Junior researchers

ახალგაზრდა მკვლევარები

Vol. 3 Issue 2, 2025

https://doi.org/10.52340/jr.2025.03.02.28

# Extrapyramidal Symptoms in Psychiatric Disorders: Current Insights, Risk Factors, and Future Directions: A Narrative Review

## Highlights

1. Early diagnosis and monitoring of Extrapyramidal Symptoms (EPS) improve treatment outcomes and medication adherence.
2. Substance abuse and psychiatric disorder severity correlate with increased EPS prevalence.
3. AI-driven monitoring and personalized approaches offer promising advancements in EPS management.

**Authors:**

Monika Sharma, MTech[1]; Navratan Suthar, MD[2]; Pankaj Yadav, PhD[3]

**Affiliations:**

[1]IDRD, Smart Healthcare, IIT-AIIMS Jodhpur

[2]Department of Psychiatry, AIIMS Jodhpur

[3]Department of Bioscience and Bioengineering, IIT Jodhpur

## Abstract

**Background:** Extrapyramidal symptoms (EPS) are drug-induced motor disorders associated with antipsychotic medications, including drug-induced parkinsonism, akathisia, dystonia, and tardive dyskinesia. EPS can lead to significant physical discomfort, functional impairment, and social withdrawal. The severity and prevalence of EPS vary based on factors such as drug choice, dosage, individual susceptibility, and duration of treatment, making it essential for healthcare providers to monitor and manage these symptoms carefully in patients undergoing antipsychotic therapy.

**Methods:** We conducted comprehensive searches in the PubMed, PsycInfo, and Google Scholar databases, initially identifying 522 records related to EPS in psychiatric disorders published between 2002 and 2024. The search strategy focused on original research articles, clinical trials, and observational studies. After screening and applying predefined inclusion and exclusion criteria, 13 studies were selected for analysis and inclusion in this review.

**Results and Discussion:** The review highlights the challenges of EPS management, emphasizing the need for early detection and personalized treatment strategies. Integrating advanced technologies, such as AI-driven platforms, offers promising prospects for improving EPS diagnosis and

management. A multidisciplinary approach that combines clinical expertise, advanced technologies, and patient-centered care is essential for effective EPS management.
**Keywords**: Extrapyramidal Symptoms, EPS, Movement Disorders, EPS monitoring Tools, Antipsychotic Medications, Psychiatric Disorders

## 1. Introduction

Extrapyramidal Symptoms (EPS) are drug-induced movement disorders that occurs due to the blockade of nigrostriatal dopamine tracts by antipsychotic medications. These blockades can increase cholinergic activity, leading to various motor disturbances such as acute dystonia, acute akathisia, antipsychotic-induced parkinsonism, and tardive dyskinesia (1). EPS is a group of motor disorders due to disruptions in the extrapyramidal system, a part of the brain's motor control (2). EPS are associated with the use of antipsychotic medications, first-generation antipsychotics (FGAs) and, to a lesser extent, second-generation antipsychotics (SGAs) (3). While these medications are effective in treating psychiatric disorders such as schizophrenia and bipolar disorder, they can induce EPS as a side effect (4).

EPS can severely impact a patient's quality of life, leading to physical discomfort, functional impairment, and social withdrawal (5). The presence of EPS can contribute to medication non-adherence, as patients may stop their treatment to avoid these side effects (6). Therefore, continuous and effective monitoring of EPS is essential for optimizing treatment regimens and enhancing patient outcomes. The primary goal of this review is to investigate and assess the existing methodologies used to monitor EPS. The review will also explore the clinical applications of EPS monitoring, including how these methods can improve patient outcomes and influence treatment decisions. We will outline future directions, focusing on research gaps and recommendations for integrating advanced monitoring methodologies into clinical practice.

### *1.1 Extrapyramidal Symptoms (EPS) and their types*

EPS encompasses a spectrum of motor disorders resulting from dysfunctions within the extrapyramidal system, a critical neural network involved in motor control regulation (7). These symptoms are observed in patients undergoing antipsychotic therapy and can significantly compromise their overall well-being and quality of life (8). Motor signals are transmitted from the brain to motor neurons via the pyramidal and extrapyramidal tracts. The pyramidal tracts, responsible for the conscious control of voluntary movements, send impulses from the cerebral cortex to the body. The reticulospinal tract is critical among the extrapyramidal tracts for modulating the activity of motor neurons(9).

Parkinsonism is associated with bradykinesia, resting tremors, and rigidity of the muscles. Clinical representation often includes a shuffling gait, decreased arm swing, and a stooped posture, reflecting impaired motor coordination (10). Dystonia is another type of EPS, involving sustained or intermittent muscle contractions that lead to abnormal postures or movements. Dystonia may be focal, affecting specific body regions, or involve multiple muscle groups. Symptoms include twisting

movements, abnormal postures, and severe cramping, which can significantly disrupt daily activities and cause considerable discomfort (5). Akathisia is an intense sensation of inner restlessness and an uncontrollable urge to move. Individuals with akathisia frequently exhibit repetitive behaviors, such as pacing or shifting from foot to foot (11). Tardive dyskinesia is a late- onset disorder characterized by repetitive, involuntary movements affecting the facial and lingual musculature. Symptoms include lip smacking, tongue protrusion, and grimacing (12).

*1.2 Epidemiology of EPS*

The epidemiology of EPS highlights significant association with various medications, especially antipsychotics and antidepressants, as well as demographic factors, which are essential for effective management and prevention strategies (13). Retrospective studies indicate that drug- induced EPS (di-EPS) can range from 9.8% to 28.9%, with medications like *paroxetine* and *imipramine* posing the highest risk(14). In first-episode psychosis, mild EPS were observed in 40% of patients, correlating with poorer cognitive performance (13). In paediatric populations, EPS are associated with dopamine antagonists used as antiemetics, particularly *metoclopramide* (15). While EPS are often linked to medication use, they can also signal underlying neurological conditions, making careful monitoring and management crucial to minimizing their impact on patient quality of life (16).

*1.3 Pathophysiology of EPS*

The pathophysiology of EPS is primarily attributed to neurochemical imbalances, particularly involving dopamine dysregulation (6). Parkinsonism occurs due to the receptor blockade in the nigrostriatal pathway, resulting in characteristic motor symptoms such as bradykinesia, tremors, and rigidity (17). Dystonia occurs from an imbalance between dopamine and acetylcholine; dopamine receptor antagonism by antipsychotics can lead to an excess of acetylcholine activity, contributing to sustained muscle contractions and abnormal postures (18). Akathisia often involves not only the blockade of dopamine receptors but also dysregulation of serotonin and norepinephrine systems, leading to an exacerbated sense of restlessness (19). On the other hand, tardive dyskinesia occurs from prolonged dopamine receptor blockade, resulting in receptor sensitivity and neuroadaptive changes within the basal ganglia (20). Genetic susceptibility and environmental factors, such as the duration and dosage of antipsychotic therapy, also influence the incidence and severity of EPS (21).

*1.4 Time of onset of EPS*

Extrapyramidal symptoms (EPS) associated with antipsychotic use have varying onset times, depending on the type of EPS and patient-specific risk factors, as shown in **Figure 1**. Acute dystonia typically occurs within the first five days of treatment, particularly in young males of Asian or Black descent (22). Akathisia appears within the first 10 days after initiating the antipsychotic treatment. Drug-induced parkinsonism develops within 30 days, with elderly females being at higher risk. Tardive dyskinesia (TD), on the other hand, is a late-onset condition, usually emerging after three months of chronic antipsychotic use as shown in **Table 1**. The emergence of these symptoms

highlights the critical need for vigilant monitoring throughout all phases of antipsychotic treatment (23).

### *1.5 Risk factors of EPS*

Several factors have been identified as significant contributors to the development of drug-induced EPS, such as age, smoking, tremor history, and previous antipsychotic use, which are major risk factors (13). In Chinese patients with schizophrenia, the use of antipsychotics with strong D2 receptor antagonism and a more prolonged illness duration also increases the likelihood of EPS (24). Additionally, factors such as age, body mass index (BMI), and the use of dopamine receptor blocking agents (DRBAs) are essential in EPS risk. Pharmacokinetic influences, particularly genetic variations in cytochrome P450 enzymes, alongside pharmacodynamic factors involving dopaminergic and other neurotransmitter systems, further contribute to the development of EPS (25). Other notable risk factors include advanced pre-existing central nervous system conditions, Parkinson's disease, high, and the concurrent use of anti-dopaminergic or serotonergic medications (26). Moreover, the use of first-generation antipsychotics, a history of CNS damage, substance abuse, and anti-dopaminergic treatment have also been highlighted as prominent risk factors (19).

## 2. Methods and Materials

We searched the PubMed and Google Scholar databases for literature on extrapyramidal symptoms (EPS) in psychiatric disorders, spanning the period from 2002 to 2024. The search strategy utilized the following terms: (EPS) OR (extrapyramidal symptoms) AND (psychiatric disorders) OR (schizophrenia) OR (bipolar disorder) OR (major depressive disorder) AND (diagnosis) AND (monitoring) AND (risk factors). The eligibility of studies was initially assessed through a screening of titles and abstracts. Articles that met the inclusion criteria in this preliminary review undergo a detailed evaluation of the full text, as depicted in **Figure 2.** Our selection included original research articles, clinical trials, and observational studies. A systematic methodology was followed for the narrative review, identifying 522 records through PubMed, PsycInfo, and Google Scholar searches. Finally, 13 studies meeting all inclusion criteria were selected for the narrative review, as represented in **Table 2.**

## 3. EPS monitoring methods

### *3.1 Physical examination of EPS*

In evaluating Parkinsonism, bradykinesia is assessed by observing the patients' movement speed and amplitude, noting any slowness in initiating and completing movements. Difficulties with tasks such as buttoning a shirt or writing can indicate bradykinesia. Resting tremors, typically observed in the hands or fingers while the patient is at rest, are also evaluated, with the tremor often diminishing with voluntary movement and presenting as a characteristic "pill-rolling" motion. Muscle rigidity is assessed through passive range-of-motion exercises, noting resistance to movement that may be described as "lead-pipe" or "cogwheel" rigidity. The patient's gait is observed for shuffling steps and

reduced arm swing, and posture is evaluated for signs of stooping or flexing. The difficulty in maintaining an upright position or turning while walking may also be noted. Additionally, a reduced range of facial expressions, masked faces, is recorded, where the patient displays a diminished expression (27).

TD movements may be subtle and not immediately visible during routine examinations. However, these movements can be elicited through specific activation techniques. For instance, asking the patient to keep their mouth open for 20 to 30 seconds and then having them hold up their hand while sequentially tapping each finger to the thumb can help reveal these movements. Additionally, instructing the patient to open and close each hand while keeping their mouth open allows for observing tongue curling or writhing movements (16).

For akathisia, patients often exhibit an inability to remain still. They may frequently cross and uncross their legs while seated or shift their body weight from one foot to another when walking (28). Pacing back and forth is also common in individuals with akathisia (19).

In assessing acute dystonia, the observations are made for twisted or contorted postures, such as cervical dystonia (head tilting), oromandibular dystonia (abnormal facial movements), or hand dystonia (writer's cramp). Additionally, abnormal, often repetitive movements, such as jerking or twisting of the limbs, face, or trunk, are noted, with continuous or episodic movements (23).

### *3.2 Clinical Assessment Scales*

Clinical assessments evaluate EPS and typically involve rating scales and clinical interviews.

*3.2.1* ***Extrapyramidal Rating Scale (ESRS)*****:** It is a comprehensive tool for evaluating a broad spectrum of EPS. It is utilized by clinicians to assess distinct types of EPS, including Parkinsonism, akathisia, dystonia, and tardive dyskinesia. The ESRS stands, as it covers all domains of EPS, making it more inclusive compared to other scales that may focus on only one specific type of movement disorder. The scale provides a detailed assessment of motor symptoms and can be used to monitor changes over time or in response to treatment. The ESRS is valuable in clinical practice and research settings for its ability to capture the full range of EPS symptoms (29).

*3.2.2* *Abnormal Involuntary Movement Scale (AIMS):* It is a 12-item clinician-rated scale specifically designed to assess the severity of TD. This scale evaluates orofacial movements as well as extremity and truncal movements. It is beneficial for patients undergoing treatment with antipsychotic medications, where TD is a common concern. The AIMS helps identify the presence and severity of involuntary movements characteristic of TD, such as lip-smacking, tongue protrusion, and grimacing. It is commonly used in clinical settings to monitor TD's progression and guide treatment adjustments (30).

*3.2.3* *Simpson-Angus Scale (SAS):* It is an established instrument to evaluate antipsychotic-induced parkinsonism. This scale assesses symptoms such as bradykinesia, rigidity, and tremors. The SAS is useful in both diagnosing and monitoring the severity of Parkinsonism that arises as a side effect of antipsychotic medications. It provides a structured approach to evaluating motor symptoms associated with antipsychotic use. It is widely used in clinical trials and research to assess the impact

of interventions on Parkinsonian symptoms(31).

*3.2.4 The Barnes Akathisia Rating Scale (BARS):* It is widely used for measuring antipsychotic-induced akathisia. Akathisia is characterized by intense inner restlessness and an uncontrollable urge to move, which can significantly affect a patient's quality of life. The BARS evaluates the severity of these symptoms by assessing the subjective experience of restlessness and the observable motor behaviors, such as pacing or shifting weight. The scale is commonly employed in clinical trials to quantify the extent of akathisia and evaluate the efficacy of treatments to alleviate these symptoms (32).

## 4. Management of EPS

Recent management strategies for EPS emphasize dose reduction of antipsychotics (11). For tardive dyskinesia, switching to a second-generation antipsychotic (SGA) such as *Clozapine* is recommended. SGAs, due to their weaker dopamine D2 receptor affinity and antagonistic effects on serotonin 5-HT2A receptors, have a lower incidence of EPS compared to first-generation antipsychotics (FGAs) (33).

Atypical antipsychotic drugs, which include *Olanzapine, Risperidone,* and *Aripiprazole*, are drugs that are effective in treating EPS with a lower risk of tardive dyskinesia (34). Specific medications like *Aripiprazole and Brexpiprazole* have shown efficacy with fewer side effects due to their unique receptor profiles. *Cariprazine,* another atypical antipsychotic, has been effective in treating schizophrenia and bipolar disorder with minimal weight gain or metabolic effects (3). Lowering the doses of antipsychotics has been shown to reduce the risk of EPS while maintaining efficacy in treating psychosis. Combination therapy, where multiple medications are used to target various aspects of EPS, has also emerged as an effective strategy. Anticholinergic drugs like *Benztropine and Trihexyphenidyl* can be used as adjunctive treatments to manage EPS, though they come with their own set of side effects, particularly in older patients (35).

Non-pharmacological interventions, including physical, occupational, and speech therapy, have proven effective in managing EPS, especially in cases like Tardive dyskinesia. These therapies aim to improve motor function, coordination, and balance. Additionally, lifestyle modifications, regular monitoring, and addressing non-adherence to treatment are crucial aspects of EPS management. Emotional and psychological support, including psychotherapy, is also essential for improving the quality of life for patients dealing with EPS (36).

## 5. AI-Driven Monitoring of Extrapyramidal Symptoms (EPS)

Integrating artificial intelligence (AI) into clinical workflows represents a transformative opportunity for monitoring EPS. AI-powered solutions, leveraging advances in computer vision, natural language processing, and predictive analytics, can address these gaps with precision, scalability, and real-time insights as shown in **Figure 3**.

*Video-Based Motion Tracking:* Computer vision, driven by deep learning, enables video-based analysis of patient movements. AI-powered pose estimation and motion tracking techniques can evaluate gait patterns, involuntary movements, or postural abnormalities. Additionally, the use of convolutional neural networks (CNNs) in tracking subtle hand and facial tremors demonstrates the ability to distinguish tardive dyskinesia from other motor disorders. Remote video monitoring offers a non-invasive, cost-effective solution, empowering clinicians to track patients outside traditional clinical settings and reducing hospital burden. (37)

*5.1 Natural Language Processing (NLP)*: AI-powered chatbots and virtual assistants employing natural language processing can collect patient-reported outcomes. Natural Language Processing (NLP) and Conversational AI have significantly transformed human-computer interaction, enabling machines to process, understand, and generate human language in a natural and contextually relevant manner (38)

*5.2 AI-Based Predictive Analytics:* AI-driven predictive models utilize patient data, including demographics, medication history, and genetic predispositions, to assess the risk of EPS development. Studies integrating clinical and genetic data have demonstrated the ability to create machine-learning models that accurately predict the onset of EPS. These models can also forecast symptom progression, helping clinicians anticipate clinical needs and make proactive treatment adjustments. Predictive analytics thus supports personalized medicine, optimizing patient outcomes and reducing healthcare costs.

*5.3 Speech and Facial Movement Analysis:* Speech and facial movement analysis powered by AI offers innovative, non-invasive methods for monitoring EPS. Voice biomarkers, such as pitch, rhythm, or fluency changes, may correlate with motor disturbances like Parkinsonism. AI algorithms analyzing voice recordings have detected early signs of Parkinsonism with notable sensitivity. Similarly, facial recognition algorithms can detect involuntary movements, such as grimacing or lip smacking, characteristic of tardive dyskinesia (39).

## 6. Discussion

Effective EPS monitoring enables clinicians to know the onset of EPS symptoms before they worsen, allowing for proactive treatment (13). By minimizing the severity of EPS, patient's daily routines and social interactions are not disrupted (40). Furthermore, efficient EPS management reduces the side effects of antipsychotic drugs, lowering the chance of noncompliance owing to discomfort or distress emanating from motor symptoms (11). Haloperidol exhibited a significantly higher EPS frequency (78.3%) compared to those treated with risperidone (55.1%), quetiapine (39.5%), and olanzapine (35.8%), highlighting the reduced EPS risk associated with atypical antipsychotics(41). In a study, 62.7% of bipolar patients on atypical neuroleptics experienced moderate to severe EPS, surpassing typical clinical trial rates (42). The incidence of TD ranges from 2.8% for olanzapine, an atypical antipsychotic, to 11.1% for depot typical antipsychotics. The lower TD risk associated with olanzapine (2.8%) aligns with the general understanding that atypical antipsychotics have a reduced propensity for causing extrapyramidal symptoms, including TD,

compared to typical antipsychotics (43).

The influence of substance abuse on EPS was significant in schizophrenia patients, particularly related to cocaine and alcohol (44). The awareness of EPS symptoms impacted medication compliance and treatment efficacy (45). The patients with EPS exhibited more severe psychiatric symptoms, suggesting a correlation between EPS risk and treatment duration as well as D2 receptor antagonism(24). Moreover, drug-induced parkinsonism (DIP) was linked to higher negative symptoms in older age and comorbidities with increased parkinsonism risk (14). It was found that a range of drug-induced EPS incidence, influenced by age and prior antipsychotic use (13). EPS patients had a significantly increased likelihood of hospitalizations, leading to greater healthcare costs (46). The overall EPS prevalence of 42.6% among schizophrenia patients, with incidence rates for tardive dyskinesia (7.9%), parkinsonism (38.6%), and akathisia (3.6%), with age and treatment duration identified as critical risk factors (47).

The management of EPS requires a multifaceted approach that includes early recognition, careful medication selection, and ongoing monitoring. By addressing these aspects, clinicians can significantly improve patient outcomes, reduce healthcare costs, and enhance the overall efficacy of antipsychotic treatments. Despite improvements in EPS monitoring, various research gaps need to be addressed to improve the usefulness of current techniques. The studies lack the long-term impacts of continuous EPS monitoring on patient outcomes and the potential psychological impact of current symptom tracking. Incorporating AI-based technologies in EPS monitoring represents a significant advancement in monitoring EPS. These tools facilitate early detection, objective symptom quantification, and data-driven treatment modifications. However, challenges persist, including algorithmic bias, data privacy concerns, and the need for robust clinical validation across heterogeneous populations. AI-driven methodologies can revolutionize EPS management, improving diagnostic accuracy, treatment efficacy, and patient outcomes. By addressing these challenges and embracing emerging technologies, the future of adverse drug reaction monitoring holds the potential to improve the management of motor symptoms in patients with mental health disorders, leading to better outcomes and enhancing quality of life.

## 7. Conclusion

Extrapyramidal symptoms remain a significant challenge in the pharmacological management of psychiatric disorders, particularly in patients treated with antipsychotic medications. Effective monitoring and timely management are crucial for reducing the burden of EPS, improving adherence, and enhancing the overall quality of life for affected patients.

Emerging artificial intelligence technologies present promising tools for improving EPS detection and monitoring. Video-based motion tracking, natural language processing for patient self-reports, predictive analytics, and facial and speech analysis offer scalable and non-invasive approaches to enhance clinical oversight. Integrating these advanced digital tools into routine psychiatric care could transform EPS management by facilitating early detection, guiding treatment adjustments, and improving long-term patient outcomes. Future research should focus on validating these AI

approaches in real-world settings and ensuring their accessibility across diverse clinical environments.

Acknowledgments

We extend our sincere gratitude to the Indian Institutes of Technology (IIT), JCKIF, Johari Digital Ltd. and the All-India Institute of Medical Sciences (AIIMS), Jodhpur for their invaluable support and collaborative efforts throughout this study. We are also thankful for the infrastructure and ethical oversight provided by both institutions, ensuring the ethical conduct of our study.

**Funding:** This study did not involve any funding.

**Conflict of Interest:** The authors declare no competing interests related to this study.

## Ethics Statement

**Statement of Human and Animal Rights:** This study did not involve human subjects or animal experiments. As a review article, it was based on analysis of publicly available data and literature.

**Statement of Informed Consent:** Not applicable to this review article as it did not involve direct human subjects research.

## Data Accessibility Statement

The data supporting the findings of this study are derived from publicly available resources and databases. Further details are available upon reasonable request from the corresponding author.

## Author Contributions

1. Background:

A. Conception, B. Organization, C. Execution

2. Analysis:

A. Design, B. Execution, C. Review and Critique

3. Manuscript Preparation:

A. Writing of the first draft, B. Review and Critique

**MS:** 1B, 1C, 2B, 3A **NS:** 1A, 1B, 2A, 3B **PY:** 1B, 2A, 2C, 3B

## REFERENCES

1. Ward KM. Antipsychotic-Related Movement Disorders : Drug- Induced Parkinsonism vs . Tardive Dyskinesia — Key Differences in Pathophysiology and Clinical Management DRUG-INDUCED PARKINSONISM. Neurol Ther [Internet]. 2018;7(2):233–48. Available from: https://doi.org/10.1007/s40120-018-0105-0
2. Dayalu P, Chou KL. Extrapyramidal Symptoms and. 2008;1451–62.

3. Divac N, Prostran M, Jakovcevski I, Cerovac N. Second-generation antipsychotics and extrapyramidal adverse effects. Biomed Res Int. 2014;2014.
4. Butler MI, Chandrakanth J. Monitoring of extrapyramidal side effects in patients on antipsychotic treatment: A completed audit cycle. Ir J Psychol Med. 2016;33(3):165–9.
5. Nillafita E, Kusuma P, Oktaviani E, Harahap WA. Study of adverse effects of extrapyramidal syndrome use of combination of antipsychotics antidepressants in outpatient schizophrenia patients in RSUP Fatmawati for the period 2016-2020. 2023;13(July):185– 96.
6. Divac N, Prostran M, Jakovcevski I, Cerovac N. Extrapyramidal Adverse Effects. 2014;
7. Park S, Tripathi A, Avasthi A, Grover S, Tanra AJ, Kato TA, et al. Relationship between body mass index and extrapyramidal symptoms in asian patients with schizophrenia : the research on asian psychotropic prescription patterns for antipsychotics ( reap-ap ). 2020; 32(2):176–86.
8. Pierre JM. Extrapyramidal Symptoms with Atypical Antipsychotics Incidence , Prevention and Management. 2005;28(3):191–208.
9. Kaar SJ, Natesan S, Mccutcheon R, Howes OD. Neuropharmacology Antipsychotics : Mechanisms underlying clinical response and side-effects and novel treatment approaches based on pathophysiology. Neuropharmacology [Internet]. 2019;(March):107704. Available from: https://doi.org/10.1016/j.neuropharm.2019.107704
10. Disease N. Drug-Induced Movement Disorders and Its Associated Factors Among Patients Attending Treatment at Public Hospitals in Eastern Ethiopia. 2020;1987–95.
11. Stroup TS, Gray N. Management of common adverse effects of antipsychotic medications. 2018;(October):341–56.
12. Hauser RA, Meyer JM, Factor SA, Comella CL, Tanner M, Xavier RM, et al. HHS Public Access Author manuscript antipsychotic-induced movement disorders in clinical practice. 2022;27(2):208–17.
13. Abu-naser D, Gharaibeh S, Meslamani AZ Al, Alefan Q, Abunaser R. Clinical Practice & Epidemiology in Assessment of Extrapyramidal Symptoms Associated with Psychotropics Pharmacological Treatments , and Associated Risk Factors Abstract : 2021;1–7.
14. Roiter B, Pigato G, Antonini A. Prevalence of Extrapyramidal Symptoms in In-Patients With Severe Mental Illnesses : Focus on Parkinsonism. 2020;11(November):1–7.
15. Das JK, Kumar R, Salam RA, Freedman S, Bhutta ZA. The effect of antiemetics in childhood gastroenteritis. 2013;13(Suppl 3).
16. Özge A, Domaç FM, Tekin N, Sünbül EA, Öksüz N, Atalar AÇ, et al. One Patient , Three Providers: A Multidisciplinary Approach to Managing Common Neuropsychiatric Cases. 2023;
17. Powell A, Gallur L, Koopowitz L, Hayes MW. Parkinsonism in the psychiatric setting : an update on clinical differentiation and management. 2020;1–5.
18. Loonen AJM, Ivanova SA. Neurobiological mechanisms associated with antipsychotic drug-induced dystonia. 2021;
19. Musco S, Mcallister V, Caudle I. Dopamine-receptor blocking agent- associated akathisia : a summary of current understanding and proposal for a rational approach to treatment. 2020;1–13.

20. Cornett EM, Novitch M, Kaye AD, Kata V, Kaye AM. Medication-Induced Tardive Dyskinesia : A Review and Update. 2017;
21. Lisoway AJ, Chen CC, Zai CC, Tiwari AK, Kennedy JL. Toward personalized medicine in schizophrenia : Genetics and epigenetics of antipsychotic treatment. Schizophr Res [Internet]. 2021;232:112–24. Available from: https://doi.org/10.1016/j.schres.2021.05.010
22. Tandon R. Antipsychotics in the Treatment of Schizophrenia: An Overview. 2011;72(suppl 1):4–8.
23. Ayd F, Wilson K. Acute dystonias. 1979. 35–67 p.
24. Weng J, Zhang Y, Li H, Shen Y, Yu W. Study on risk factors of extrapyramidal symptoms induced by antipsychotics and its correlation with symptoms of schizophrenia. 2019;14–21.
25. Konstandi M, Johnson EO. Age-related modi fi cations in CYP-dependent drug metabolism : role of stress. 2023;(May):1–10.
26. Eun J, Dong Y, Shin W, Jang W, Han K, Kim D, et al. Female reproductive factors and the risk of Parkinson ' s disease : a nationwide cohort study. Eur J Epidemiol [Internet]. 2020;35(9):871–8. Available from: https://doi.org/10.1007/s10654-020-00672-x
27. Bologna M, Paparella G, Fasano A, Hallett M, Berardelli A. Evolving concepts on bradykinesia Bradykinesia : terminology and clinical aspects. 2020;(2019).
28. Akathisia A, Pringsheim T, Gardner D, Addington D, Martino D, Morgante F, et al. The Assessment and Treatment of. 2018;
29. Chouinard G, Margolese HC. Manual for the Extrapyramidal Symptom Rating Scale (ESRS ). 2005;76:247–65.
30. Guy R, Assessment WE, Revised P. Abnormal Involuntary Movement Scale (AIMS).1988; 173(6):118–9.
31. Janno S, Holi MM, Tuisku K, Wahlbeck K. schizophrenia population. 2005;6:1–6.
32. Barnes TR. A rating scale for drug-induced akathisia . A Rating Scale for Drug-Induced. 2012;672–6.
33. Carbon M, Kane JM, Leucht S, Correll CU. Tardive dyskinesia risk with fi rst- and second-generation antipsychotics in comparative randomized controlled trials : a meta-analysis. 2018;(October):330–40.
34. Caroff SN, Morley JF. Risk of Drug-induced Movement Disorders with Newer Antipsychotic Agents. 2022;12(1):1–18.
35. Muench J, Hamer ANNM. Adverse Effects of Antipsychotic Medications. 2010;81(5):617– 22.
36. Article R. Recent management of extrapyramidal syndrome in antipsychotic use. 23(2023):320–8.
37. Id JS, Hsu MM, Pantelyat AY, Id RTR. PLOS DIGITAL HEALTH Clinical gait analysis using video-based pose estimation : Multiple perspectives , clinical populations , and measuring

change. 2024; Available from: http://dx.doi.org/10.1371/journal.pdig.0000467
38. Pothuri V. Natural Language Processing and Conversational AI. 2024;(September).
39. Reddy GP, Rohan D, Venkata Y, Kumar P, Prakash KP, Srikanth M. Artificial Intelligence-Based Effective Detection of Parkinson ' s Disease Using Voice Measurements. 2024;1–8.
40. Claxton KL, Chen JJ, Swope DM. Drug-Induced Movement Disorders. 2007;415–29.
41. Bobes J, Rejas J. Frequency of Extrapyramidal Adverse Reactions in Schizophrenic Outpatients Treated with Risperidone , Olanzapine, Quetiapine or Haloperidol Results of the EIRE Study. 2002; 22(9):609–22.
42. Ghaemi SN, Hsu DJ, Rosenquist KJ, Pardo TB, Goodwin FK. Extrapyramidal side effects with atypical neuroleptics in bipolar disorder. 2006;30:209–13.
43. Novick D, Haro ÞJM, Bertsch J, Haddad PM. Incidence of Extrapyramidal Symptoms and Tardive Dyskinesia in Schizophrenia Outpatient Health Outcomes Study. 2010;30(5):531– 40.
44. Zhornitsky S, Stip E, Pampoulova T, Chiasson J. Extrapyramidal Symptoms in Substance Abusers with and Without Schizophrenia and in Nonabusing Patients with Schizophrenia. 2010;25(13):2188–94.
45. Kirgaval RS, Revanakar S, Srirangapattna C. Prevalence of Extrapyramidal Side Effects in Patients on Antipsychotics Drugs at a Tertiary Care Center5. 2017;20(5).
46. Kadakia A, Brady BL, Dembek C, Williams GR, Kent M, Kadakia A, et al. The incidence and economic burden of extrapyramidal symptoms in patients with schizophrenia treated with second generation antipsychotics in a Medicaid population with schizophrenia treated with second generation antipsychotics in a. J Med Econ [Internet]. 2022;25(1):87–98. Available from: https://doi.org/10.1080/13696998.2021.2019501
47. Shettima FB, Sheikh TL, Wakil MA. Prevalence and Correlates of Extrapyramidal Side Effects Among Patients with Schizophrenia Spectrum Disorders on Typical and Atypical Antipsychotics. 2023;225–40.

*Table 1: Comparison of extrapyramidal symptoms in Psychiatric disorders.*

| Extrapyramidal Symptoms | Onset | Scales for evaluation | Symptoms |
|---|---|---|---|
| Acute dystonia | Within 5 days | Extrapyramidal Symptom Rating Scale (ESRS), Dystonia Severity Scale (DSS) | Prolonged abnormal postures, involuntary muscle contractions, and muscle spasms, such as oculogyric crisis, laryngospasm, or torticollis. |
| Akathisia | Within 10 days | Barnes Akathisia Rating Scale (BARS), Extrapyramidal Symptom Rating Scale (ESRS) | Restless motor activity, a crawling sensation in the legs, feelings of distress. |
| Parkinsonism | Within 30 days | Movement Disorder Society-Unified Parkinson's Disease Rating Scale (MDS- UPDRS), Extrapyramidal Symptom Rating Scale (ESRS) | Jerky muscle stiffness, tremors, balance instability, a hunched posture, and a shuffling walk. |
| Tardive dyskinesia | After 3 months | Abnormal Involuntary Movement Scale (AIMS), Extrapyramidal Symptom Rating Scale (ESRS) | Continuous, involuntary twisting movements primarily affecting the facial muscles, and less frequently, the limbs. |

*Table 2: Selected studies for the review.*

| S.No. | Author | Year | Sample size | Key findings | Risk Factors |
|---|---|---|---|---|---|
| 1. | Julio Bobes et al. | 2002 | 636 | The frequency of EPS was significantly higher in patients treated with haloperidol (78.3%) compared to risperidone (55.1%), quetiapine (39.5%), and olanzapine (35.8%) ($p< 0.05$). Akathisia was more prevalent in the haloperidol (36.8%) and risperidone (19.7%) groups compared to olanzapine (11.4%) and quetiapine (2.6%). | Atypical antipsychotics (risperidone, quetiapine, olanzapine) are associated with a lower risk of EPS compared to haloperidol, even after dosage adjustments. |
| 2. | S. Nassir Ghaemi et al. | 2006 | 37 | 62.7% of trials with atypical neuroleptics in bipolar patients resulted in moderate to severe EPS, exceeding the 5–15% range seen in clinical trials. | Younger age increases akathisia risk; low potency agents are associated with lower akathisia compared to high potency. |
| 3. | Diego Novick et al. | 2010 | 7,728 | TD incidence ranged from 2.8% for olanzapine to 11.1% for depot typical agents, with depot typical agents and risperidone at higher risk than olanzapine. | Age and severity of symptoms |
| 4. | Simon Zhornitsky et al. | 2010 | 115 | Patients with a dual diagnosis of schizophrenia and psychoactive substance abuse exhibited significantly more parkinsonism than non-abusing schizophrenia patients, with cocaine and | Cocaine and alcohol abuse/dependence are associated with increased parkinsonism. |

| | | | | | |
|---|---|---|---|---|---|
| | | | | alcohol abuse identified as key contributing factors. | Alcohol and cannabis abuse/dependence contribute to a higher occurrence of akathisia |
| 5. | Kirgaval et al. | 2017 | 70 | 64.28% of patients experienced moderate EPS severity, and 54.28% were aware of their symptoms, which caused mild distress, influencing medication compliance and treatment efficacy. | Gender, Age, use of Risperidone |
| 6. | Jiajun Weng et al. | 2019 | 679 | EPS patients have more severe psychiatric symptoms. | High D2 receptor antagonism in antipsychotics and longer illness duration increase EPS risk. |
| 7. | David Misdrahi et al. | 2019 | 674 | DIP prevalence is 13.2% and TD is 8.3%; DIP is linked to higher negative symptoms and first-generation antipsychotics, while TD is associated with disorganization symptoms. | Higher negative symptoms and first-generation antipsychotic use increase DIP risk; disorganization symptoms elevate TD risk. |
| 8. | Beatrice Roiter et al. | 2020 | 285 | EPS occurred in 50.5% of in-patients; tremor was most common (33%); parkinsonism (13.3%) linked to older age and comorbidities. | Older age and more medical comorbidities increase parkinsonism risk. |
| 9. | Dania Abu-Naser et al. | 2021 | 104,694 | EPS incidence ranged from 9.8% (Amitriptyline 25mg) to 28.9% (Imipramine 25mg); patients on paroxetine, | Age, smoking, history of tremors, and prior antipsychotic use |

| | | | | | |
|---|---|---|---|---|---|
| | | | | imipramine, or fluoxetine had a higher risk than those on citalopram. | increase the risk of di-EPS. |
| 10. | Naista Zhand et al. | 2022 | 92 | No significant difference in total ESRS scores among partial agonists, second-generation, and first-generation antipsychotics; risperidone showed higher ESRS scores than paliperidone, aripiprazole, and flupenthixol. | Higher ESRS scores associated with risperidone use. |
| 11. | Aditi Kadakia et al. | 2022 | 3,558 | 22.1% of patients starting atypical antipsychotics developed EPS within a year; incidence rate was 26.9 cases per 100-person-years. | Initiating treatment with atypical antipsychotics increases the risk of developing EPS. |
| 12. | Mohammed Abdulaziz et al. | 2023 | 340 | Overall prevalence of EPS in schizophrenia patients on antipsychotics was 42.6%; specific rates included 7.9% for tardive dyskinesia, 38.6% for parkinsonism, and 3.6% for akathisia. | Age, treatment duration, and illness severity increase the risk of specific EPS. |
| 13. | Ema Nillafita Putri Kusuma et al. | 2023 | 449 | Paranoid schizophrenia was the most common diagnosis (79.4%); acute dystonia was the prevalent extrapyramidal adverse effect, affecting 32.5% of patients. | Diagnosis of paranoid schizophrenia is linked to higher rates of acute dystonia. |

***Abbreviations****: DIP: Drug-induced Parkinsonism; EPS: Extrapyramidal symptoms; ESRS: Extrapyramidal Symptom Rating Scale TD; Tardive Dyskinesia.*

## Figures

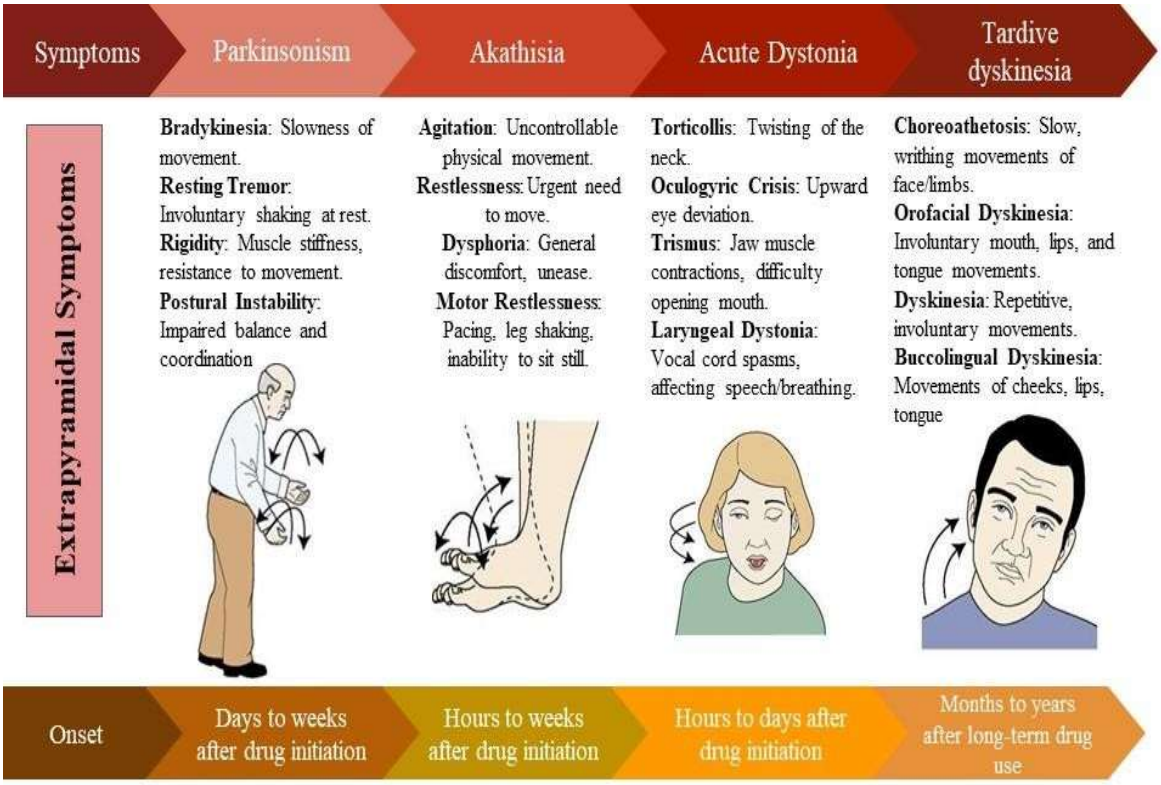


***Figure 1:*** *Overview of Extrapyramidal Symptoms, and onset of EPS following antipsychotic therapy.*

**Description:** This figure illustrates the clinical presentation and typical onset timelines of key extrapyramidal symptoms (EPS) associated with medications. The EPS highlighted include: Parkinsonism (characterized by bradykinesia, resting tremor, rigidity, and postural instability), Akathisia (manifesting as agitation, restlessness, dysphoria, and motor restlessness such as pacing and leg shaking), Acute Dystonia (including torticollis, oculogyric crisis, trismus, and laryngeal dystonia affecting speech and breathing), and Tardive Dyskinesia (featuring choreoathetosis of the face/limbs, orofacial dyskinesia, general dyskinesia, and buccolingual dyskinesia). Onset times range from hours after drug initiation for acute dystonia to months or years of long-term drug use for tardive dyskinesia.

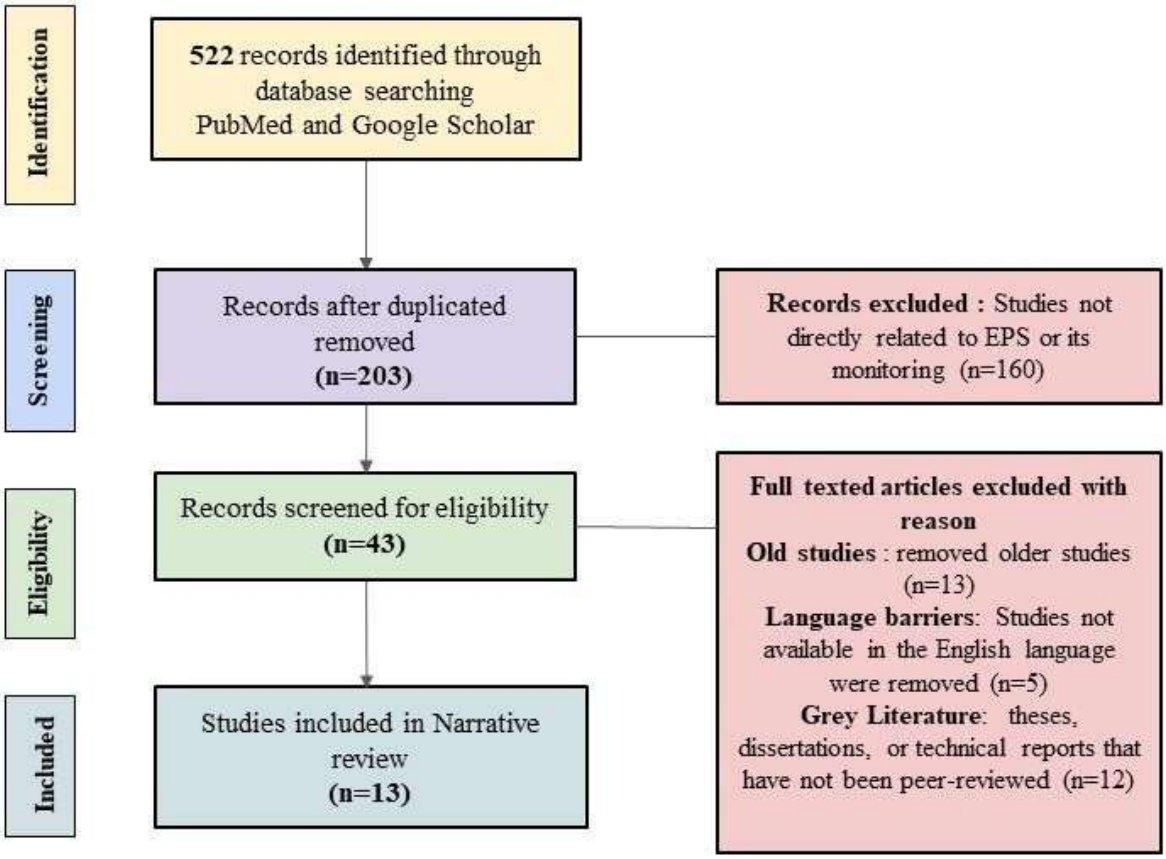


***Figure 2:*** *The flow diagram detailing the database searches, the number of records screened, and the full texts retrieved*

**Description:** The image illustrates the study selection process for a narrative review, beginning with the identification of 522 records from PubMed and Google Scholar. After removing duplicates, 203 records were excluded. The remaining records were screened for eligibility, resulting in the exclusion of 160 studies not directly related to Extrapyramidal Symptoms (EPS) or its monitoring. Full-text articles were further excluded due to being old studies (n=13), language barriers (n=5), and classification as grey literature (n=12). Ultimately, 13 studies met the inclusion criteria and were included in the narrative review

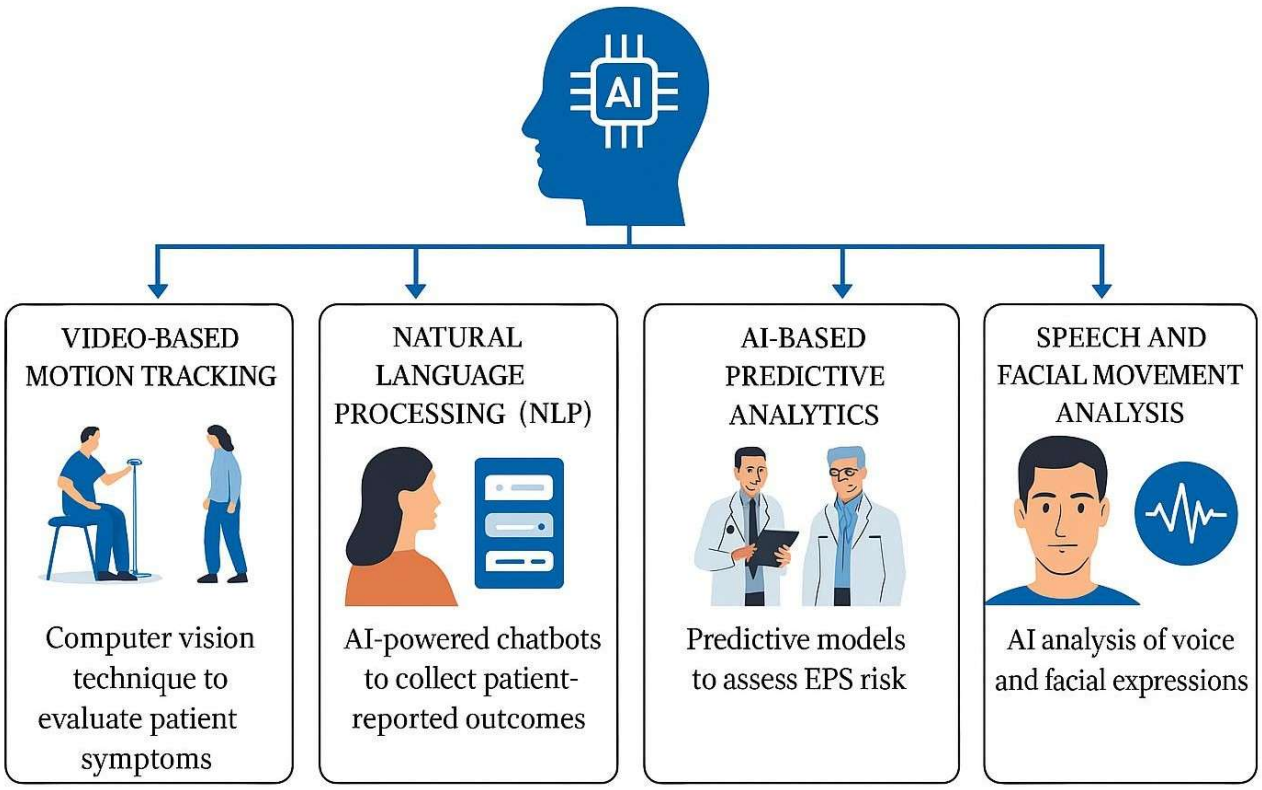


***Figure 3:*** *AI-Driven Monitoring of Extrapyramidal Symptoms (EPS)*

**Description:** This infographic illustrates how artificial intelligence enhances the detection and management of EPS through four key approaches: video-based motion tracking, natural language processing for patient-reported symptoms, AI-powered predictive analytics, and speech and facial movement analysis. By integrating these technologies into clinical workflows, healthcare providers can achieve earlier diagnosis, personalized care, and improved treatment outcomes for patients experiencing antipsychotic-induced motor disorders.