criteria and were included in the final synthesis. The review findings indicated that unbalanced physical activity, poor sleep quality, and excessive gadget use were associated with an increased risk of anemia among adolescent girls. Both insufficient and excessive physical activity without adequate nutritional support may affect hemoglobin levels. Poor sleep quality was linked to impaired iron metabolism and hemoglobin synthesis, while excessive gadget use indirectly contributed to anemia through increased screen time, sedentary behavior, and reduced sleep quality. These findings suggest that these three lifestyle factors interact and collectively influence the risk of anemia. In conclusion, preventing anemia among adolescent girls requires a comprehensive approach that addresses not only nutritional factors but also healthy physical activity, adequate sleep, and responsible gadget use. The findings provide evidence for developing adolescent health programs and future research on lifestyle determinants of anemia.

Keywords: Adolescent Girls, Anemia, Screen Time, Physical Activity, Sleep Quality

INTRODUCTION

Anemia remains one of the most prevalent public health issues among adolescent girls in both developing and developed countries. The World Health Organization (WHO) defines anemia as a condition in which hemoglobin levels in the blood fall below the normal range for a person's age and sex, thereby reducing the blood's ability to transport oxygen to body tissues. Adolescent girls are a group highly vulnerable to anemia because they are in a phase of rapid growth, experience monthly menstruation, and have higher iron requirements compared to other age groups. Globally, the WHO reports that anemia still affects approximately 30% of women of reproductive age, while the prevalence of anemia among adolescent girls in various developing countries remains in the category of moderate to severe public health problems (WHO, 2025). This situation indicates that anemia among adolescent girls remains a global health issue requiring serious attention.

In Indonesia, the prevalence of anemia among adolescent girls also remains high. According to the results of the Indonesian Health Survey (SKI), the prevalence of anemia among adolescent girls reached 16.3% for the 5–14 age group and 15.5% for the 15–24 age group (Ministry of Health BKKP, 2023). Recent studies report that the prevalence of anemia among adolescent girls ranges from 30–44% across various regions of Indonesia (Yaumil Fauziah et al., 2025). This high prevalence indicates that existing anemia prevention programs still face various challenges, including those related to adolescent behavior, environment, and lifestyle. Additionally, low adherence to iron supplement

intake, changes in modern lifestyles, and the increasing use of digital technology also contribute to the health status of adolescent girls (Indonesian Ministry of Health, 2023) .

Anemia in adolescent girls not only affects their physical health but also impacts their cognitive function, academic performance, productivity, and future reproductive health. A lack of hemoglobin reduces the supply of oxygen to the body's tissues, making adolescents more prone to fatigue, difficulty concentrating, memory loss, and impaired learning ability. In the long term, anemia that begins during adolescence can increase the risk of pregnancy complications, low birth weight , and stunting in the next generation (Agustina et al., 2021) . Therefore, identifying the factors contributing to the incidence of anemia in adolescent girls is a crucial step in efforts to prevent and control this problem.

Over the past few years, research on anemia in adolescent girls has advanced rapidly. Various studies have identified nutritional factors—such as low intake of iron, protein, folic acid, and vitamin C—as the primary causes of anemia. However, recent research is beginning to show that non-nutritional factors also play a significant role in the development of anemia. These factors include physical activity, sleep quality, gadget use, sedentary behavior, psychological conditions, and modern lifestyle habits prevalent among adolescents (Rahmatina et al., 2025) . Changes in lifestyle due to the development of digital technology have led adolescents to spend more time using electronic devices, get less sleep, and experience a decline in physical activity, all of which can impact their overall health.

Physical activity is one of the factors associated with the incidence of anemia in adolescent girls. Physical activity is defined as any bodily movement produced by skeletal muscles that requires energy expenditure. Regular physical activity can improve physical fitness and metabolic health. However, excessive physical activity without adequate nutritional intake has the potential to increase the body's oxygen and iron requirements, which can affect hemoglobin levels. A study by Fitri, Sudaryanti, and Amalia on adolescent girls with a history of anemia in Gresik found a significant association between physical activity and the incidence of anemia in adolescent girls (Fitri et al., 2024) . Meanwhile, another study reported that physical activity was not significantly associated with the incidence of anemia (Patrisia et al., 2025) .

In addition to physical activity, sleep quality has also become a factor receiving increasing attention in adolescent health research. Sleep is a physiological need that plays a crucial role in the body's recovery process, hormone regulation, energy metabolism, and red blood cell production. Impaired sleep quality is known to increase oxidative stress, systemic inflammation, and iron metabolism disorders, all of which contribute to decreased hemoglobin levels. Several studies on adolescent girls have shown that poor sleep quality is associated with an increased risk of anemia and lower hemoglobin levels (Dyah Krisnawati Satia Pratiwi et al., 2024) . A study by Pibriyanti et al. in **Amerta Nutrition** found that moderate sleep quality significantly increases the risk of mild anemia, with an OR of 22.932 and a p-value of 0.013 (Pibriyanti et al., 2025) .

The rise in gadget use among adolescents adds to the complexity of anemia research because gadgets are not only associated with *screen time* duration but also with *sedentary behavior*, delayed sleep onset, exposure to screen light at night, irregular eating patterns, and reduced physical activity. A recent *systematic review* and meta-analysis by He et al. indicates that increased *screen time* is associated with shorter sleep duration, a higher risk of *short sleep*, symptoms of insomnia, delayed sleep onset, and difficulty falling asleep; adolescents are considered a group vulnerable to these effects (He et al., 2025) . Research by Sharief, Hamang, and Nurhayati in Makassar directly links gadget usage duration, sleep quality, and anemia in adolescent girls, , finding that prolonged gadget use is associated with poor sleep quality and that adolescents with poor sleep quality are more likely to experience anemia. These findings reinforce the assumption that gadget use can be an indirect risk factor for anemia through sleep disturbances and changes in daily behavior (Sharief & Hamang, 2026)

Although the number of studies on anemia in adolescent girls continues to increase, the available knowledge remains fragmented. Some studies focus on iron intake, adherence to iron supplements,

menstruation, and nutritional status, while others have begun to include physical activity, sleep quality, gadget use, or screen time. A previous review of risk factors for anemia among adolescents in developing countries found that dietary practices, parasitic infections, menstruation, adolescent age, and parental education are important factors; however, it did not specifically address physical activity, sleep quality, and gadget use as part of an integrated behavioral framework (Ocktariyana et al., 2024) . Most studies have focused on only one risk factor at a time and thus have not been able to explain the complex interactions among lifestyle factors that influence the incidence of anemia in adolescent girls (Dyah Krisnawati Satia Pratiwi et al., 2024) (Sahashika & Setiyaningrum, 2024) . Similar findings were also reported in studies on sleep quality and gadget use (Maghfirah et al., 2024) . This situation has led to fragmented knowledge, making it difficult for researchers and practitioners to understand the comprehensive relationship between lifestyle factors and anemia.

The primary research gap in this topic lies in the absence of a comprehensive synthesis that integrates physical activity, sleep quality, and gadget use as behavioral risk factors for anemia in adolescent girls. Previous studies have tended to address these variables separately, so it remains unclear whether gadget use acts as a direct factor, an indirect factor via sleep quality, or a factor associated with low physical activity. Furthermore, few studies have evaluated methodological trends, the consistency of research findings, and the biological mechanisms underlying the relationship between these three factors and the incidence of anemia. The 2020 PRISMA guidelines emphasize the importance of systematic reporting in the process of identifying, selecting, assessing, and synthesizing articles so that the review's results can be considered transparent and replicable. Therefore, this systematic literature review (SLR) is essential for developing a more focused and critical map of the scientific evidence.

Consequently, this systematic literature review aims to analyze and synthesize research findings on the relationship between physical activity, sleep quality, and gadget use with the incidence of anemia in adolescent girls. The results of this review are expected to provide a theoretical contribution in the form of an integration of concepts and empirical findings regarding lifestyle factors associated with anemia, while also offering a practical contribution as a basis for developing health promotion strategies, school-based interventions, and policies for the prevention of anemia in adolescent girls.

RESEARCH METHODS

This study employed a *Systematic Literature Review* (SLR) approach to systematically identify, evaluate, and synthesize scientific evidence regarding the relationship between dietary patterns and the incidence of anemia among adolescent girls. The SLR method was chosen because it provides a comprehensive, transparent, and replicable synthesis of evidence , thereby yielding a deeper understanding compared to conventional literature reviews. The review process was conducted in accordance with the *2020 Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)* guidelines, which provide a systematic framework for the identification, selection, evaluation, and reporting of scientific articles (Page et al., 2021) . In addition, the research stages also took into account the *systematic review framework* developed by Kitchenham to ensure that the processes of data search, selection, extraction, and synthesis were carried out in a structured manner (Rzanny & Ochodek, 2025) .

This systematic literature review was designed to answer the following four main research questions:

RQ1: What are the research findings regarding the relationship between physical activity and the incidence of anemia in adolescent girls?

RQ2: How does sleep quality contribute to the risk of anemia in adolescent girls based on available empirical evidence?

RQ3: How do gadget use and screen time affect the incidence of anemia in adolescent girls?

RQ4: Which factors are most strongly and consistently associated with the incidence of anemia in adolescent girls based on the results of the literature synthesis?

These four questions were formulated to identify the relationship between lifestyle factors and the incidence of anemia and to understand the mechanisms underlying this relationship.

A systematic literature search was conducted across six electronic databases with broad coverage in the fields of health, nutrition, and public health: PubMed, Scopus, ScienceDirect, ProQuest, Google Scholar, and Garuda. These databases were selected to identify relevant, high-quality national and international articles.

The search was conducted using a combination of keywords in English and Indonesian tailored to the study's objectives. English keywords included "anemia," "adolescent girls," "physical activity," "sleep quality," "screen time," "gadget use," "hemoglobin," and "risk factors." Indonesian keywords included "anemia remaja putri," "aktivitas fisik," "kualitas tidur," "penggunaan gadget," "screen time," and "kadar hemoglobin."

The search strategy uses a combination of the Boolean operators AND, OR, and NOT to improve the sensitivity and specificity of the search. An example of the search strategy used is: ("anemia" OR "iron deficiency anemia") AND ("adolescent girls" OR "female adolescents") AND ("physical activity" OR "exercise") AND ("sleep quality" OR "sleep duration") AND ("screen time" OR "gadget use") or ("anemia in adolescent girls") AND ("physical activity" OR "exercise") AND ("sleep quality") AND ("gadget use"). The articles considered in this review are limited to publications from 2020 to 2026.

Inclusion criteria were used to identify articles relevant to the study's objectives. Included articles must have been published between 2020 and 2026, be available in *full text*, be published in peer-reviewed scientific journals, address anemia in adolescent girls, examine physical activity, sleep quality, gadget use, or screen time as research variables, and contain empirically verifiable data. Conversely, exclusion criteria were applied to eliminate duplicate articles, editorials, *commentaries*, *letters to the editor*, *non-peer-reviewed conference proceedings*, theses, dissertations, or institutional reports; articles not available in *full text*; articles irrelevant to *the research questions*; non-systematic review articles; and articles with low methodological quality based on quality assessment results.

The article selection process followed the PRISMA 2020 flowchart, which consists of four main stages: *identification*, *screening*, *eligibility*, and *included studies*. During the identification stage, all articles retrieved from the databases were collected and imported into the Mendeley reference management software to identify and remove duplicate articles.

The next stage was *screening*, which involved reviewing titles and abstracts to assess the articles' relevance to the study's objectives. Articles meeting the initial criteria were then advanced to the *eligibility* stage through a *full-text* review. At this stage, an in-depth evaluation was conducted regarding the relevance of the topic, study design, sample characteristics, research variables, and alignment with *the research questions*. The final phase (*Included Studies*) yields a set of final articles deemed representative, valid, and meeting scientific quality standards for inclusion in the data synthesis matrix.

The methodological quality of articles meeting the inclusion criteria was evaluated using the Joanna Briggs Institute (JBI) Critical Appraisal Tools appropriate for each study's design (Briggs, 2019).

The extracted data were analyzed using a *narrative synthesis* approach combined with *thematic analysis*. The *narrative synthesis* approach was used to organize, compare, and interpret research findings with different designs and characteristics. Meanwhile, *thematic analysis* was used to identify the main themes that consistently emerged across various studies on the relationship between dietary patterns and anemia in adolescent girls.

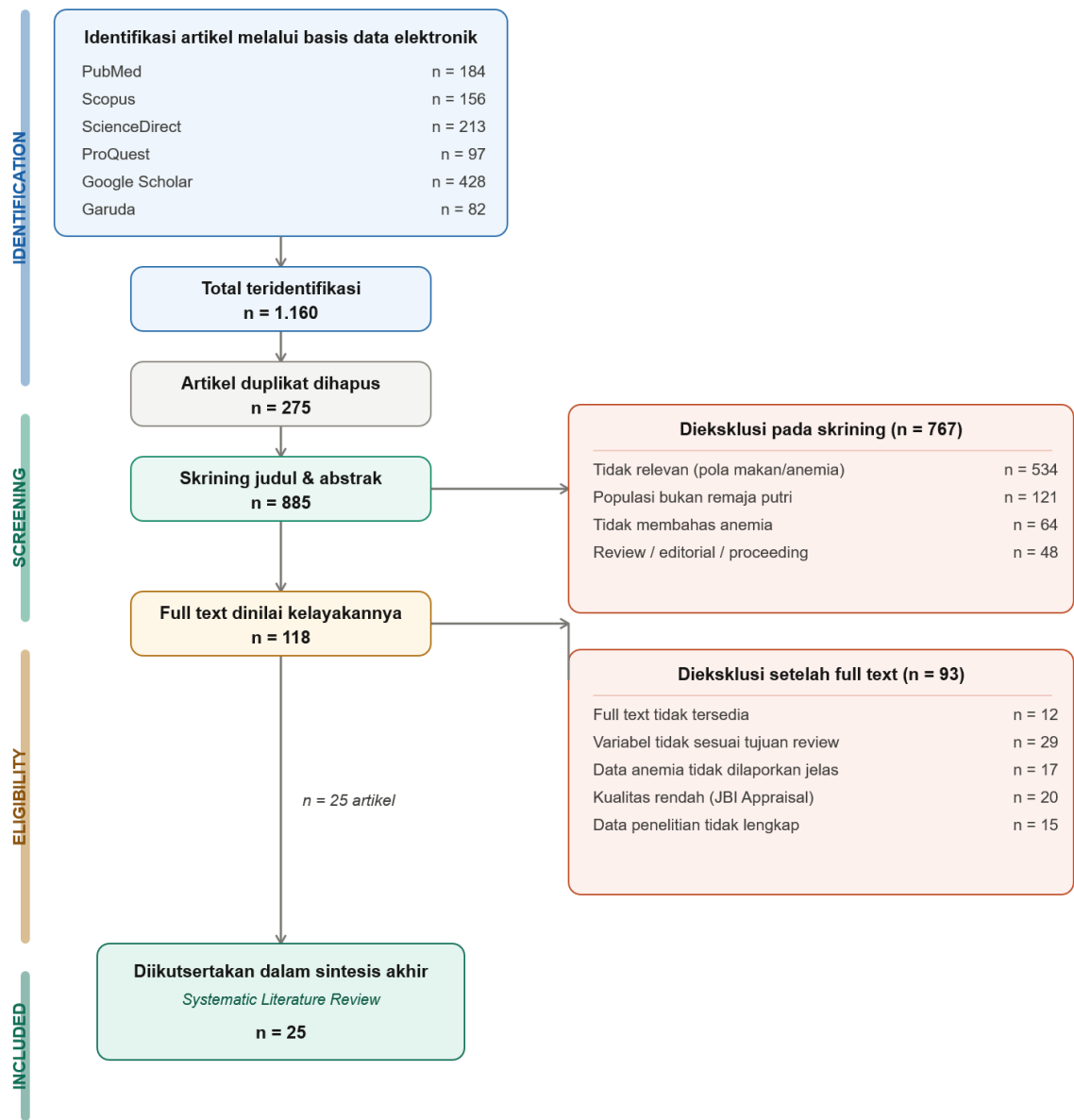
The analysis process was conducted in several stages: data familiarization, *initial coding*, grouping codes into categories, identifying main themes, and interpreting the results. Coding was performed manually using a synthesis matrix table organized based on *the research questions*. To

ensure the validity of the analysis, the coding results and interpretations were cross-checked against the source articles and discussed among the reviewers.

RESULTS AND DISCUSSION

The literature search was conducted across six databases: PubMed, Scopus, ScienceDirect, ProQuest, Google Scholar, and Garuda. Based on the initial search results, a total of 1,160 articles were identified, comprising 184 from PubMed, 156 from Scopus, 213 from ScienceDirect, 97 from ProQuest, 428 from Google Scholar, and 82 from Garuda. After removing 275 duplicate articles, 885 articles remained for title and abstract screening. At this stage, 767 articles were excluded because they were irrelevant to the research topic, did not use an adolescent female population, did not discuss anemia, or were review articles and editorials. Subsequently, 118 articles underwent full-text assessment, and 93 were excluded for failing to meet the inclusion criteria. At the end of the selection process, 25 articles that met all criteria were included in the final synthesis. The article selection flowchart is presented in the PRISMA 2020 diagram.

PRISMA 2020 Flowchart



Periode artikel: 2020–2025 · Diadaptasi dari PRISMA 2020 (Page et al., 2021)

Table 1. Characteristics of the Articles Reviewed

o	Author/ Year	Article Title	Research Objective	Research Design	Population/Sample	Variables	Instruments	Research Findings
	Sharief et al., 2026	<i>Gadget Use Duration, Sleep Quality, and Anemia Among Adolescent Girls</i>	Analyzing the relationship between gadget use duration, sleep quality, and anemia	Cross-sectional	Adolescent girls in Makassar	Gadget use, sleep quality, anemia	Questionnaire, Hb, sleep quality instrument	High gadget use is associated with poor sleep quality and anemia.
	Hanif et al., 2026	<i>Association of Iron and Nutritional Status with Sleep Quality in Adolescent Girls</i>	Assessing the relationship between Hb, ferritin, nutritional status, and sleep quality	Cross-sectional	80 adolescent girls	Hb, ferritin, sleep quality	PSQI, ELISA, hematology analyzer	Hb is significantly associated with sleep quality.
	Asrullah et al., 2025	<i>Sleep Quality, Depression, and the Risk of Anemia in Indonesian Adolescents</i>	Assessing sleep quality, depression, and Hb levels	Longitudinal	452 adolescents	Sleep quality, depression, Hb	Questionnaire, Hb	Poor sleep quality is associated with a higher risk of anemia
	Putra & Mulyani, 2025	<i>Analysis of the Relationship Between Screen Time and Sleep Quality and Iron Deficiency Anemia</i>	Assessing the relationship between screen time, sleep quality, and iron deficiency anemia	Cross-sectional	High school girls	Screen time, sleep quality, anemia	PSQI, Hb meter	High screen time and poor sleep increase the risk of anemia.
	Idahafni et al., 2025	<i>The Relationship Between Gadget Addiction and Body Mass Index and Anemia</i>	Assessing the relationship between gadget addiction and anemia	Cross-sectional	340 adolescent girls	Gadget addiction, BMI, anemia	SAS Scale, Hb	Gadget addiction is significantly associated with anemia.

o	Author/ Year	Article Title	Research Objective	Research Design	Population/Sample	Variables	Instruments	Research Findings
	Putri & Fauziyah, 2023	<i>Knowledge about Anemia and Physical Activity and Its Relationship to the Incidence of Anemia Among Adolescent Girls</i>	Assessing physical activity and anemia	Cross-sectional	49 adolescent girls	Physical activity, anemia	Hb	Low physical activity was found in the majority of respondents, but the association was not significant.
	Pratiwi et al., 2024	<i>Anemia and Sleep Patterns Among Adolescent Women</i>	Assessing the relationship between sleep patterns and anemia	Cross-sectional	76 adolescent girls	Sleep patterns, anemia	Sleep questionnaire, Hb	There is a significant association between sleep patterns and anemia.
	Sahashika et al., 2024	<i>The Relationship Between Sleep Quality and the Incidence of Anemia in Adolescent Girls</i>	Assessing sleep quality and anemia	Cross-sectional	60 adolescent girls	Sleep quality, anemia	PSQI, Cyanmethemoglobin	Poor sleep is associated with lower Hb levels.
	Kartika et al., 2025	<i>Correlation of Sleep Quality and Diet Quality with Hemoglobin Levels</i>	Assessing sleep quality and Hb levels	Cross-sectional	Adolescent girls	Sleep quality, diet quality, Hb	PSQI, Hb test	Moderate sleep quality increases the risk of mild anemia.
0	Dhanny et al., 2026	<i>The Relationship Between Sleep Duration and Iron Intake and Hemoglobin Levels</i>	Assessing sleep duration and Hb	Cross-sectional	33 teenage girls	Sleep duration, iron intake, Hb	PSQI, SQ-FFQ, Hb meter	Short sleep duration is not significantly associated with low Hb.

o	Author/ Year	Article Title	Research Objective	Research Design	Population/Sample	Variables	Instruments	Research Findings
1	Asnir et al., 2025	<i>Breakfast Habits, Sleep Quality, and Menstrual Duration as Determinants of Anemia</i>	Assessing sleep and anemia	Cross-sectional	68 adolescent girls	Sleep quality, anemia	PSQI, Hb	Sleep quality is significantly associated with anemia.
2	Fitriana et al., 2026	<i>The Relationship Between Iron Inhibitors and Hemoglobin Levels</i>	Assessing iron inhibitors and Hb	Cross-sectional	Adolescent girls	Sleep quality, Hb	Questionnaire, Hb	Poor sleep increases the risk of low Hb by 2.9 times.
3	Handini et al., 2023	<i>The Relationship Between Knowledge of Anemia, Sleep Patterns, Dietary Patterns, Inhibitors, and Enhancers with the Incidence of Anemia in Adolescent Girls at the Al-Amanah Al-Gontory Islamic Boarding School in South Tangerang City</i>	Assessing sleep patterns and anemia	Cross-sectional	113 adolescent girls	Sleep patterns, anemia	Questionnaire	Poor sleep patterns are associated with anemia.
4	Rahmatina et al., 2025	<i>Scoping Review of Nutritional Intake</i>	Reviewing physical activity and anemia	Scoping Review	International article	Physical activity, anemia	Database review	Physical activity is an important

o	Author/ Year	Article Title	Research Objective	Research Design	Population/Sample	Variables	Instruments	Research Findings
5	Gucie et al., 2024	<i>and Physical Activity in Adolescent Anemia</i> <i>Sleep Quality and Nutritional Status in Relation to Anemia Incidence</i>	Assessing sleep quality and anemia	Cross-sectional	Vocational high school students	Sleep quality, anemia	PSQI	determinant of anemia in adolescents Poor sleep quality increases the incidence of anemia.
6	Bin Laeto et al., 2022	<i>The Relationship Between Adolescents' Sleep Quality During the COVID-19 Pandemic and the Physical Activity- , as Well as Screen Time</i>	Assessing screen time and sleep quality	Cross-sectional	Adolescents	Screen time, sleep quality	PSQI	High screen time is associated with poor sleep quality.
7	Alnawwar et al., 2023	<i>The Effect of Physical Activity on Sleep Quality and Sleep Disorders</i>	Assessing physical activity and sleep	Systematic Review	Various studies	Physical activity, sleep	Review	Physical activity affects adolescents' sleep quality.
8	Chen et al., 2022	<i>Associations Between Sleep Duration, Sleep Quality, and Weight Status</i>	Assessing sleep quality in adolescents	Cross-sectional	Children and adolescents	Sleep duration, sleep quality	Sleep questionnaire	Poor sleep is associated with poorer health.
9	Hanif et al., 2022	<i>The Relationship Between Iron Status</i>	Analyzing the relationship between ferritin levels,	Cross-sectional	80 adolescent girls	Sleep duration,	Questionnaire	Sleep disorders are

o	Author/ Year	Article Title	Research Objective	Research Design	Population/Sample	Variables	Instruments	Research Findings
		and Nutritional Status and Sleep Quality in Adolescent Girls: A Cross-Sectional Study	hemoglobin, and nutritional status with sleep quality in adolescent girls.			sleep quality		common among adolescents.
0	Okan et al., 2019/cited 2026	Association of Ferritin Levels with Sleep Quality	Assessing ferritin and sleep quality	Cross-sectional	Adolescents/clinical	Ferritin, sleep quality	Ferritin test	Iron status is associated with sleep quality.
1	Dhamayanti et al., 2025	Screen Time and Hemoglobin Levels in Adolescents	Assessing screen time and Hb	Cross-sectional	Adolescents	Screen time, Hb	Questionnaire, Hb	High screen time is associated with low Hb.
2	Putra & Mulyani, 2024	Analysis of the Relationship Between Screen Time and Sleep Quality and Iron Deficiency Anemia in 10th-Grade Girls at SHS 1 Dukun	Investigating the relationship between screen time duration and sleep quality and the incidence of anemia	Cross-sectional	Adolescent girls	Lifestyle, anemia	Questionnaire	Lifestyle factors contribute to anemia.
3	Sari et al., 2022	Anemia Among Adolescent Girls in West Java	Assessing the prevalence of anemia and related factors	Cross-sectional	Adolescent girls	Lifestyle, anemia	Hb, anthropometry	Behavioral factors and nutritional status play a role in anemia.
4	Sharief, Hamang, &	Gadget Use Duration, Sleep Quality, and Anemia	Assessing the relationship between gadget use duration,	Cross-sectional	Adolescent girls in Makassar	Gadget use duration,	Gadget use questionnaire	Gadget use of more than 3 hours per day is

o	Author/ Year	Article Title	Research Objective	Research Design	Population/Sample	Variables	Instruments	Research Findings
	Nurhayati (2026)	<i>Among Adolescent Girls: A Cross-Sectional Study in Makassar, Indonesia</i>	sleep quality, and anemia in adolescent girls			sleep quality, anemia	e, sleep quality instrument, Hb	associated with poor sleep quality and an increased risk of anemia in adolescent girls.
5	Fitri, Sudaryanti, & Amalia (2024)	<i>The Relationship between Nutrition, Physical Activity, and Sleep Quality and Changes in Anemia Status in Adolescent Girls with Anemia</i>	Analyzing the relationship between nutritional status, physical activity, and sleep quality and changes in anemia status among adolescent girls	Cross-sectional	Students at Manyar Gresik State High School No. 1	Nutrition, physical activity, sleep quality, anemia status	Physical activity questionnaire, PSQI, Hb	There is a significant association between physical activity ($p=0.011$), sleep quality ($p=0.014$), and changes in anemia status among adolescent girls.

Of the 25 included articles, the majority used a *cross-sectional* design (92%), while one study used a longitudinal design and one study used a *scoping review* approach. The majority of the studies were from Indonesia, with a primary focus on the relationship between physical activity, sleep quality, gadget use, *screen time*, hemoglobin status, and other lifestyle factors and the incidence of anemia in adolescent girls. The most consistently identified themes were poor sleep quality, high duration of gadget use, low physical activity, and sedentary behavior, all of which were associated with an increased risk of anemia in adolescent girls.

DISCUSSION

Overview of Anemia Incidence in Adolescent Girls

The review results indicate that anemia in adolescent girls is associated with biological, nutritional, behavioral, and environmental factors. These findings align with the theory of iron-deficiency anemia, which explains that hemoglobin levels are influenced by iron sufficiency, the process of erythropoiesis, blood loss, and the body's ability to maintain oxygen balance. In adolescent girls, this risk increases because iron requirements rise during growth, while menstruation causes periodic blood loss. A study by Sari et al. (2022) in West Java showed that anemia in adolescent girls is not only related to nutritional status and menstruation but also impacts quality of life (Sari et al., 2022). These findings reinforce the understanding that anemia is not merely a hematological issue but also a multidimensional adolescent health problem.

The most frequently identified factors in the reviewed articles include low consumption of micronutrient-rich foods, limited knowledge and poor practices regarding anemia prevention, poor sleep quality, high screen time, and an imbalance in physical activity. A study by Knijff et al. (2021) showed that consumption of micronutrient-rich foods is associated with a reduced risk of anemia among Indonesian adolescents (Knijff et al., 2021). Agustina et al. (2021) also found that knowledge, attitudes, and practices related to anemia play a role in the anemia status of adolescent girls (Agustina et al., 2021). These two findings support health behavior theory, which posits that anemia is influenced not only by biological factors but also by daily behaviors shaped by knowledge, habits, environmental support, and access to nutritious food.

Physical Activity and the Risk of Anemia in Adolescent Girls

Physical activity is one of the lifestyle factors frequently discussed in relation to adolescent health. The results of the review indicate that the relationship between physical activity and anemia is not straightforward but depends on intensity, duration, adequate nutritional intake, and the individual's physiological condition. Rahmatina et al. (2025), through a scoping review, demonstrated that adequate nutritional intake and consistent physical activity can complement each other in preventing anemia among adolescents (Rahmatina et al., 2025). These findings support the energy balance theory and the iron requirement theory, which explain that the body requires adequate nutrients to support metabolic activity, hemoglobin formation, and oxygen distribution during physical activity.

Among adolescents with light or low levels of physical activity, the risk of anemia may increase indirectly through reduced fitness, sedentary behavior, poor sleep quality, and irregular eating patterns (Patrisia et al., 2025). Low physical activity is also frequently observed in adolescents with high screen time. This finding supports the theory of *sedentary behavior*, which states that prolonged low levels of physical activity can impair metabolic health. However, excessively intense physical activity can also increase the body's demand for oxygen and iron. If not balanced by adequate intake of iron, protein, vitamin C, and energy, intense activity can exacerbate the risk of iron deficiency (Rahmatina et al., 2025).

Based on intensity levels, light physical activity tends to reflect a sedentary lifestyle, moderate activity can support physical fitness and metabolism, while vigorous activity requires greater nutritional support (Rahmatina et al., 2025). These findings expand the theory on the relationship between physical activity and anemia, as it is not sufficient to simply assess whether a person is active or inactive. Researchers need to simultaneously measure the intensity, duration, and frequency of physical activity, as well as the adequacy of nutritional intake. Balanced physical activity can serve as

a protective factor, but inadequate or excessively strenuous physical activity without sufficient nutritional intake can become a risk factor (Patrisia et al., 2025) .

Physical activity affects tissue oxygen demand. Hemoglobin plays a role in transporting oxygen from the lungs to all body tissues. When physical activity increases, the body requires a higher oxygen supply. In adolescent girls with low iron stores, this increased demand can exacerbate symptoms of anemia such as fatigue, dizziness, weakness, and reduced exercise tolerance (Anwar et al., 2025) . Therefore, the findings of this review support the theory of erythropoiesis, which states that red blood cell production depends not only on iron but also on the body's physiological needs, which are influenced by physical activity (Grootendorst et al., 2021) .

Sleep Quality and the Risk of Anemia in Adolescent Girls

Several studies indicate that adolescent girls with poor sleep quality have a higher risk of anemia or lower hemoglobin levels. Pratiwi et al. (2024) found an association between anemia and sleep patterns among adolescent girls in Surakarta. Asrullah et al. (2025) also demonstrated that sleep quality and depression are associated with the risk of anemia among adolescents in Indonesia during the COVID-19 pandemic (Asrullah et al., 2025) . These findings support the *sleep-health* theory, which explains that sleep plays a role in physiological recovery, hormone regulation, immunity, energy metabolism, and the process of blood cell formation (Vorster et al., 2024) .

Biologically, poor sleep can affect anemia through several pathways. First, sleep disturbances can increase oxidative stress and inflammatory responses (Nguyen et al., 2024) . Inflammatory conditions can disrupt iron metabolism through hepcidin regulation, resulting in suboptimal iron absorption and mobilization in the body. Second, poor sleep quality can disrupt hormonal regulation and tissue repair processes, including red blood cell formation (Jiao et al., 2025) . Third, insufficient sleep is often associated with unhealthy eating behaviors, skipping breakfast, consumption of fast food, and low physical activity (Rogers et al., 2024) . Thus, sleep quality can act as both a direct and indirect risk factor for anemia.

The findings of this review expand the theory of iron-deficiency anemia, which has traditionally focused more on iron intake and blood loss. Findings regarding sleep quality indicate that the process of hemoglobin formation is also influenced by the body's overall physiological condition (Jiao et al., 2025) . Adolescents who sleep for short durations, wake up frequently, stay up late, or experience poor sleep quality may develop metabolic disorders that increase their risk of anemia (Hanif & Margawati, 2026) . However, some studies still show results that are not entirely consistent. These discrepancies may arise from variations in sleep measurement instruments, differences in respondent characteristics, and variations in the control of confounding factors such as nutritional status, menstruation, iron intake, and mental health.

The inconsistency in these results highlights the need for further research using a longitudinal design. While cross-sectional designs can illustrate the relationship between sleep quality and anemia, they cannot determine the direction of the relationship. Anemia can cause adolescents to feel weak and sleepy, while poor sleep quality can also impair metabolism and hemoglobin production. Therefore, the relationship between sleep and anemia is likely bidirectional.

Gadget Use and the Risk of Anemia in Adolescent Girls

Gadget use has become an increasingly relevant factor in modern lifestyles within the study of anemia in adolescents. Sharief et al. (2026) directly examined the duration of gadget use, sleep quality, and anemia among adolescent girls in Makassar. The study showed that a high duration of gadget use is associated with sleep quality and anemia. This finding is important because it broadens the perspective that gadgets not only affect eye health, posture, or academic performance, but may also be linked to hematological health status through behavioral and physiological pathways (Sharief & Hamang, 2026) .

High *screen time* can influence anemia through several indirect mechanisms. Gadget use at night can disrupt sleep timing, prolong sleep latency, and reduce sleep quality (He et al., 2025) . Exposure to screen light can also disrupt the circadian rhythm (Ricketts et al., 2022) . In addition, prolonged

gadget use increases sedentary behavior, reduces physical activity, and can affect eating patterns (Idahafni et al., 2025). Adolescents who spend too much time using gadgets tend to skip meals, choose convenience foods, or consume snacks that are high in energy but low in micronutrients. This pattern increases the risk of low intake of iron, protein, and vitamins that support hemoglobin production (Votsi & Koutelidakis, 2025).

These findings support *the ecological model of health behavior*, as adolescents' health behaviors are determined not only by individual choices but also by the digital environment, the school environment, peer norms, and family supervision patterns. Gadgets can serve as environmental factors that shape sleep behavior, physical activity, and eating patterns. In other words, gadget use is not the sole cause of anemia but can act as a link between various risk behaviors (Aura et al., 2016).

This review also expands the conceptual framework of adolescent anemia by incorporating gadget use as an indirect risk factor. Previous studies on anemia have primarily focused on dietary patterns, menstruation, and adherence to iron supplement intake as the main factors. The results of this review indicate that gadget use should be included as a lifestyle variable that can influence anemia through sleep quality, sedentary behavior, and changes in dietary patterns.

Interactions Between Physical Activity, Sleep Quality, and Gadget Use on Anemia

The synthesis results show that physical activity, sleep quality, and gadget use are not independent of one another. All three form a pattern of interaction in which they influence one another. Excessive gadget use tends to increase screen time and sedentary behavior. This can reduce physical activity and disrupt sleep quality. Poor sleep quality, in turn, can affect iron metabolism and hemoglobin production. Unbalanced physical activity—whether too low or too intense without adequate nutrition—can also worsen the risk of anemia.

A conceptual model that can be developed from this review is as follows: excessive gadget use increases screen time and sedentary behavior; high screen time reduces sleep quality and physical activity; poor sleep quality disrupts bodily metabolism and hemoglobin formation; unbalanced physical activity increases the body's need for oxygen and iron; and the combination of these factors increases the risk of anemia in adolescent girls. This model expands the framework of adolescent anemia from a single-factor nutritional model to an integrated lifestyle model.

Compared to *the scoping review* by Rahmatina et al. (2025), this review provides a more specific perspective on the relationship between physical activity, sleep quality, gadget use, and anemia. Rahmatina et al. emphasized the relationship between nutritional intake and physical activity in adolescent anemia. This review expands on those findings by incorporating sleep quality and screen time as variables of modern lifestyle. Thus, the understanding of adolescent anemia has evolved from a nutritional approach to a multideterminant approach involving digital behavior, sleep, physical activity, and biological factors.

These findings also support the results of Agustina et al. (2021), which highlight the importance of health practices in preventing anemia. While health practices were previously largely associated with the consumption of iron supplements and nutritious foods, the results of this review indicate that health practices must also include sleep management, limiting gadget use, and balanced physical activity (Agustina et al., 2021). Consequently, health behavior theory needs to be expanded to account for changes in adolescents' lifestyles in the digital age.

Limitations and Strengths of the Review

This *systematic literature review* has several limitations. First, most of the reviewed studies used *cross-sectional* designs, so they cannot establish causal relationships. Second, several variables—such as physical activity, sleep quality, and gadget use—were primarily measured using self-reports, which may introduce recall bias. Third, there was variation in the instruments used across studies, so direct comparisons of results must be made with caution. Fourth, the possibility of publication bias remains, as studies with significant results are more likely to be published than those with nonsignificant results.

Other limitations relate to language and access to articles. A review that includes only articles in Indonesian and English may overlook relevant studies in other languages. Additionally, some

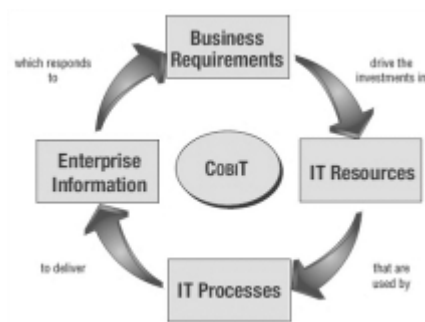
paywalled articles or those without *full-text* availability may not be analyzed in depth. Subjectivity in the thematic coding process may also occur, although this can be minimized through the use of clear inclusion criteria, a data extraction matrix, and discussions among *reviewers*.

Nevertheless, this review has significant strengths. The review process was systematically designed in accordance with PRISMA 2020, utilized multiple databases, and integrated various perspectives from nutrition, health behavior, *sleep-health*, *sedentary behavior*, and adolescent health. The added value of this review lies in the integration of three lifestyle factors—physical activity, sleep quality, and gadget use—into a single conceptual model of anemia in adolescent girls. This synthesis provides a broader understanding than reading individual studies separately.

Overall, the review’s findings indicate that anemia in adolescent girls is a multifactorial issue. Unbalanced physical activity, poor sleep quality, and excessive gadget use can contribute to the risk of anemia through physiological, behavioral, and environmental pathways. Therefore, the prevention of anemia in adolescent girls requires an integrated approach that includes nutritional improvement, education on healthy sleep, limiting screen time, increasing physical activity, and strengthening school-based iron supplementation programs.

Sample Tables and Figures

Artikel X	N	Ket.
1	Affiliates, Table Titles, Image Titles	
2	Name of author, torso of paper	



The discussion material mainly explores whether the results obtained in accordance with the hypothesis or not, and point out the argument.

Referral citation in the discussion should not be too long (if necessary avoid).

Citation results of research or opinions of others should be abstracted and written in the sentence itself (not using the exact same sentence).

A collection of similar research may be referred to in groups.

CONCLUSIONS

The results of the Systematic Literature Review indicate that physical activity, sleep quality, and gadget use are associated with the incidence of anemia in adolescent girls. Unbalanced physical activity, poor sleep quality, and excessive gadget use are the most frequently reported lifestyle factors associated with an increased risk of anemia. These findings suggest that the incidence of anemia in adolescent girls is not only related to nutritional factors but is also influenced by various aspects of daily lifestyle.

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