

PROKOPCZYK, Kamila, PESZT, Michał Józef, JAKUBOWSKA, Paulina, PORĘBA, Kacper, PORĘBA, Martyna, WASILCZUK, Antoni, SZARYŃSKI, Mikołaj, LEWANDOWSKA-MACKIEWICZ, Aleksandra, RUSIŁOWICZ, Rafał, MATUSZEWSKA, Julia and JAKUBOWSKA, Martyna. Effects of Ashwagandha Supplementation on Strength, Endurance, and Post-Exercise Recovery: A Review. Quality in Sport. 2025;48:66886. eISSN 2450-3118.

<https://doi.org/10.12775/QS.2025.48.66886>

<https://apcz.umk.pl/QS/article/view/66886>

The journal has been awarded 20 points in the parametric evaluation by the Ministry of Higher Education and Science of Poland. This is according to the Annex to the announcement of the Minister of Higher Education and Science dated 05.01.2024, No. 32553. The journal has a Unique Identifier: 201398. Scientific disciplines assigned: Economics and Finance (Field of Social Sciences); Management and Quality Sciences (Field of 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). © The Authors 2025.

This article is published with open access under the License Open Journal Systems of Nicolaus Copernicus University in Torun, Poland. Open Access: This article is distributed under the terms of the Creative Commons Attribution Noncommercial License, which permits any noncommercial use, distribution, and reproduction in any medium, provided the original author(s) and source are credited. This is an open access article licensed under the terms of the Creative Commons Attribution Non-commercial Share Alike License (<http://creativecommons.org/licenses/by-nc-sa/4.0/>), which permits unrestricted, non-commercial use, distribution, and reproduction in any medium, provided the work is properly cited.

The authors declare that there is no conflict of interest regarding the publication of this paper.

Received: 26.11.2025. Revised: 03.12.2025. Accepted: 08.12.2025. Published: 08.12.2025.

Effects of Ashwagandha Supplementation on Strength, Endurance, and Post-Exercise Recovery: A Review

Prokopczyk Kamila

0009-0006-8972-8525

kamila.prokopczyk@gmail.com

University Clinical Hospital In Białystok, M. C. Skłodowskiej 24a, 15-276 Białystok, Poland

Peszt Michał Józef

0009-0008-3794-0174

Pesztmichal@gmail.com

University Clinical Hospital In Białystok, M. C. Skłodowskiej 24a, 15-276 Białystok, Poland

Jakubowska Paulina

0009-0007-6376-3135

paula.bialystok@wp.pl

University Clinical Hospital In Białystok, M. C. Skłodowskiej 24a, 15-276 Białystok, Poland

Poręba Kacper

0009-0003-3980-3038

Email: iplkacper@gmail.com

University Clinical Hospital In Białystok, M. C. Skłodowskiej 24a, 15-276 Białystok, Poland

Poręba Martyna

0009-0007-9251-404X

martynamucka@onet.pl

University Clinical Hospital In Białystok, M. C. Skłodowskiej 24a, 15-276 Białystok, Poland

Jakubowska Martyna

0009-0008-7234-5178

m.jakubowska2003@gmail.com

Medical University of Białystok, Jana Kilinskiego 1, 15-089 Białystok, Poland

Lewandowska-Mackiewicz Aleksandra

0009-0006-6427-2023

a.lewandowskamackiewicz@gmail.com

Regional Specialist Hospital in Biała Podlaska, ul. Terebelska 57-65, 21-500 Biała Podlaska

Wasilczuk Antoni

0009-0005-7140-1009

antoniwasilczuk@icloud.com

University Clinical Hospital In Białystok, M. C. Skłodowskiej 24a, 15-276 Białystok, Poland

Matuszewska Julia

0009-0009-6002-9335

jmatuszewska39@gmail.com

University Clinical Hospital No. 1 In Lublin, Stanisława Staszica 16, 20-400 Lublin, Poland

Rusiłowicz Rafał

0009-0009-6255-9161

rafalrusilowicz31@gmail.com

Medical University of Białystok, ul. Jana Kilińskiego 1, 15-089 Białystok, Poland

Szaryński Mikołaj

0009-0001-7344-8020

mikolaj.szarynski@gmail.com

Faculty of Medicine, Medical University of Białystok, ul. Jana Kilińskiego 1, 15-089 Białystok, Poland

Abstract

Introduction: Ashwagandha (*Withania somnifera*) is a traditional adaptogenic herb widely used in Ayurveda - traditional Indian medicine. Recent studies have investigated its potential benefits in sports and physical activity, including improvements in cardiorespiratory fitness, muscle strength, recovery, and psychophysiological adaptation. Its effects are attributed to adaptogenic, antioxidant, anti-inflammatory properties, and modulation of hormonal responses.

Aim of the Study: The aim of this study is to review the scientific literature regarding the effects of Ashwagandha supplementation on parameters relevant to sports performance.

Materials and Methods: **An extensive literature search was conducted in the PubMed database up to the year 2025.**

Summary: Evidence indicates that Ashwagandha supplementation provides multidimensional benefits in sports and physical activity. Improvements include increased VO₂max, extended time to exhaustion, enhanced muscle strength and lean body mass, and increased arm circumference and testosterone levels. Ashwagandha also supports recovery by reducing perceived fatigue, improving sleep quality, decreasing exercise-induced muscle enzyme elevation, and lowering inflammatory markers such as CRP. Additional effects include antioxidant protection, reduced oxidative stress, and favorable hormonal modulation (e.g., cortisol reduction of 27–30%, increased testosterone).

Conclusions: Ashwagandha appears to be a safe and promising supplement for enhancing performance, strength, and recovery. However, due to methodological limitations, variability in dosing, and heterogeneity of study populations, its use should be guided by individual assessment and consultation with a qualified professional. Further well-designed clinical trials are needed to establish optimal supplementation protocols and long-term effects.

Keywords: ashwagandha; withania somnifera; physical performance; muscle strength; recovery.

1. Introduction

Ashwagandha (*Withania somnifera*), also known as Indian ginseng, is an adaptogenic herb traditionally used in Ayurveda.[1] In recent years, interest in its application in sports and physical activity has increased. Adaptogens are herbal and nutritional substances that support the body's capacity to cope with stress, improve resilience, and maintain overall function in demanding situations.[2] Their use is associated with better metabolic regulation and enhanced cognitive and physical performance. The effects of plant-based adaptogens are observed largely due to the wide range of bioactive compounds such as phytochemicals.[3] Studies indicate that supplementation with Ashwagandha root extract may improve aerobic capacity, muscle strength, and recovery processes. Its mechanisms of action are attributed to adaptogenic, antioxidant, anti-inflammatory properties, and potential effects on hormonal regulation.[4]

2. Materials and Methods

This review was based on publications available in the open-access PubMed, PubMed Central (PMC) repository. It included clinical trials (randomized, placebo-controlled), systematic reviews and meta-analyses published up to 2025. The studies analyzed the effects of Ashwagandha supplementation on physical performance (e.g., VO₂max, time to exhaustion), muscle strength, muscle mass, and recovery after exercise. The literature covers studies differing in doses (approximately 300–1000 mg/day), duration (2–12 weeks), and participants (athletes, physically active individuals, various ages and sexes).

3. Literature Review

3.1 Endurance

The effect of Ashwagandha supplementation on physical endurance has been confirmed in numerous randomized trials and meta-analyses. VO_2max , which represents the maximal oxygen uptake of the body, serves as a critical indicator of aerobic capacity, and improvements in VO_2max are directly associated with enhanced endurance and the ability to sustain prolonged physical exercise. [5] In a study involving elite Indian cyclists, supplementation with 500 mg of extract twice daily for eight weeks increased VO_2max from 57.9 ± 5.4 ml/kg/min to 60.9 ± 5.7 ml/kg/min. Time to exhaustion increased from 12.1 ± 1.4 min to 13.6 ± 1.6 min, and METS improved from 16.5 ± 2.1 to 17.9 ± 2.3 . [6] Similar effects were observed in hockey players, with VO_2max increasing by an average of 4.91 ml/kg/min after eight weeks, whereas no significant changes were observed in the placebo group. [7] A meta-analysis of eight clinical trials including athletes and physically active individuals additionally found that supplementation with 300–500 mg twice daily for 8–12 weeks resulted in a significant VO_2max increase of 4.09 ml/kg/min compared with placebo. [8] A systematic review and meta-analysis found that ashwagandha supplementation consistently enhances VO_2 max in both trained and untrained individuals, most likely by improving oxygen utilization and reducing fatigue. [9] These results confirm that Ashwagandha may enhance exercise performance, particularly aerobic capacity and endurance.

3.2 Strength and Muscle Mass

Data on the effects of Ashwagandha on muscle strength and mass are equally significant. In a study involving young men taking 300 mg of extract twice daily for eight weeks, notable differences compared to the placebo group were observed. Bench-press strength increased by 46.0 kg in the supplemented group versus 26.4 kg in controls, and leg-extension strength increased by 14.5 kg versus 9.8 kg. These changes were accompanied by an increase in arm circumference (5.3 cm versus 2.9 cm in placebo) and lean body mass (+2.1 kg versus +1.4 kg in the control group). [10] Significant improvements were observed in handgrip strength, quadriceps strength, and back extensor force, indicating enhanced muscle activity. [11] Another clinical study employing the Kinematic Measuring System (KMS)TM evaluated the average absolute power of the lower limbs during ten vertical jumps. After eight weeks of *Withania somnifera* supplementation, without any additional physical training, a statistically significant improvement was recorded. [12]

These results suggest that Ashwagandha can support strength and hypertrophic adaptations, particularly when combined with regular resistance training.

3.3 Recovery and Fatigue

Clinical studies indicate that Ashwagandha supplementation promotes faster recovery after exercise and reduces perceived fatigue. [13] In a study with female soccer players taking 600 mg of extract daily for 28 days, subjective recovery assessed by the Total Quality Recovery score increased from 15.2 to 17.3 points, while remaining unchanged in the placebo group. Participants also reported improved sleep quality (increase of ~1.1 points on a five-point scale), and the Hooper index, including fatigue and stress, decreased from 13.5 to 10.1. [14]

Ashwagandha supplementation was also significantly more effective than placebo in reducing muscle fatigue, as assessed by Perceived Recovery Scores. [15] Positive effects on recovery were also confirmed by physiological biomarkers. In physically active individuals, Ashwagandha supplementation reduced CRP levels by an average of 0.6 mg/L. [10] Sleep quality was further improved in a meta-analysis of clinical trials, with supplementation (300–600 mg/day for 6–12 weeks) resulting in a decrease of 1.67 points on the Pittsburgh Sleep Quality Index compared with placebo, confirming its role in supporting rest and recovery. [16]

3.4 Antioxidant Effects

Studies have shown that Ashwagandha exhibits significant antioxidant properties that may support the body during intense exercise. [17] In active individuals, supplementation with 300–600 mg/day for eight weeks significantly reduced oxidative stress markers such as malondialdehyde (MDA) by an average of $-0.41 \mu\text{mol/L}$ compared with placebo, which showed no significant change. In another study, participants taking Ashwagandha for eight weeks showed an increase in antioxidant enzyme activity, including catalase and superoxide dismutase, by 14–18% compared with placebo. [10]

3.5 Muscle Protection

In a randomized, double-blind, placebo-controlled trial investigating the effects of Ashwagandha supplementation combined with resistance training, notable differences in creatine kinase (CK) responses were observed. After eight weeks, the placebo group exhibited a mean CK level of **1307.5 U/L** (95% CI: 1202.8–1412.1), whereas participants supplemented with Ashwagandha (300 mg twice daily) showed a mean value of **1462.6 U/L** (95% CI: 1366.2–1559.1). This difference was statistically significant ($p = 0.03$). The findings suggest that Ashwagandha may modulate CK activity and attenuate exercise-induced muscle damage, supporting more efficient recovery and adaptive responses to resistance training.[10] Notably, bioactive compounds in Ashwagandha, including withanone, have been shown to support muscle cell differentiation, indicating their potential role in muscle repair. [18] These findings suggest that Ashwagandha not only supports recovery and performance but also protects muscles from exercise-induced oxidative stress, limiting cellular damage and promoting adaptation to training loads.

3.6 Psychophysiological Adaptation and Hormonal Regulation

Ashwagandha, recognized for its adaptogenic properties, helps regulate the stress response by lowering cortisol and supporting homeostasis. Reduced stress levels not only enhance psychological well-being but also contribute to improved physical performance, recovery, and overall physiological resilience, which is particularly relevant in the context of sports and exercise.

Elevated cortisol levels during training can impair recovery, reduce muscle protein synthesis, and increase the risk of overtraining, negatively affecting overall performance and adaptation. [19] By reducing cortisol levels, Ashwagandha may support the body's adaptation to chronic training stress, thereby lowering the risk of overtraining. [20] Several randomized placebo-controlled trials reported reductions in serum cortisol levels, which may decrease the burden on the hypothalamic–pituitary–adrenal axis during intense training. [21]

Evidence from trials conducted in elderly adults [22], athletes [23], and the general population [24] confirms the herb's beneficial effects across varied groups. Simultaneously, testosterone levels increased in men undergoing resistance training (average +96.2 ng/dl versus +18.0 ng/dl in placebo), partially explaining greater gains in strength and muscle mass. [10] Subjective adaptogenic effects were also reported, including improved well-being, higher energy levels, and better concentration during periods of increased training load. [25] These findings suggest that the benefits of Ashwagandha may result not only from physiological effects but also from reduced psychological stress, which plays a crucial role in adaptation and recovery in sports.

3.7 Safety

In studies involving healthy adult participants who took a standardized Ashwagandha root extract for 4 to 8 weeks, no serious adverse effects were reported. Many participants did not experience any unwanted symptoms, and improvements were observed in parameters such as cognitive function, cortisol levels, and sleep quality. In one study, after 8 weeks of supplementation, no changes in biochemical parameters were detected. [26] An analysis of 30 clinical trials on Ashwagandha safety indicated that root extracts of this plant are generally safe, with adverse effects being rare and usually mild. The most commonly reported symptoms included drowsiness, abdominal discomfort, loose stools, and dizziness, all of which were transient and resolved after discontinuation of the supplement. [27] While the majority of research suggests that Ashwagandha supplementation is safe and well-tolerated, further studies are needed to assess the safety of higher doses and extended supplementation periods.

3.8 Limitations and Remarks

Although the findings are encouraging, this review highlights several important limitations: the limited number of available studies, variability in dosing regimens and supplementation duration, as well as the heterogeneity of study populations. Consequently, further rigorously designed clinical trials are required to establish more precise recommendations regarding the optimal use of Ashwagandha supplementation in the context of sports performance.

4. Conclusions

Current evidence indicates that Ashwagandha supplementation provides multidimensional benefits in sports and physical activity, impacting endurance, strength, recovery, and psychophysiological adaptation. Regular intake of 300–1000 mg/day for several weeks has been associated with measurable improvements in aerobic capacity, including $\text{VO}_{2\text{max}}$ increases of 3–5 ml/kg/min and extended time to exhaustion by approximately 1.5 minutes, highlighting its potential to enhance endurance performance. Supplementation also promotes gains in muscle strength and lean body mass, as well as increases in arm circumference and testosterone levels, suggesting support for hypertrophic and neuromuscular adaptations.

In addition to physical performance, Ashwagandha positively affects recovery and fatigue management. Studies report reductions in perceived fatigue, improved sleep quality, lower exercise-induced elevations of muscle enzymes (e.g., creatine kinase), and decreased inflammatory markers such as CRP. Its antioxidant properties further contribute to cellular protection, mitigating oxidative stress induced by intensive exercise.

Moreover, adaptogenic effects, including reductions in cortisol (up to 27–30%) and improved subjective well-being, energy, and concentration, indicate a role in psychophysiological resilience and stress modulation, which are crucial for optimal training adaptation and recovery. Overall, the evidence positions Ashwagandha as a safe and promising supplement for supporting endurance, strength, and recovery. However, variability in study protocols, dosing, and participant characteristics warrants cautious interpretation. Personalized assessment and professional consultation are recommended, particularly for elite athletes, and additional rigorously designed trials are needed to define optimal supplementation strategies and long-term outcomes.

Disclosure

Author's contribution

Conceptualization: Kamila Prokopczyk, Michał Józef Peszt

Methodology: Kacper Poręba, Antoni Wasilczuk

Formal analysis: Martyna Poręba, Paulina Jakubowska

Investigation: Paulina Jakubowska, Lewandowska-Mackiewicz Aleksandra, Antoni Wasilczuk

Writing-rough preparation: Rafał Rusiłowicz, Lewandowska-Mackiewicz Aleksandra

Writing-review and editing: Kamila Prokopczyk, Mikołaj Szaryński

Supervision: Matuszewska Julia, Jakubowska Martyna, Kacper Poręba

Received funding- no specific funding.

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

Financing statement

This research received no external funding.

Institutional Review Board Statement

Not applicable.

Informed Consent Statement

Not applicable.

Data Availability Statement

Not applicable.

Conflict of interest

The authors deny any conflict of interest.

Declaration of the Use of Generative AI and AI-Assisted Technologies in the Writing Process:

In preparing this work, the authors used ChatGPT by OpenAI to improve language, readability, and text formatting. Following the use of this tool, the authors thoroughly reviewed and edited the content as necessary and accept full responsibility for the final version and all substantive content of the publication.

References

- [1] Joshi VK, Joshi A. Rational use of Ashwagandha in Ayurveda (Traditional Indian Medicine) for health and healing. *J Ethnopharmacol.* 2021 Aug 10;276:114101. doi: 10.1016/j.jep.2021.114101.
- [2] Panossian AG, Efferth T, Shikov AN, Pozharitskaya ON, Kuchta K, Mukherjee PK, Banerjee S, Heinrich M, Wu W, Guo DA, Wagner H. Evolution of the adaptogenic concept from traditional use to medical systems: Pharmacology of stress- and aging-related diseases. *Med Res Rev.* 2021 Jan;41(1):630-703. doi: 10.1002/med.21743.
- [3] Todorova V, Ivanov K, Delattre C, Nalbantova V, Karcheva-Bahchevanska D, Ivanova S. Plant Adaptogens-History and Future Perspectives. *Nutrients.* 2021 Aug 20;13(8):2861. doi: 10.3390/nu13082861.
- [4] Lopresti AL, Smith SJ, Malvi H, Kodgule R. An investigation into the stress-relieving and pharmacological actions of an ashwagandha (*Withania somnifera*) extract: A randomized, double-blind, placebo-controlled study. *Medicine (Baltimore).* 2019 Sep;98(37):e17186. doi: 10.1097/MD.00000000000017186.
- [5] Lundby C, Montero D, Joyner M. Biology of VO₂ max: looking under the physiology lamp. *Acta Physiol (Oxf).* 2017 Jun;220(2):218-228. doi: 10.1111/apha.12827.
- [6] Shenoy S, Chaskar U, Sandhu JS, Paadhi MM. Effects of eight-week supplementation of Ashwagandha on cardiorespiratory endurance in elite Indian cyclists. *J Ayurveda Integr Med.* 2012 Oct;3(4):209-14. Doi: 10.4103/0975-9476.104444.
- [7] Malik, A., Mehta, V., & Dahiya, V. (2013). Effect of Ashwagandha (*Withania somnifera*) root powder supplementation on the VO₂ max. and hemoglobin in hockey players. *International Journal of Behavioral Social and Movement Sciences*, 2(3), 91-99.
- [8] Jayawardena R, Weerasinghe K, Sooriyaarachchi P. Trunk muscle endurance and upper extremity performance in healthy adults. *Turk J Sports Med.* 2025;60(2):64-73; <https://doi.org/10.47447/tjsm.0862>
- [9] Bonilla DA, Moreno Y, Gho C, Petro JL, Odriozola-Martínez A, Kreider RB. Effects of Ashwagandha (*Withania somnifera*) on Physical Performance: Systematic Review and Bayesian Meta-Analysis. *J Funct Morphol Kinesiol.* 2021 Feb 11;6(1):20. doi: 10.3390/jfmk6010020.
- [10] Wankhede S, Langade D, Joshi K, Sinha SR, Bhattacharyya S. Examining the effect of *Withania somnifera* supplementation on muscle strength and recovery: a randomized controlled trial. *J Int Soc Sports Nutr.* 2015 Nov 25;12:43. doi: 10.1186/s12970-015-0104-9.
- [11] Raut AA, Rege NN, Tadv FM, Solanki PV, Kene KR, Shirolkar SG, Pandey SN, Vaidya RA, Vaidya AB. Exploratory study to evaluate tolerability, safety, and activity of Ashwagandha (*Withania somnifera*) in healthy volunteers. *J Ayurveda Integr Med.* 2012 Jul;3(3):111-4. Doi: 10.4103/0975-9476.100168.
- [12] Sandhu JS, Shah B, Shenoy S, Chauhan S, Lavekar GS, Padhi MM. Effects of *Withania somnifera* (Ashwagandha) and *Terminalia arjuna* (Arjuna) on physical performance and cardiorespiratory endurance in healthy young adults. *Int J Ayurveda Res.* 2010 Jul;1(3):144-9. doi: 10.4103/0974-7788.72485.

- [13] Singh N, Bhalla M, de Jager P, Gilca M. An overview on ashwagandha: a Rasayana (rejuvenator) of Ayurveda. *Afr J Tradit Complement Altern Med*. 2011;8(5 Suppl):208-13. doi: 10.4314/ajtcam.v8i5S.9.
- [14] Coope OC, Reales Salguero A, Spurr T, Páez Calvente A, Domenech Farre A, Jordán Fisas E, Lloyd B, Gooderick J, Abad Sangrà M, Roman-Viñas B. Effects of Root Extract of Ashwagandha (*Withania somnifera*) on Perception of Recovery and Muscle Strength in Female Athletes. *Eur J Sport Sci*. 2025 Mar;25(3):e12265. doi: 10.1002/ejsc.12265. Erratum in: *Eur J Sport Sci*. 2025 May;25(5):e12292. doi: 10.1002/ejsc.12292.
- [15] Ziegenfuss TN, Kedia AW, Sandrock JE, Raub BJ, Kersick CM, Lopez HL. Effects of an Aqueous Extract of *Withania somnifera* on Strength Training Adaptations and Recovery: The STAR Trial. *Nutrients*. 2018 Nov 20;10(11):1807. doi: 10.3390/nu10111807.
- [16] Sprengel M, Laskowski R, Jost Z. *Withania somnifera* (Ashwagandha) supplementation: a review of its mechanisms, health benefits, and role in sports performance. *Nutr Metab (Lond)*. 2025 Feb 5;22(1):9. doi: 10.1186/s12986-025-00902-7.
- [17] Gómez Afonso A, Fernandez-Lazaro D, Adams DP, Monserdà-Vilaró A, Fernandez-Lazaro CI. Effects of *Withania somnifera* (Ashwagandha) on Hematological and Biochemical Markers, Hormonal Behavior, and Oxidant Response in Healthy Adults: A Systematic Review. *Curr Nutr Rep*. 2023 Sep;12(3):465-477. doi: 10.1007/s13668-023-00481-0.
- [18] Wang J, Zhang H, Kaul A, Li K, Priyandoko D, Kaul SC, Wadhwa R. Effect of Ashwagandha Withanolides on Muscle Cell Differentiation. *Biomolecules*. 2021 Oct 4;11(10):1454. doi: 10.3390/biom11101454.
- [19] Stults-Kolehmainen MA, Bartholomew JB, Sinha R. Chronic psychological stress impairs recovery of muscular function and somatic sensations over a 96-hour period. *J Strength Cond Res*. 2014 Jul;28(7):2007-17. doi: 10.1519/JSC.0000000000000335.
- [20] Chandrasekhar K, Kapoor J, Anishetty S. A prospective, randomized double-blind, placebo-controlled study of safety and efficacy of a high-concentration full-spectrum extract of ashwagandha root in reducing stress and anxiety in adults. *Indian J Psychol Med*. 2012 Jul;34(3):255-62. Doi: 10.4103/0253-7176.106022.
- [21] Lopresti AL, Smith SJ, Malvi H, Kodgule R. An investigation into the stress-relieving and pharmacological actions of an ashwagandha (*Withania somnifera*) extract: A randomized, double-blind, placebo-controlled study. *Medicine (Baltimore)*. 2019 Sep;98(37):e17186. doi: 10.1097/MD.00000000000017186.
- [22] Speers AB, Cabey KA, Soumyanath A, Wright KM. Effects of *Withania somnifera* (Ashwagandha) on Stress and the Stress- Related Neuropsychiatric Disorders Anxiety, Depression, and Insomnia. *Curr Neuropsychopharmacol*. 2021;19(9):1468-1495. doi: 10.2174/1570159X19666210712151556.
- [23] Salve J, Pate S, Debnath K, Langade D. Adaptogenic and Anxiolytic Effects of Ashwagandha Root Extract in Healthy Adults: A Double-blind, Randomized, Placebo-controlled Clinical Study. *Cureus*. 2019 Dec 25;11(12):e6466. doi: 10.7759/cureus.6466.
- [24] Della Porta M, Maier JA, Cazzola R. Effects of *Withania somnifera* on Cortisol Levels in Stressed Human Subjects: A Systematic Review. *Nutrients*. 2023 Dec 5;15(24):5015. doi: 10.3390/nu15245015.

- [25] Remenapp A, Coyle K, Orange T, Lynch T, Hooper D, Hooper S, Conway K, Hausenblas HA. Efficacy of *Withania somnifera* supplementation on adult's cognition and mood. *J Ayurveda Integr Med*. 2022 Apr-Jun;13(2):100510. doi: 10.1016/j.jaim.2021.08.003.
- [26] Verma N, Gupta SK, Tiwari S, Mishra AK. Safety of Ashwagandha Root Extract: A Randomized, Placebo-Controlled, study in Healthy Volunteers. *Complement Ther Med*. 2021 Mar;57:102642. doi: 10.1016/j.ctim.2020.102642.
- [27] Tandon N, Yadav SS. Safety and clinical effectiveness of *Withania Somnifera* (Linn.) Dunal root in human ailments. *J Ethnopharmacol*. 2020 Jun 12;255:112768. doi: 10.1016/j.jep.2020.112768.