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Review Article

# Role of *Withania somnifera* (*Ashwagandha*) in Stress Management: A Systematic Review of Randomized Controlled Trials

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**ABSTRACT**

*Withania somnifera* (*Ashwagandha*) is a well-recognized adaptogenic herb in Ayurveda, traditionally used to enhance stress tolerance and improve psychological well-being. Increasing clinical evidence suggests its role in modulating stress-related neuroendocrine pathways, particularly the Hypothalamic–Pituitary–Adrenal axis. This systematic review aimed to evaluate the efficacy and safety of *Withania somnifera* in stress management. A systematic literature search was conducted exclusively in the PubMed database following PRISMA guidelines. Randomized, double-blind, placebo-controlled clinical trials assessing the effects of *Withania somnifera* on stress-related outcomes were included. Two independent reviewers screened studies, extracted relevant data, and performed qualitative synthesis. Both subjective stress scales and objective biochemical markers were considered as outcome measures. Six randomized, double-blind, placebo-controlled trials met the inclusion criteria. The reviewed studies demonstrated consistent improvements in perceived stress, anxiety scores, cortisol levels, sleep quality, psychological well-being, autonomic function, and selected hormonal parameters following *Withania somnifera* supplementation. Most studies reported statistically significant reductions in stress-related scales and cortisol levels compared to placebo. The interventions were generally well tolerated, with only mild and transient adverse events reported. The findings of this systematic review indicate that *Withania somnifera* exerts beneficial effects on stress and related psychosomatic parameters and appears to be safe for short-term use. These results support its potential role as a natural adaptogen in stress management and integrative mental health care.

**Keywords:** Ashwagandha, Stress, *Withania somnifera*.

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## INTRODUCTION

Stress is increasingly recognized as a major global public health challenge. It is characterized as a state of psychological strain or worry arising from demanding or adverse situations and has profound effects on both individual health and societal well-being. Worldwide, stress often accompanied by anxiety and depression contributes to substantial economic losses through reduced productivity and increased healthcare expenditure. Beyond its economic implications, stress adversely affects social functioning by disrupting interpersonal relationships, increasing vulnerability to substance misuse, and weakening community cohesion (Smith and Wesselbaum, 2025).

From a health perspective, chronic stress exerts widespread physiological and psychological effects. Persistent activation of stress-response mechanisms is associated with the development and progression of metabolic disorders such as diabetes and obesity, as well as diabetes-related microvascular complications including diabetic retinopathy, end-stage renal disease, atherosclerosis, and cardiovascular diseases. Additionally, stress has been linked to cancer, immune dysfunction, and a general decline in quality of life at the community level (Reddy, 2023). Mental health disorders, particularly anxiety and depression, are closely intertwined with prolonged stress exposure. Collectively, these outcomes place a significant burden on healthcare systems through increased treatment costs, disability, and loss of productivity. Consequently, prioritizing stress management is essential for improving population health, fostering healthier social environments, and reducing health disparities.

In this context, there has been growing interest in complementary and traditional medical systems that emphasize holistic and preventive approaches to stress management. Herbal medicines represent a cumulative body of knowledge derived from

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indigenous medical traditions and long-standing therapeutic experience across generations. These systems provide guidance on the selection, preparation, and application of plant-based formulations for the prevention and management of various diseases (Ahmad Khan and Ahmad, 2019). Despite their extensive historical use, the scientific validation of many herbal interventions remains inconsistent, with evidence often scattered and debated.

Among medicinal plants, *Withania somnifera* (L.) Dunal, commonly known as *Ashwagandha*, has attracted considerable attention for its stress-modulating properties. Each plant-derived substance is assigned a standardized scientific Latin name by botanists. In the same manner, *Ashwagandha* is scientifically classified as *Withania somnifera* (L.) Dunal, belonging to the family Solanaceae (Joshi and Joshi, 2021). *Withania somnifera* is an evergreen woody shrub widely known as Indian winter cherry or Indian ginseng, reflecting both its regional significance and functional similarity to ginseng. The species name *somnifera*, meaning "sleep-inducing," alludes to its traditional use in alleviating stress and promoting restorative sleep. The name *Ashwagandha*, derived from Sanskrit (*ashwa*—horse and *gandha*—smell), refers to the characteristic odour of its roots and symbolically denotes strength and vitality (Paul *et al*., 2021).

*Ashwagandha* holds a prominent position in Ayurveda, where it is classified as a "Sattvic Kapha Rasayana." it has been traditionally used for over three millennia as a rejuvenative tonic to enhance immunity, vitality, and physiological balance (Vashi, Patel, and Goyal, 2020). It is use in the management of stress-related disorders, insomnia, nervous conditions, inflammation, weakness, reproductive disorders, and chronic illnesses. Its importance is further reflected by its inclusion as an official drug in the Indian Pharmacopoeia. The roots are the most commonly used part in Ayurvedic and Unani medicine and contain a wide range of bioactive constituents, including alkaloids, steroids, glycosides, amino acids, and volatile compounds. Other parts of the plant—such as leaves, flowers, fruits, and seeds—are also used therapeutically for various indications.

Contemporary experimental and clinical studies report that extracts of *Withania somnifera* roots and leaves exhibit notable antistress and antianxiety effects. Beneficial effects on depression and sleep disturbances have also been observed, although these outcomes have been less extensively explored. The stress-reducing actions of *Withania somnifera* are primarily attributed to its ability to regulate stress-response pathways and modulate neurotransmitter systems involved in mood and relaxation. While certain identified constituents contribute to these effects, the presence and role of additional bioactive compounds remain to be fully elucidated (Speers *et al*., 2021).

Despite growing scientific interest, the existing evidence on *Withania somnifera* in stress management remains fragmented across diverse study designs, populations, and outcome measures. This heterogeneity limits a clear understanding of its efficacy, mechanisms of action, and safety profile. Therefore, a systematic review is warranted to critically evaluate and synthesize the existing scientific evidence on the role of *Withania somnifera* in stress management, with the objective of clarifying its therapeutic potential, identifying gaps in current knowledge, and informing future clinical and translational research.

## OBJECTIVES

This systematic review aims to evaluate and synthesize clinical evidence on the role of *Withania somnifera* in stress management, focusing on its effects on psychological, physiological, and biochemical stress markers. It also seeks to assess the safety and tolerability of the intervention and identify gaps in the current literature to guide future research.

## METHODOLOGY

### Search Strategy

A systematic search of the published literature was conducted exclusively using the PubMed database to identify studies evaluating the role of *Withania somnifera* in stress management. Relevant Medical Subject Headings terms, keywords were used, including "*Withania somnifera* OR stress "*Ashwagandha* OR stress. These terms were combined using Boolean operators (AND/OR) to enhance the sensitivity and relevance of the search results.

The search was independently performed by two reviewers and limited to articles indexed in PubMed. Titles and abstracts were screened according to predefined inclusion and exclusion criteria, followed by full-text assessment of eligible studies. All retrieved records were imported into Rayyan software for efficient organization, duplicate removal, and blinded screening. Data extraction and methodological quality assessment were carried out using standardized tools to ensure consistency and reliability of the review process.

### Eligibility Criteria

In this systematic review, clearly defined inclusion and exclusion criteria were applied to ensure the selection of relevant and methodologically sound studies evaluating the role of *Withania somnifera* in stress management.

### Inclusion Criteria

The inclusion criteria comprised original human studies that specifically investigated the effects of *Withania somnifera* (*Ashwagandha*) on stress and stress-related outcomes.

Studies fulfilling the following Population, Intervention, Comparison, and Outcome (PICO) criteria were considered eligible for inclusion:

## Population, Intervention, Comparison, and Outcome Criteria

The PICO criteria for the study are provided in Table 1.

## Exclusion Criteria

Exclusion criteria were applied to maintain the focus and scientific rigour of the review. Studies that did not evaluate *Withania somnifera* as the primary intervention or did not assess stress or stress-related outcomes were excluded. Animal studies, *in vitro* experiments, narrative reviews, systematic reviews, meta-analyses, case reports, and conference abstracts were excluded to ensure inclusion of only original clinical research. Only articles published in the English language were considered. Studies lacking accessible or complete full-text articles were also excluded to allow for thorough appraisal and data extraction.

The strict application of these eligibility criteria enhanced the relevance, reliability, and overall quality of evidence included in this systematic review.

## Screening

The screening process for this systematic review was conducted independently by two reviewers to identify studies eligible for inclusion. Initially, the titles and abstracts of all records retrieved from the PubMed database were screened based on the predefined inclusion and exclusion criteria relevant to the role of *Withania somnifera* in stress management. To enhance efficiency and minimize selection bias, the Rayyan software platform was used, allowing both reviewers to independently classify studies as "Include," "Exclude," or "Maybe" according to their relevance.

Studies that appeared to meet the eligibility criteria or required further clarification were advanced to the full-text screening stage. Subsequently, full-text articles were carefully assessed to confirm their compliance with the predefined criteria, including study design, population, intervention with *Withania somnifera*, and stress-related outcome measures. Any discrepancies between the reviewers during the screening process were resolved through discussion and consensus. This systematic and rigorous screening approach ensured that only studies directly relevant to evaluating the effectiveness and safety of *Withania somnifera* in stress management were included in the final review. The PRISMA flow diagram was used to summarize the screening and selection process, as shown in Figure 1.

## PRISMA Flow Diagram

The search results were carefully read and analysed based on the predefined inclusion and exclusion criteria. After thorough scrutiny, six publications were identified and selected for inclusion in this review.

## Data Extraction

Data extraction was carried out independently by two reviewers using a predefined and standardized data extraction form designed for this systematic review. From each included study, key information was collected, including author details, year of publication, age groups, sample size, Intervention Details (Study Group), Intervention Details (Control Group), Outcome Variables, Results, Outcome summary. Discrepancies between reviewers during the data extraction process were resolved through mutual discussion, and when required, a third reviewer was consulted to achieve consensus. This structured approach ensured the reliability, consistency, and completeness of the data used for qualitative synthesis.

## Synthesis of Data

The primary objective of data synthesis was to facilitate comparability and enable a coherent interpretation of findings across the included studies. Three reviewers collaboratively organized and synthesized the extracted data into predefined domains, including author details, year of publication, age groups, sample size, Intervention Details (Study Group), Intervention Details (Control Group), Outcome Variables, Results, Outcome summary. The detailed characteristics and synthesized data of the included studies are presented in Table 2. This structured synthesis

**Table 1: Population, Intervention, Comparison, and Outcome (PICO) criteria for the systematic review.**

| Component | Description |
|---|---|
| Population (P) | Adults (≥18 years) experiencing psychological or chronic stress, including individuals with self-reported stress or stress-related symptoms. |
| Intervention (I) | Oral supplementation with *Withania somnifera* (*Ashwagandha*) root or root-leaf extracts in standardized formulations, administered at any dose and duration. |
| Comparison (C) | Placebo or no active intervention. |
| Outcomes (O) | Primary outcomes: Reduction in stress levels assessed by validated scales (Perceived Stress Scale, HAM-A, DASS). Secondary outcomes: Improvement in psychological well-being, sleep quality, cognitive function, quality of life, and modulation of stress-related biomarkers (serum/salivary cortisol, ACTH, DHEA-S, HRV). |
| Study design | Randomized, double-blind, placebo-controlled clinical trials. |
| Database | PubMed. |
| Language | English. |
| Time frame | Studies published up to the date of final search. |

Abbreviations: ACTH-Adrenocorticotropic hormone.

approach allowed for systematic comparison across studies and supported a clear and comprehensive qualitative assessment of the evidence regarding the role of *Withania somnifera* in stress management.

## RESULTS

A total of 422 studies were initially identified through a comprehensive PubMed search. After removing 6 duplicate records, 416 unique studies remained for further evaluation. During the initial screening of titles and abstracts, 16 studies were selected as potentially relevant and moved forward for full-text assessment. Upon detailed review, two studies were excluded because their full texts were not accessible, and eight studies were excluded as their methodologies did not align with the rigorous criteria required for inclusion in this review. Ultimately, six studies that met the predefined eligibility criteria-specifically randomized, double-blind, placebo-controlled trials-were included. These selected studies provided high-quality evidence

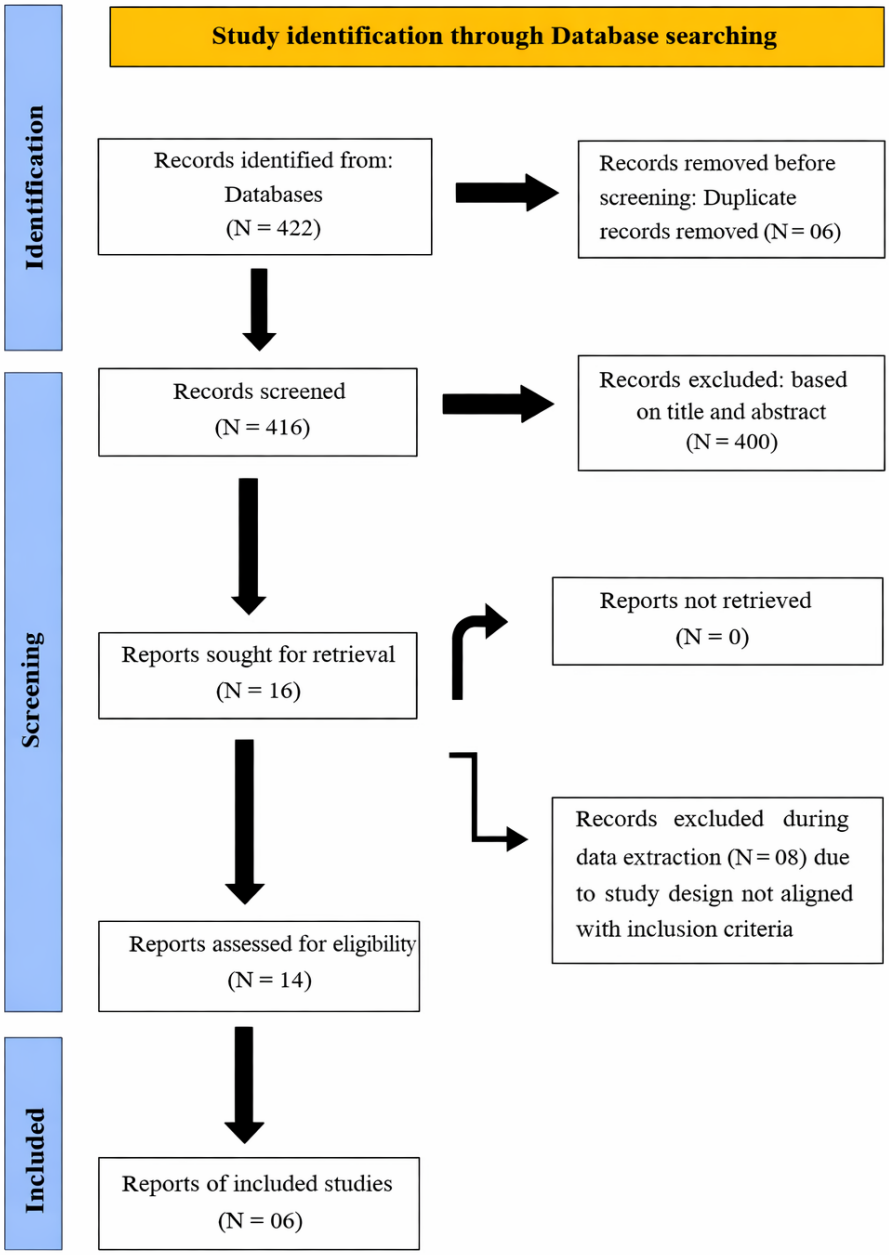


**Figure 1:** PRISMA flow diagram of study selection process.

**Table 2: Summary of characteristics of the included studies.**

| Sl. No. | Author (year, location) | Age (years) | Sample size | Study design | Intervention details (study Group) | Intervention details (Control Group) | Adverse events | Outcome variables | Results (p-values) | Outcome (summary) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Chandrasekhar, Kapoor, and Anishetty (2012), Hyderabad, India | 18–54 | 64 | Randomized, double-blind, placebo-controlled trial. | 300 mg high-concentration, full-spectrum Ashwagandha root extract capsule, twice daily for 60 days. | Placebo capsule. | Rhinitis, constipation, cough, and cold. | PSS, DASS, serum cortisol, GHQ-28. | PSS ($p < 0.0001$), Serum cortisol ($p = 0.0006$). | Significant improvement in stress tolerance and quality of life. |
| 2 | Lopresti, Smith, Malvi, and Kodgule (2019), Nagpur, India | 18–65 | 60 | Randomized, double-blind, placebo-controlled trial. | 240 mg standardized Ashwagandha extract (Shoden®) once daily. | Placebo capsule. | None reported. | HAM-A, DASS-21, serum cortisol, DHEA-S, testosterone. | HAM-A ($p = 0.040$), DASS-21 ($p = 0.096$), Serum cortisol ($p < 0.001$), DHEA-S ($p = 0.004$), testosterone ↑ in males ($p = 0.038$). | Reduction in anxiety and stress markers via HPA-axis modulation. |
| 3 | Choudhary, Bhattacharyya, and Joshi (2016), Kolkata, India | 18–60 | 52 | Randomized, double-blind, placebo-controlled trial. | 300 mg standardized Ashwagandha root extract (KSM-66®, 5% withanolides), twice daily for 8 weeks. | Placebo capsule. | Mild events: giddiness, head heaviness, blurred vision, hyperacidity. | PSS, FCQ-T, OHQ, TFEQ, serum cortisol. | PSS ($p < 0.0001$). | Improvement in psychological well-being and reduction in stress biomarkers. |
| 4 | Pandit *et al.* (2024), Kolkata, India | Mean age 35 | 111 (40 women, 71 men). | Randomized, double-blind, placebo-controlled trial. | Aqueous Ashwagandha extract (roots and leaves) at 125, 250 mg, or 500 mg/day for 8 weeks. | Placebo capsule. | No serious adverse events. | Salivary α-amylase, plasma cortisol, ACTH, DHEA-S, hs-CRP, HAM-A, HAM-D, PSQI, VAS-S, VAS-E, WHOQOL-bref. | Salivary α-amylase ($p < 0.001$), plasma cortisol ($p < 0.001$), ACTH ($p < 0.05$); DHEA-S NS; Multiple VAS and PSQI outcomes ($p < 0.05$ to $<0.001$). | Dose-dependent reduction in mild to moderate chronic stress. |
| 5 | Gopukumar *et al.* (2021) | 20–55 | 130 | Randomized, double-blind, placebo-controlled trial. | 300 mg Sustained-release Ashwagandha root extract capsule daily for 90 days. | Placebo capsule. | None reported. | CANTAB, PSS-10, serum cortisol, OHQ, PSQI, BDNF. | PSS ($p < 0.0001$), Serum cortisol ($p < 0.0001$), OHQ ($p = 0.0003$), PSQI ($p < 0.0001$). | Reduced stress with improvements in sleep, memory, and psychological well-being. |
| 6 | Smith, Lopresti, and Fairchild (2023), Australia | 40–75 | NR | Randomized, double-blind, placebo-controlled trial. | 200 mg Ashwagandha root extract (Witholytin®) capsule, twice daily for 12 weeks. | Placebo capsule. | Not reported. | PSS, Chalder Fatigue Scale, HRV, free testosterone, luteinizing hormone. | Fatigue ($p = 0.016$), HRV ($p = 0.003$); Stress NS ($p = 0.867$); testosterone ↑ ($p = 0.048$), LH ↑ ($p = 0.002$). | Improvement in fatigue and autonomic function; limited stress benefit. |

Abbreviations: ACTH-Adrenocorticotropic hormone; BDNF-Brain-derived neurotrophic factor; CANTAB-Cambridge neuropsychological test automated battery; HPA-Hypothalamic–Pituitary–Adrenal; PSS-Perceived Stress Scale.

to systematically evaluate the effects of *Withania somnifera* on stress management in human subjects.

Chandrasekhar, Kapoor, and Anishetty (2012), Hyderabad, India, conducted a single-centre, prospective, double-blind, randomized, placebo-controlled trial on 64 adults aged 18–54 with a history of chronic stress. Participants received 300 mg of high-concentration *Ashwagandha* root extract twice daily for 60 days. Supplementation significantly improved stress tolerance and quality of life, with reductions in Perceived Stress Scale (PSS, $p < 0.0001$) and serum cortisol ($p = 0.0006$). Mild adverse events reported included rhinitis, constipation, cough, and cold.

Lopresti, Smith, Malvi, and Kodgule (2019), Nagpur, India, conducted a 60-day randomized, double-blind, placebo-controlled study on 60 adults aged 18–65. Participants received 240 mg of standardized *Ashwagandha* extract (Shoden®) once daily. Supplementation significantly reduced anxiety (HAM-A, $p = 0.040$), morning cortisol ($p < 0.001$), and DHEA-S ($p = 0.004$), with an increase in testosterone in males ($p = 0.038$). DASS-21 showed a near-significant reduction ($p = 0.096$). No adverse events were reported.

Choudhary *et al.*, (2016), Kolkata, India, conducted a double-blind, randomized, placebo-controlled trial on 52 adults aged 18–60 experiencing chronic stress. Participants received 300 mg of standardized *Ashwagandha* root extract (KSM-66®, 5% withanolides) twice daily for 8 weeks. Treatment significantly improved psychological well-being and reduced stress biomarkers, with a notable decrease in PSS ($p < 0.0001$). Mild adverse events included giddiness, head heaviness, blurred vision, and hyperacidity.

Pandit *et al.*, (2024), Kolkata, India, conducted a double-blind, placebo-controlled study on 111 adults (40 women, 71 men) with a mean age of 35. Participants received aqueous *Ashwagandha* extract (roots and leaves) at doses of 125, 250 mg, or 500 mg/day for 8 weeks. The extract safely reduced mild to moderate chronic stress in a dose-dependent manner, significantly lowering salivary α-amylase ($p < 0.001$), plasma cortisol ($p < 0.001$), and adrenocorticotropic hormone (ACTH) ($p < 0.05$), while DHEA-S levels were not significant. Improvements were also observed in multiple VAS and PSQI outcomes ($p < 0.05$ to $<0.001$), with no serious adverse events reported.

Gopukumar *et al.*, (2021), India, conducted a randomized, double-blind, placebo-controlled study on 130 adults aged 20–55 years. Participants received 300 mg of sustained-release *Ashwagandha* root extract (*Ashwagandha* SR) or placebo once daily for 90 days. *Ashwagandha* SR significantly improved memory and focus (CANTAB), reduced stress (PSS-10, $p < 0.0001$), lowered serum cortisol ($p < 0.0001$), enhanced psychological well-being (OHQ, $p = 0.0003$), and improved sleep quality (PSQI, $p < 0.0001$), with no adverse events reported.

Smith *et al.*, (2023), Australia, conducted a 12-week randomized, double-blind, placebo-controlled trial in overweight or mildly obese adults aged 40–75 years. Participants received 200 mg of *Ashwagandha* root extract (Witholytin®) twice daily. *Ashwagandha* significantly reduced fatigue (Chalder Fatigue Scale, $p = 0.016$) and improved autonomic function (HRV, $p = 0.003$), with increases in free testosterone ($p = 0.048$) and luteinizing hormone ($p = 0.002$) in men. However, there was no significant improvement in perceived stress compared to placebo (PSS, $p = 0.867$). No adverse events were reported.

## DISCUSSION

This systematic review synthesizes evidence from six high-quality randomized, double-blind, placebo-controlled trials to evaluate the adaptogenic potential of *Withania somnifera* (*Ashwagandha*) in stress management. Collectively, the findings demonstrate that *Ashwagandha* supplementation is associated with significant improvements in psychological and physiological indicators of stress, supporting its role as an effective adaptogen in adults.

Across the included trials, *Ashwagandha* consistently reduced perceived stress, anxiety, and fatigue, as assessed by validated psychometric scales. These subjective improvements were accompanied by favourable changes in objective biomarkers of stress, particularly reductions in cortisol and other Hypothalamic–Pituitary–Adrenal (HPA) axis–related parameters. Since cortisol is a central mediator of the stress response, its consistent reduction suggests that *Ashwagandha* may help normalize dysregulated HPA-axis activity commonly observed in chronic stress conditions.

Physiologically, stress activates the sympathetic nervous system and the HPA axis, leading to increased secretion of catecholamines and cortisol. While this response is adaptive in the short term, sustained cortisol elevation can contribute to anxiety, fatigue, sleep disturbances, metabolic imbalance, immune dysregulation, and impaired cognitive function. The observed cortisol-lowering effect of *Ashwagandha* across multiple studies indicates its potential to restore hormonal homeostasis and enhance resilience to prolonged stress exposure.

In addition to stress reduction, *Ashwagandha* supplementation demonstrated broader benefits, including improvements in energy levels, sleep quality, cognitive performance, and overall psychological well-being. These effects suggest that *Ashwagandha* adaptogenic action extends beyond symptom relief and may positively influence daily functioning and quality of life. Evidence of dose responsiveness further indicates that therapeutic effects can be achieved at lower doses, with enhanced benefits at higher doses, offering flexibility for clinical application.

The mechanisms underlying these effects are likely multifactorial. Bioactive constituents of *Ashwagandha*, particularly withanolides, exhibit anti-inflammatory, antioxidant, and neuroprotective

properties. These compounds may modulate glucocorticoid receptor activity, reduce chronic inflammation, and improve receptor sensitivity, thereby indirectly attenuating cortisol secretion. Additionally, *Ashwagandha* may influence autonomic nervous system balance by reducing sympathetic overactivity and enhancing parasympathetic tone, which may explain improvements in heart rate variability, fatigue, and sleep quality. Potential modulation of neuroendocrine and neurotrophic factors may further contribute to observed improvements in mood, cognition, and mental performance.

Despite the overall consistency of findings, methodological heterogeneity across studies should be considered when interpreting the results. Variations in *Ashwagandha* formulations, dosages, treatment durations, and timing of administration may have influenced outcomes. Furthermore, cortisol follows a pronounced circadian rhythm, and differences in sampling time or biological matrices (plasma vs. saliva) may partially account for variability in cortisol-related findings. These factors highlight the importance of standardized assessment protocols in future research.

The available evidence supports *Ashwagandha* as a safe and effective adaptogenic intervention for reducing stress and improving psychological and physiological well-being in adults. Its benefits appear to be mediated through modulation of the HPA axis, autonomic-nervous-system regulation, and anti-inflammatory mechanisms, resulting in meaningful improvements in stress resilience, energy, cognition, and quality of life. Nevertheless, large scale, well-designed randomized controlled trials with standardized preparations, consistent dosing regimens, controlled timing of administration, and comprehensive safety assessments are required to establish its long-term efficacy, safety profile, and clinical applicability in stress-related disorders.

### Research Gap

One notable limitation of this review is the relatively small number of clinical trials included, which may limit the generalizability of the conclusions regarding *Ashwagandha*'s effects on stress. Additionally, variations in extract formulations, doses, and intervention durations across studies made direct comparisons challenging and may have influenced the overall synthesis of findings. Some studies also relied heavily on self-reported measures of stress and well-being, which could introduce subjective bias. Future research with larger sample sizes, standardized interventions, and longer follow-up periods is needed to provide a more comprehensive and robust understanding of *Ashwagandha*'s role in stress management.

## CONCLUSION

The findings of this systematic review strongly support *Withania somnifera* as an effective natural adaptogen for alleviating stress, anxiety, and fatigue while enhancing cognitive function, sleep quality, and overall psychological well-being in adults experiencing high stress. Its stress-mitigating effects appear to be mediated through modulation of the HPA axis and optimization of autonomic nervous system function, reflected in reduced cortisol levels, improved heart rate variability, and balanced hormonal profiles. Across different standardized extracts and formulations, *Ashwagandha* consistently demonstrated improvements in perceived stress, vitality, and quality of life, underscoring its versatility and potency. These findings position *Ashwagandha* as a valuable, evidence-based intervention in integrative mental health care, offering a safe, natural, and holistic approach to enhancing resilience and promoting overall well-being.

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## ABBREVIATIONS

**ACTH:** Adrenocorticotropic hormone; **DASS-21:** Depression, Anxiety, and Stress Scale–21 Items; **DHEA-S:** Dehydroepiandrosterone sulfate; **FCQ-T:** Food Cravings Questionnaire–Trait; **GHQ-28:** General Health Questionnaire–28 Items; **HAM-A:** Hamilton Anxiety Rating Scale; **HAM-D:** Hamilton Depression Rating Scale; **HPA:** Hypothalamic–pituitary–adrenal; **HRV:** Heart rate variability; **hs-CRP:** High-sensitivity C-reactive protein; **LH:** Luteinizing hormone; **MeSH:** Medical Subject Headings; **NR:** Not reported; **NS:** Not significant; **OHQ:** Oxford Happiness Questionnaire; **PICO:** Population, intervention, comparison, and outcomes; **PRISMA:** Preferred Reporting Items for Systematic Reviews and Meta-Analyses; **PSQI:** Pittsburgh Sleep Quality Index; **PSS:** Perceived Stress Scale; **TFEQ:** Three-Factor Eating Questionnaire; **VAS:** Visual Analogue Scale; **VAS-E:** Visual Analogue Scale–Effort; **VAS-S:** Visual Analogue Scale–Stress; **WHO QoL-Bref:** World Health Organization Quality of Life–Abbreviated Version.

## CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

## AUTHORS' CONTRIBUTIONS

All authors made substantial contributions to the study conception and design, data acquisition, analysis, manuscript preparation, and critical revision. Each author has read and approved the final version of the manuscript and affirms its originality and integrity.

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