**Appendix: Summary of fall risk factors in the synucleinopathies**

|  |  |  |
| --- | --- | --- |
| **Risk Factors** | **Found to be a risk factor** | **Not found to be a risk factor** |
| **Non-modifiable risk factors** |  |  |
| * Increased age
 | (1, 2)  | (3-14) |
| * Gender
 | (15, 16) | (1-4, 7-13, 17-19) |
| Disease severity* H&Y Scale
 | (1, 3-5, 7, 11-13, 15, 18, 20-24) | (8, 10, 17, 25, 26) |
| * UPDRS total score
 | (1, 3, 4, 6, 8, 13, 14, 20, 21, 23, 25) |  |
| * UPDRS motor sub-score
 | (2-4, 6, 7, 10, 11, 18, 20, 22-24, 26, 27) | (5, 8, 12, 13, 17, 25) |
| * Disease duration
 | (2-4, 7, 11, 15, 18, 19, 23, 24, 26, 27) | (1, 2, 6, 9, 12, 13, 20, 21, 25) |
| **Medications** |  |  |
| Parkinsonism-specific medications* Levodopa equivalent dose
 | (4, 6, 11, 13, 20, 24) | (3, 5, 8, 17, 18, 25, 26) |
| * Dopamine agonists
 | (14) | (3, 11, 17, 20) |
| * Amantadine
 | (15) | (6) |
| * COMT inhibitor
 |  | (11, 20) |
| * MAO inhibitor
 |  | (11) |
| Other medications* Benzodiazepines
 | (11) | (20) |
| * Anti-cholinergics
 |  | (6, 17, 20) |
| * Anti-psychotics
 |  | (6, 16, 19) |
| * Narcotics
 |  | (6) |
| * Cardioactives
 |  | (20, 28) |
| * Anti-depressants
 | (6, 15) | (20) |
| * Polypharmacy
 |  | (1, 6) |
| **Motor dysfunction** |  |  |
| * Tremor
 |  | (6, 15, 17, 29) |
| * Dyskinesias
 | (3, 21, 30) | (4, 20, 26, 27, 29) |
| * Axial rigidity
 |  | (20, 29) |
| * Limb rigidity
 | *(29)* |  |
| * Speech disturbance
 | *(29)* |  |
| * Dysphagia
 | *(29)* |  |
| * Pyramidal signs
 | *(29)* |  |
| **Balance & mobility** |  |  |
| Postural instability* PIGD phenotype
 | (1-3, 6, 11, 17, 22) | (13, 26) |
| * Tinetti balance score
 | (3, 16, 25) |  |
| * Berg Balance scale
 | (3, 24, 26, 27, 31) |  |
| * Functional reach
 | (24, 26, 30) | (3) |
| * Postural sway
 | (3, 20, 30, 31) | (16) |
| * Tandem stand
 | (22, 30) |  |
| * Single-leg stand
 | (17, 22) | (13) |
| * Pull-test
 | (27, 30-33) | *(29)* |
| * Coordinated stability test
 | (30, 32) | (20, 26) |
| * Mini-BESTest
 | (12, 18) |  |
| * Tandem walk
 | (16) |  |
| Transfers* TUG
 | (3, 4, 10, 13, 15, 20, 24, 31) | (26) |
| * Sit-to-stand
 | (12, 13, 30) | (5, 17) |
| Freezing of gait* FOG-q
 | (3, 8, 11, 12, 18, 21, 27, 30, 32) | (17) |
| * UPDRS Freezing
 | (2, 4, 20, 26, 34) | (1, 17) |
| Slowed mobility* Tinetti gait
 | (3, 16, 25) |  |
| * Slowed velocity
 | (5, 10, 13, 17, 22, 27, 30) | (20, 32) |
| * Ambulatory capacity score
 | (6) |  |
| * Dynamic gait index
 | (24) | (26) |
| **Non-Motor features** |  |  |
| Autonomic dysfunction* Symptomatic orthostasis
 | (3) |  |
| * Orthostatic hypotension
 | (6, 20, 35) | (4, 14, 17, 23, 25) |
| * Urinary incontinence
 | (23) | (20) |
| * Total autonomic symptom score
 | (16, 28) | *(29)* |
| * Time taken for blood pressure to return to baseline on standing
 | **(28)** |  |
| Psychiatric symptoms* REM Behavior disorders
 | (35) |  |
| * Visual Hallucinations

Depression scales |  | *(29)* |
| * CES-D
 | (23) |  |
| * GDS
 | (1) | (5, 12, 13, 17, 18) |
| * MADRS
 | (2) |  |
| * Zung depression score
 |  | (25) |
| * HDRS
 |  | (8) |
| * BDI-II
 |  | (9) |
| Fear of falling* By questionnaire
 |  | (25) |
| * FES
* PDQ-39: Fear of falling
 | (24, 26, 27)(1, 6) | (8) |
| * ABC
 | (5, 18, 22, 26) | (11, 13, 17) |
| Fluctuations* Motor
 | (15) | (4, 15, 26) |
| * Cognitive
 | (36) |  |
| **Cognitive impairment** |  |  |
| Global impairment* MMSE total
 | (2, 10, 20, 27, 30) | (3-5, 7, 12, 13, 21, 23, 25, 26) |
| * MMSE orientation
 | (30, 32) |  |
| * SCOPA-Cog
 | (6) |  |
| * MoCA total
 |  | (9, 17, 22) |
| * Clinical Dementia Rating Scale
 | (34) |  |
| * CAMCOG score
 |  | (16, 28) |
| * NPI aberrant motor behavior
 |  |  |
| * Caregiver-reported
 |  | *(29)* |
| Frontal impairment* FAB
 | (20, 25, 30)  | (1, 32)  |
| * MMSE Attention/Concentration
 |  | (30) |
| * Power of attention
 | (14, 22) | (17) |
| * OTS
 |  | (17) |
| * TMT B-A
 |  | (9) |
| * MDRS-IP
 | (18) |  |
| Visuospatial impairment* MoCA visuospatial
 | (22) |  |
| * ADAS Constructions
 | (36) |  |
| Processing speed* SDMT total
 | (6) |  |
| * Cognitive reaction time
 | (14) |  |
| Memory impairment* Immediate/Delayed recall
 | (15) |  |
| * PRM
 |  | (17) |
| * SRM
 |  | (17) |
| * MMSE memory sub-score
 |  | (30) |
| Verbal impairment* Semantic fluency
 | (15) |  |
| * MMSE language
 | (30) |  |
| Dual-Tasking* By questionnaire
 | (27) |  |
| * Dual-motor task
 | (9) |  |
| * Motor-cognitive task
 |  | (9, 10) |
| **Activities of Daily Living/Quality of Life** |  |  |
| * UPDRS ADL sub-score
 | (3-8, 11, 24, 26) |  |
| * PDQ
 | (1, 15) | (17, 25) |
| * Schwab & English score
 | (11, 21, 24, 26) | (26) |
| * PADLS
 | (27) |  |
| * EQ-5D total
 | (6) |  |
| * SF8
 | (25) |  |
| * SADS
 | (8) |  |
| * Physical activity score
 | (28) |  |
| * Barthel scale
 | **(16)** |  |
| Use of assistive devices | (13) | (23) |
| **Other impairments** |  |  |
| * Visual
 | (20, 23) |  |
| * Proprioception
 | (30) | (1) |
| * Light touch
 |  | (20) |
| * Hand/foot reaction time
 |  | (20) |
| * Lower extremity strength
 | (20, 30) |  |

Studies assessing fall risk in PD were limited to prospective studies within the last 10 years. Those that compared frequent vs infrequent fallers: (4, 7, 10-13, 15, 16, 18, 24). Studies listed in **bold** assessed fall risk factors in DLB. The study listed in *italics* assessed fall risk factors in MSA.

ABC: Activities-Specific Balance Confidence scale; ADAS: Alzheimer’s disease assessment scale; BDI-II: Beck depression inventory II; CES-D: Center for epidemiological studies depression scale; EQ-5D: EuroQOL 5 dimensional questionnaire; FES: Falls efficacy scale; GDS: Geriatric depression scale; HDRS: Hamilton depression rating scale; HY: Hoehn and Yahr; MADRS: Montgomery and Asberg depression rating scale; MDRS-IP (Mattis dementia rating scale-initiation/perserveration subset; MMSE: Mini mental status exam;

MoCA: Montreal cognitive assessment; NPI: Neuropsychiatric inventory; OTS: One touch stocking of Cambridge;PADLS: Parkinson's disease activities of daily living scale; PDQ: Parkinson’s disease questionnaire; PRM: Pattern Recognition Memory; SADS: Self-Assessment disability scale (SADS); SCOPA-Cog: Scales for Outcomes in Parkinsons-Cognition; SDMT: Symbol digit modalities test; SRM: Spatial Recognition Memory; SF-8: Short-form health survey; TUG: Timed up-and-go.

**References:**

1. Voss TS, Elm JJ, Wielinski CL, Aminoff MJ, Bandyopadhyay D, Chou KL, Sudarsky LR, Tilley BC. Fall frequency and risk assessment in early Parkinson's disease. Parkinsonism and Related Disorders. 2012;18(7):837-41.

2. Hiorth YH, Alves G, Larsen JP, Schulz J, Tysnes OB, Pedersen KF. Long-term risk of falls in an incident Parkinson’s disease cohort: the Norwegian ParkWest study. Journal of Neurology. 2017;264(2):364-72.

3. Kerr GK, Worringham CJ, Cole MH, Lacherez PF, Wood JM, Silburn PA. Predictors of future falls in Parkinson disease. Neurology. 2010;75(2):116-24.

4. Matinolli M, Korpelainen JT, Sotaniemi KA, Myllylä VV, Korpelainen R. Recurrent falls and mortality in Parkinson's disease: A prospective two-year follow-up study. Acta Neurologica Scandinavica. 2011;123(3):193-200.

5. Mactier K, Lord S, Godfrey A, Burn D, Rochester L. The relationship between real world ambulatory activity and falls in incident Parkinson's disease: Influence of classification scheme. Parkinsonism & Related Disorders. 2015;21(3):236-42.

6. Chou KL, Elm JJ, Wielinski CL, Simon DK, Aminoff MJ, Christine CW, Liang GS, Hauser RA, Sudarsky L, Umeh CC, Voss T, Juncos J, Fang JY, Boyd JT, Bodis-Wollner I, Mari Z, Morgan JC, Wills AM, Lee SL, Parashos SA. Factors associated with falling in early, treated Parkinson's disease: The NET-PD LS1 cohort. Journal of the Neurological Sciences. 2017;377:137-43.

7. Lamont RM, Morris ME, Menz HB, McGinley JL, Brauer SG. Falls in people with Parkinson’s disease: A prospective comparison of community and home-based falls. Gait & Posture. 2017;55(April):62-7.

8. Gazibara T, Kisic Tepavcevic D, Svetel M, Tomic A, Stankovic I, Kostic VS, Pekmezovic T. Near-falls in people with Parkinson's disease: Circumstances, contributing factors and association with falling. Clinical Neurology and Neurosurgery. 2017;161(July):51-5.

9. Heinzel S, Maechtel M, Hasmann SE, Hobert MA, Heger T, Berg D, Maetzler W. Motor dual-tasking deficits predict falls in Parkinson's disease: A prospective study. Parkinsonism Relat Disord. 2016;26:73-7.

10. Smulders K, Esselink RA, Weiss A, Kessels RP, Geurts AC, Bloem BR. Assessment of dual tasking has no clinical value for fall prediction in Parkinson's disease. J Neurol. 2012;259(9):1840-7.

11. Cole MH, Rippey J, Naughton GA, Silburn PA. Use of a Short-Form Balance Confidence Scale to Predict Future Recurrent Falls in People With Parkinson Disease. Arch Phys Med Rehabil. 2016;97(1):152-6.

12. Mak MKY, Auyeung MM. The mini-bestest can predict parkinsonian recurrent fallers: A 6-month prospective study. Journal of Rehabilitation Medicine. 2013;45(6):565-71.

13. Mak MK, Pang MY. Parkinsonian single fallers versus recurrent fallers: different fall characteristics and clinical features. J Neurol. 2010;257(9):1543-51.

14. Allcock LM, Rowan EN, Steen IN, Wesnes K, Kenny RA, Burn DJ. Impaired attention predicts falling in Parkinson's disease. Parkinsonism & Related Disorders. 2009;15(2):110-5.

15. Parashos SA, Bloem BR, Browner NM, Giladi N, Gurevich T, Hausdorff JM, He Y, Lyons KE, Mari Z, Morgan JC, Post B, Schmidt PN, Wielinski CL. What predicts falls in Parkinson disease?: Observations from the Parkinson's Foundation registry. Neurol Clin Pract. 2018;8(3):214-22.

16. Ballard CG, Shaw F, Lowery K, McKeith I, Kenny R. The prevalence, assessment and associations of falls in dementia with Lewy bodies and Alzheimer's disease. Dement Geriatr Cogn Disord. 1999;10(2):97-103.

17. Lord S, Galna B, Yarnall AJ, Coleman S, Burn D, Rochester L. Predicting first fall in newly diagnosed Parkinson's disease: Insights from a fall-naïve cohort. Movement Disorders. 2016;31(12):1829-36.

18. Mak MK, Wong A, Pang MY. Impaired executive function can predict recurrent falls in Parkinson's disease. Archives of Physical Medicine and Rehabilitation. 2014;95(12):2390-5.

19. Allan LM, Ballard CG, Rowan EN, Kenny RA. Incidence and prediction of falls in dementia: a prospective study in older people. PLoS One. 2009;4(5):e5521.

20. Latt MD, Lord SR, Morris JGL, Fung VSC. Clinical and physiological assessments for elucidating falls risk in Parkinson's disease. Movement Disorders. 2009;24(9):1280-9.

21. Rudzinska M, Bukowczan S, Stozek J, Zajdel K, Mirek E, Chwala W, Wojcik-Pedziwiatr M, Banaszkiewicz K, Szczudlik A. The incidence and risk factors of falls in Parkinson disease: prospective study. Neurol Neurochir Pol. 2013;47(5):431-7.

22. Lord S, Galna B, Yarnall AJ, Morris R, Coleman S, Burn D, Rochester L. Natural history of falls in an incident cohort of Parkinson’s disease: early evolution, risk and protective features. Journal of Neurology. 2017;264(11):2268-76.

23. Sakushima K, Yamazaki S, Fukuma S, Hayashino Y, Yabe I, Fukuhara S, Sasaki H. Influence of urinary urgency and other urinary disturbances on falls in Parkinson's disease. J Neurol Sci. 2016;360:153-7.

24. Almeida LR, Valenca GT, Negreiros NN, Pinto EB, Oliveira-Filho J. Comparison of Self-report and Performance-Based Balance Measures for Predicting Recurrent Falls in People With Parkinson Disease: Cohort Study. Phys Ther. 2016;96(7):1074-84.

25. Kataoka H, Ueno S. Low FAB score as a predictor of future falling in patients with Parkinson's disease: a 2.5-year prospective study. J Neurol. 2015;262(9):2049-55.

26. Almeida LR, Sherrington C, Allen NE, Paul SS, Valenca GT, Oliveira-Filho J, Canning CG. Disability is an Independent Predictor of Falls and Recurrent Falls in People with Parkinson's Disease Without a History of Falls: A One-Year Prospective Study. J Parkinsons Dis. 2015;5(4):855-64.

27. Lindholm B, Hagell P, Hansson O, Nilsson MH. Prediction of falls and/or near falls in people with mild Parkinson's disease. PLoS One. 2015;10(1):e0117018.

28. McKeith IG, Perry RH, Fairbairn AF, Jabeen S, Perry EK. Operational criteria for senile dementia of Lewy body type (SDLT). Psychol Med. 1992;22(4):911-22.

29. Kollensperger M, Geser F, Ndayisaba JP, Boesch S, Seppi K, Ostergaard K, Dupont E, Cardozo A, Tolosa E, Abele M, Klockgether T, Yekhlef F, Tison F, Daniels C, Deuschl G, Coelho M, Sampaio C, Bozi M, Quinn N, Schrag A, Mathias CJ, Fowler C, Nilsson CF, Widner H, Schimke N, Oertel W, Del Sorbo F, Albanese A, Pellecchia MT, Barone P, Djaldetti R, Colosimo C, Meco G, Gonzalez-Mandly A, Berciano J, Gurevich T, Giladi N, Galitzky M, Rascol O, Kamm C, Gasser T, Siebert U, Poewe W, Wenning GK, Emsa SG. Presentation, diagnosis, and management of multiple system atrophy in Europe: final analysis of the European multiple system atrophy registry. Mov Disord. 2010;25(15):2604-12.

30. Paul SS, Sherrington C, Canning CG, Fung VS, Close JC, Lord SR. The relative contribution of physical and cognitive fall risk factors in people with Parkinson's disease: a large prospective cohort study. Neurorehabil Neural Repair. 2014;28(3):282-90.

31. Brandmeir NJ, Brandmeir CL, Kuzma K, McInerney J. A Prospective Evaluation of an Outpatient Assessment of Postural Instability to Predict Risk of Falls in Patients with Parkinson's Disease Presenting for Deep Brain Stimulation. Mov Disord Clin Pract. 2016;3(2):151-5.

32. Paul SS, Allen NE, Sherrington C, Heller G, Fung VS, Close JC, Lord SR, Canning CG. Risk factors for frequent falls in people with Parkinson's disease. J Parkinsons Dis. 2014;4(4):699-703.

33. Lindholm B, Nilsson MH, Hansson O, Hagell P. External validation of a 3-step falls prediction model in mild Parkinson's disease. J Neurol. 2016;263(12):2462-9.

34. Camicioli R, Majumdar SR. Relationship between mild cognitive impairment and falls in older people with and without Parkinson's disease: 1-Year Prospective Cohort Study. Gait and Posture. 2010;32(1):87-91.

35. Romagnolo A, Zibetti M, Merola A, Canova D, Sarchioto M, Montanaro E, Artusi CA, Vallelonga F, Maule S, Lopiano L. Cardiovascular autonomic neuropathy and falls in Parkinson disease: a prospective cohort study. J Neurol. 2019;266(1):85-91.

36. Kudo Y, Imamura T, Sato A, Endo N. Risk factors for falls in community-dwelling patients with Alzheimer's disease and dementia with Lewy bodies: walking with visuocognitive impairment may cause a fall. Dement Geriatr Cogn Disord. 2009;27(2):139-46.