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Original Research Article

Significancy of human motor tasks during dual gate execution for uncovering Parkinson disease early

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ABSTRACT

Background: Parkinson's, i.e., Parkinson diseased (PD) patients appear beyond decreased gait execution during motor dual cognitive task tests. Yet, the impact of motor cognition task difficulty in early detection of PD has not been seen scientifically.
Objective: the purpose is to detect the PD very early during the gait implementation of motor's dual-tsks.
Materials and Methods: Twenty-five advanced idiopathic Parkinson's also fourteen healthy controls recruited in this study. As per the neuroscientist, all must complete a composite motor-task with and without 3 distinct mental-tasks. Based on spatiotemporal gait parameters plus joint-kinematics, the interventional composite issue features were computed. The outcome of task complexity plus cohort over the complex task interference (CTI) was studied first with the continual (repetitive) measures analysis-of-variance (ANOVA). Support vector machine (SVM)-based classifiers of Parkinson's were constructed based on characterized features-of CTI.
Results: Our findings showed that the complexity of motor-issue has had a larger impact over gait accomplishment that much contributed to the advanced precision in categorizing Parkinson's. The set with accuracy (97.7%), precision (98.9%), and recall(97.7%) was attained best. This study showed the application of a rotary-based motor's dual task cognition idea of test in clinical settings to detect PD early is great.
Conclusion: This study investigated a new method for early detection of Parkinson's disease (PD) using a dual-task test with cognitive and motor components.

1. Introduction

Universal Parkinson's, i.e., patients with advanced idiopathic Parkinson disease(PD) generally demonstrate difficulty in gait and walking followed by the postural instability in and gait and walk difficulty (PIGD),[1,2] for instance, walking in difficulty and also very slow in speed-of the walk, reduced (very condensed during walk) stride(i.e., step)length plus declined and diminished range-of-motion in physiology of the lower limb joints and also hip joints.[3] Therefore, the more early diagnosis the more prevention, plus timely involvement are necessary for averting, medical checking, precluding, and preventing the PD progression as well as increasing the QoL of Parkinson's[4] patients. Nonetheless, the symptoms of PIGD may perhaps be numerous yet elusive at an early-stage of disease. Existing

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clinical procedures depend on the patients self-reports plus clinicians subjective evaluation of examinations and observations subjectively[5] which quite yields moderately, relatively, and reasonably in a high dogmatic approach also misdiagnosis rate-of Parkinson's early-stage disease. Therefore, concentration plus executive—management function play significant role within the Parkinson's motor controls and perceptual abilities.[6,7] The mental means and resourcefulness contest concerning the motor as well as activity of the mind issues like cognitive-tasks throughout cognitive test dual-tasks primes to a lesser extent, meaning that, control within the execution of motor (EoM), empowering early Parkinsonians to interpretation and representation of further impairments-of-gait and walk.[8]

Gait—analysis through optical-capture system (OCS), instrumented (i.e., the shoe equipped with some smart instrument in sole pad) gravity pathway have been widely used for the evaluation of irregular yet unusual gait and walk characteristics in Parkinsonians.[9] But, such systems are exclusive and pricy plus limited to the scientific laboratory environment for the objective evidence purposes. The Inertial measurement-unit(IMU) is a prospective key for the gait assessment because of its miniature-size, low—cost, bit low-price plus accuracy is high.[10] The models have been built to approximate the spatio temporal (or temporal-spatio) parameters of gait as well as joint—kinematics.[11] A researcher and his team study[12] explored the outcome-of-sensor positional point and feature—manifestations assortment over the Parkinsonians categorization and initiate that the feature—manifestations and the derived joint—range of signal was more with higher precision than those derived temporal-spatio (time domain –time and space) limits and/or parameters. A study by Trabasi and his team[13] demonstrated that support vector machine (S V M) proven supervised machine learning classification technique(MLCT) performance by associating and/or linking the several artificial intelligence-based supervised machine learning(SML) algorithmic techniques for the PD categorization plus individual normal healthy-controls via I M U derived feature—sets of gait and pathway. On the other hand, there was no efficient as well as systematic investigations of the dual cognitive task tests intricacy impact on supervised classification learning (SCL) of early Parkinson's and also elders with good health (older normal controls).

Earlier studies focused on the influences of resulting techniques of mental (cognition) tasks on Parkinson's gait functioning and thoroughly working on.[14] Another study by Brownand his team[15] demonstrated further diminished and reduced stride-length plus speed in Parkinson's whilst mental problem issue improved. Another researcher by name, Lordand his team[16] studied the impact of mental-task form associated distinctive 'cognitive-functions' on Parkinson's gait execution. Their findings demonstrated that the Parkinson's had the gradual and leisureliest walking speed through the continued care- adapted mental issues-tasks. Study[17] hinted that the deficit of gait generated through the dual cognition tests (i.e.,cognitive task tests) were akin not many limited functions of cognition but pretty and significantly overall decrease in the exclusive functions. Likewise, Parkinson's patients demonstrated more distinguished gait characteristics, for instance, gradual moving and strolling rate plus substantial turning angles, at chances attributable to condensed stability very energetically[18,19] signifying that the human motor-task issues like gait and walkway difficulty might be the not ignorable factor-and-feature in dual-cognitive-tasks (gait-and-walk) accomplishment. yet, the human motor role as well as cognitive task-issues difficulty for detecting the early Parkinson's disease patients neurodegenerative disorder is not investigated thoroughly.

Thus, we aim to first study–determine the paraphernalia of human motor controls and cognitive issues like task complexities on early Parkinsonians in which the complex human motor-tasks, like few meters distance, say 5 straight walk, with 180° turning onto left and 5meters straight walk and 180° turning onto right) was implemented with 3 diverse cognitive-issues like tasks, and also without the issues. A model-simulation[2,20] which was previously proposed inertial-based gait analysis technique used to estimate and guess the gait-walk temporal—spatio limits/parameters as well as kinematic—joints whilst complex-task-issue interferences (i.e.,CTIs)of unique yet characteristic limits and parameters of the gait-walk were computed to measure the task-complexities which induce on Parkinsonians gait-and-walk. And lastly, the Parkinson disease SVB-based classifiers are established plus evaluated amongst the diverse model dual-cognition-task issues.

2. Materials and Methods

2.1. Demographics

25Parkison's with advanced idiopathic Parkinson disease were employed in this study in a tertiary care hospital. The inclusion criterion is as follows: firstly, they were diagnosed as advanced idiopathic Parkinson disease(PD) and following the united kingdom(UK) Parkinson's Disease Society Brain Bank criteria, and H and Y score 2 to 3; age classification was between 58-76years, and lastly they were capable of performing the essential human cognition motor issues like dual-tasks models within the experimentation. 14age paired and normal-healthy-controls who are elders and voluntarily joined in the investigation as the normal cohorts. The study was approved by the ethics committee following the Helsinki principles. The participants were notified and updated approval received from them prior to the experimental investigation.

2.2. Experimentation procedure

All the subjects who were participants done 4 types of model tasks correspondingly, a single—take-task (STT) plus 3cognitive human-motor dual-cognitive task(DT) issues. Within the single motor—task model, one contestant is needed to do 5consecutive—laps of 5 meters walk straightly and 180° turning towards left and 5 meters walking straight, and taking left turning at 180° subsequent path at a person-contented step which can be seen in the following Figure 1 [A].

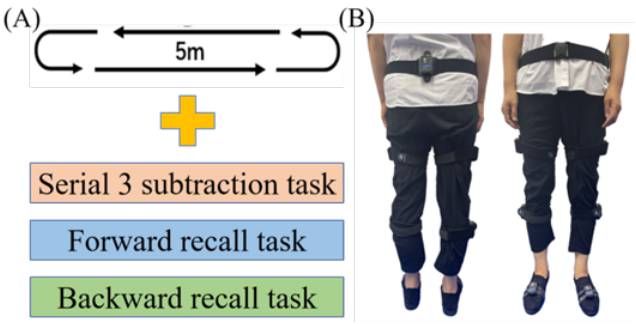

Figure 1: Set-Up of the experimental—investigation procedure. (**A**) Model paradigms of the investigation. (**B**) Point of the sensing-instrumented sensors

3cognitive-issues, correspondingly forward memory-task's' "F", back-ward "B", plus the successive-3 elimination-task, "S", were mutual though aforementioned human-motor task-issues which can be used as 3cognitive human-motor's dual-task-models (i.e., represented with 'DTF', 'DTB', plus 'DTS'). Cognitive task-issues implicated the application of mental—resources of the memory, meaning, short-term-memory, long-term functional-memory plus attentions towards working-functions. Before the experimental investigation, every subject, i.e., participant done the mental-tasks while sitting naturally and positioning for the task-issue adaptation and habituation plus trouble level fortitude.

The instrument was applied to determine the contestant's data whilst in motion which can be observed in Figure 1[B], 7I M U-sensors were targeted over the applicant's hips plus both the second joints o called thighs, the trunks that are shanks as well as pedes. The data of the 3D plus kinematics-of-joints were concurrently gathered with a rate of 100Hz sampling-frequency and mental-tasks accomplishment, like length in digital (means amplitudes), completing the digit plus accurateness, i.e., precision acquired.

2.3. Assessing the gait quantitatively (Gait assessment quantitatively)

Earlier developed model[2,20] was applied to guess and estimate the spatio—temporals of gait parameters, like(stride) step-length (STL), walk-speed (WAS), stride-time(SRT), the stance(ST) and followed by the swinging-time(SWT), plus the range-of-motion(RoM)of hip, the knee-joints, plus ankle—joints were computed correspondingly to walk-straight, turning-based dual-cognitive-task model-paradigms respectively. The C T I was planned for computing the impact of working-complexity over the gait-walk accomplishment contrasted to the electrical-baseline, i.e., the zero-line of the single straight walk task-issue[21]:

$$\text{C.T.Ii}\ (\ \%\ ) = \frac{C.T.i - S.W.i}{S.W.i} \times 100\% \ldots (1)$$

Where, the C.T.Ii yields the parameter value-of-gait, 'i' throughout the complicated model task, the S.W.i yields parameter value 'i' on the individual straight-walk task-issue.

2.4. Clinico—statistical analysis

The independent sample student t-test was employed for investigating the important transformations within the cognitive-mental task-issues accomplishment amongst the Parkinsonians and cohort of normal-controls. The clinic-statistical A N O V A was applied for determining the outcome of group (Parkinson's vs. normal controls)) plus the working-complexity on gait-and-walk accomplishment also many pair-wise differences assessed through Bonferroni procedural-strategy were employed then for exploring the important transformations within the gait-walk limits/or parameters amongst the task-issues as well as cohorts. Offline Mat Lab statistical software tools were used for execution. The standard p-vale was set at <0.05 for statistical significancy with chi-square more than 9 and with 2-degree freedom.

2.5. Supervised-learning SVM-based classification

The success of the human motor and sensory cognition dual-cognitive model task-issue for uncovering the Parkinson's at early-stage or predicting early was investigated further. Area under curve (A.U.C) values-of-receiver operating-characteristic (RoC) arcs of the C.T.I.i values werederived as of gait temporal-spatio plus kinematics-joint limits nd/orparameters were computed. The discriminatory C.T.I.i feature-manifestations (i.e.,A.U.C.. >.0.6) were decided on and then selected plus classified in to 6cohorts depending on the sequence of 2motor task-issues and through the 3cognitive task-issues. The parkinsonian-classifiers were made derived as of the S.V.M. through linear—kernel. The C-S.V.M was ultimately chosen through consent ace, i.e., single-out fractious-corroboration and/or justification. The categorization accomplishments were then matched amongst the dual-cognition-tasks-model issues.

3. Findings

We found no difference between the normal controls and subjects with Parkinson's disease cohorts in all the

Table 1: Clinicals characteristics and demographics of the population in the study

	HEG	PDC	P value
Age(years)	62.64(5.39)	68.24(5.27)	0.789
Gender(M/F)	5/9	11/14	0.625
Mass(kg)	62.05(5.01)	68.24(13.40)	0.047
Height(cm)	159.43(8.52)	164.20(8.12)	0.092
MoCA(score)	25.57(2.17)	24.40(2.12)	0.109
MMSE(score)	27.57(1.91)	27.40(1.50)	0.758
UPDRS(score)	-	19.80(10.43)	-
H&Y(score)	-	1.62(0.48)	-

aHEG - Healthy elderly group, PDC - ParkinsonDisease cohort, MoCA - Montreal Cognitive Assessment, MMSE - Mini-Mental State Examination, UPDRS - Unified-Parkinson Disease Rating Scale, H&Y - Hoehn-Yahr Stage.

Table 2: Findings of thereciprocal recurrent trials of the A N O V A of the gait—walk-parameters

Parameters (of Gait)	Task		Cohort		TaskxCohort	
	F	P	F	P	F	P
SRT(ms)	113.86	6.09E-73	1.21	0.27	3.39	1.40E-2
STT(ms)	119.79	1.92E-65	8.16	4.00E-3	3.77	1.20E-2
SWT(ms)	14.33	9.88E-15	21.31	5.00E-6	1.58	0.16
STL(cm)	1235.63	0.00	174.94	7.96E-35	4.22	1.00E-4
WAS(cm/s)	1374.04	0.00	135.36	4.29E-28	4.24	6.07E-4
PelvicTilt(Deg)	231.30	1.95E-156	18.56	2.1E-5	43.87	5.00E-35
PelvicObliquity(Deg)	46.80	3.47E-31	10.84	1.00E-3	7.38	3.30E-5
PelvicRotation(Deg)	354.50	6.5E-242	293.56	1.84E-49	84.18	6.10E-72
HipFlexion(Deg)	518.07	0.00	152.10	9.82E-30	7.57	2.00E-6
HipAbduction(Deg)	6.32	1.7E-5	1.04	0.31	11.49	3.10E-10
HipRotation Ext(Deg)	2431.03	0.00	130.60	2.77E-26	6.27	6.80E-5
KneeFlexion(Deg)	359.17	4.1E-281	125.61	1.84E-25	31.43	1.10E-31
AnkleDorsiflexion(Deg)	422.54	7.3E-305	33.91	1.21E-8	11.69	6.40E-11
AnkleInversion(Deg)	57.26	6.13E-60	37.76	1.98E-9	5.26	5.30E-5
AnkleAbduction(Deg)	69.71	1.17E-58	17.01	4.6E-5	3.80	3.00E-3

aSRT - stride time, STT - stance phase time, SWT - swing phase time, STL - stride length, WKS - walking speed

3 cognitive-issues-task accomplishments, which showed Parkinsonians early had a analogous and comparable level-of cognitive-working function through all the normal healthy controls. The A N O V A stat technique was applied to explore the variation within the performance-of the gait walk amid cohorts plus within the task-issues. From the Table 2, there were substantial contacts and the findings in all the temporal-spatio limits and parameters of the gait excluding the swinging-phase record or period as well as all the kinematic-joints R.o.M which was showed that the outcome of the task-issues difficulty might be numerous and possibly may be contingent over the cohorts.

The CTI results are shown in the following Figure 2 [A].

On observation, there was a reduction in C.T.I.s of the stride—lengths as well as speed-of the walk plus an upsurge within the C.T.I.s of the temporals parameters of gait. On comparison, reliable with preceding investigations' that while contestants did dual-tasks concurrently, the accomplishment over one or two-test-tasks would worsen because of more applications of resources pertaining to the cognition.[22] The dual-cognitive model test tasks derived the tasks-of-turnings have had the more impact over the gait-walkway accomplishment equated to individuals throughout straight gait-based straight dual-cognitive test walkway tasks, that was because of the connection amid dual-test-task motoric symptoms postural-instabilities as well as decision-making(executive) disfunctions within the Parkinsonians through the advanced idiopathic Parkinson disease was more distinct and noticeable whilst turning.[23] The C.T.I.s of the W.K.S, the S.R.T as well as the S.T.T within the Parkinson's cohorts in gait-walk straightly augmented subsequent the order of the D.T.F, the D.T.S also the D.T.B. The D.T.F has had meaningfully the minor C.T.I result than the D.T.B also the D.T.S whilst rotary, showing that the Parkinsonians were further intricate to the task—complexity. Alternatively, in contrast, the H.E.G didn't display or reveal considerably substantial transformation within the spatial temporal parameters of the gait amongst diverse dual tasks. Solitary the D.T.B.-T disclosed the substantial outcome over the augmented S.R.T as well as the S.T.T.

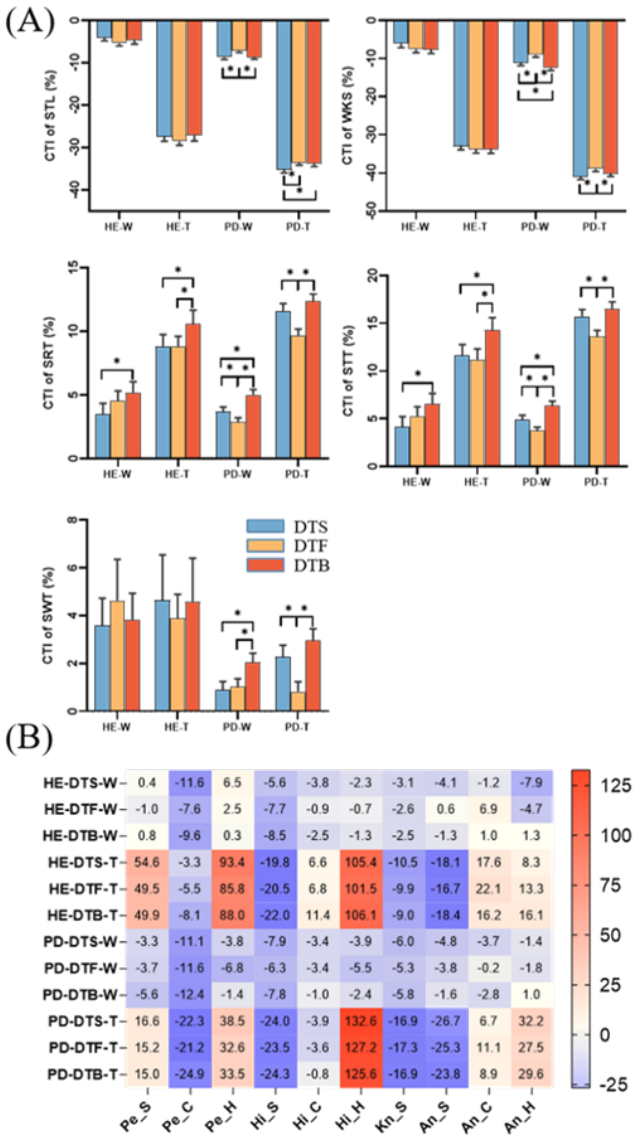

Figure 2: Findings of complex-task-interference (C.T.I) through the computation plus values-of-gait spatial temporal-parameters also R.o.Ms joint. [**A**]. Contrast of spatio temporals gait C.T.I in changed dual-cognitive-test-tasks. The* gives the difference of statical-significancy, [**B**]. The heat—map of the C.T.I of R.o.Ms joint-parameters of Parkinson's plus control cohorts throughout diverse dual-cognitive-test tasks in which the R.o.Ms joints of-pelvis(Pe),the hips(Hi), the knees (Kn) plus angles of ankles (An) within sagittal(S) plane, i.e., flat and smooth (horizontal), hydroplane, lei-coronal (C)plane as well as horizontal(H)planes were incorporated.

4. Discussion

Varied cortico basal-ganglion cerebellar-net work triggered through loss of dopamine neurons of Parkinsonians cause discrepancies within motoric automaticity also executive functions.[24] Thus in our observation, dual-test- tasks have had further asserted C.T.I effect related to direct gait-walk-based dual-test- tasks which are based-rotary (Figure 2 (B)). The PD cohort (PDC) demonstrated the important shrink in R.o.M.s of physiology-of-lower limb and joint-movements of sagittal plus has had enhanced R.o.M.s of joints very less next to two additional planes while turnings are contrasted to normal-cohorts. It's remarkable that 2cohorts demonstrated the opposite contrapositive, i.e., inverse or reverse alters within R.o.Ms of lumbar (pelvic) or sacral asynclitism and/or deceptiveness (i.e.,obliquity) whilst turns which indicates that the Parkinsonians might assume further moderate (conventional) motoric symptom postural—stability' symptomatic stratagem by dropping the movements of joints to balance or recompense for the decrease of accessible resources of cognition within motoric-control, that yields suggestion to provision the our theory/hypothesis which the dual-cognitive test-task model-simulation through the difficult density or intricacy that might additionally and supplementarily depict the gait-walkway discrepancies in Parkinsonians early. Yet, there was no regular development was seen in variations in the R.o.Ms joints throughout the dual-cognition test-tasks by 3 altered distinct cognitive— test-tasks, implying and indicating the total discrepancy in data and evidence (info) computing and process the procedural plus directive or rule-of-gait.[25] The motoric-task difficulty does matter further in the gait-walk implementation of Parkinsonians and with early Parkinson disease.

Beyond the classified C.T.I feature-manifestations of spatial (spatio) temporals of the gait–walk limits/parameters as well as kinematics-of the joints detected in rotary turns-based tasks like dual-test-tasks (the A.U.C is more than 6ss) contrasted to conventional square walk-based dual-cognition-test tasks as depicted in the Figure3. The stride step c.t.i. length as well as walk velocity has had fine classifying capability in all the dual-cognition-test tasks models, whilst for step-time (i.e.,stride) plus viewing angle-phase period that was depicted in D.T.S plus D.T.B only. While in turns-based dual-cognition-test tasks, the A.U. curve-values of the R.o.M.s joints and also C.T.Is were>0.6 in hips and pelvic-girdles, flexion-of-knee, plus ankle dorsi flexion angle's as of left and right. R.o.Ms joints and C.T.I of flexion-of-knee angle had a good sensitivity in identifying the early-stage PD group (AUC = 0.662 ~ 0.782) while those of right pelvis flexion and left pelvis rotation showed the greatest AUC values (Right Pe S: AUC > 0.762; Left Pe H: AUC > 0.743). The CTIs of joint RoM parameters showed higher sensitivity and specificity for distinguishing PDC and HEG. Confusion matrices of the SVM classifier

for cross-validation based on various dual-task tests are shown in TABLE III. We can see that the accuracy of all dual-task tests is above 82.2%. Features from the turning-based dual-task tests enhanced the performance of the SVM classifier with accuracy over 94.2%, recall rate over 96.2% and precision over 94.3%. However, there was no significant difference between the classification performance across three different cognitive tasks based on the same motor task. Our results could inform a clinical approach to the diagnosis of early-stage PD patients that focuses more on patient performance during complex motor tasks rather than cognitive tasks.

5. Conclusions

The diseased subjects displayed substantial decrease within the tep-length(of stride), speed of the walk plus Ro.M.s joints of the sagittal although enlarged very less joint—R.o.M.s, they were detected by the side of the coronal-plane (which divides the body into front and back) as well as straight/horizontal—planes during turn-based dual-task-tests. Feature-manifestations like C.T.Is as of turn-based dual-cognitive test-tasks that are promote to improving the categorization (i.e., machine learning supervised-classification) presentation of parkinsonians very early matched to direct gait-based dual-cognition-test –task tasks.

Our findings showed that the complexity of motor-issue has had a larger impact over gait accomplishment that much contributed to the advanced precision in categorizing Parkinson‘s. The set with accuracy (97.7%), precision (98.9%), and recall (97.7%) was attained best. This study showed the application of a rotary-based motor‘s dual task cognition idea of test in clinical settings to detect PD early is great.

6. Source of Funding

None.

7. Conflict of Interest

None.

References

1. Ahrweiller K, Houvenaghel J, Riou A, Drapier S, Sauleau P, Haegelen C, et al. Postural instability and gait disorders after subthalamic nucleus deep brain stimulation in parkinson's disease: A pet study. *J Neurol*. 2019;266(11):2764–71.
2. Ren J, Hua P, Li Y, Pan C, Yan L, Yu C, et al. Comparison of three motor subtype classifications in de novo parkinson's disease patients. *Front Neurol*. 2020;11:601225. doi:10.3389/fneur.2020.601225.
3. Rusz J, Krupicvka R, Vítečková S, Tykalová T, Novotný M, Novák J, et al. Speech and gait abnormalities in motor sub- types of de-novo parkinson's disease. *CNS Neurosci Ther*. 2023;29(8):2101–10.
4. Parnetti L, Gaetani L, Eusebi P, Paciotti S, Hansson O, El-Agnaf O, et al. Csf and blood biomarkers for parkinson's disease. *Lancet Neurol*. 2019;18(6):573–86.
5. Tolosa E, Garrido A, Scholz SW, Poewe W. Challenges in the diagnosis of parkinson's disease. *Lancet Neurol*. 2021;20(5):385–97.
6. Kang SH, Kim J, Lee J, Koh SB. Mild cognitive impairment is associated with poor gait performance in patients with parkinson's disease. *Front Aging Neurosci*. 2022;14:1003595. doi:10.3389/fnagi.2022.1003595.
7. Wu T, Hallett M, Chan P. Motor automaticity in parkinson's disease. *Neurobiol Dis*. 2015;82:226–34. doi:10.1016/j.nbd.2015.06.014.
8. Johansson H, Folkerts AK, Hammarström I, Kalbe E, Leavy B. Effects of motor-cognitive training on dual-task performance in peo- ple with parkinson's disease: a systematic review and meta-analysis. *J Neurol*. 2023;270(6):2890–907.
9. Zanardi APJ, Silva ES, Costa RR, Passos-Monteiro E, Santos IO, Kruel LFM, et al. Gait parameters of parkinson's disease compared with healthy controls: A systematic review and meta-analysis. *Sci Rep*. 2021;11(1):752. doi:10.1038/s41598-020-80768-2.
10. Ullrich M, cke AM, derle AK, Roth N, Gladow T, Gaßner H, et al. Detection of unsupervised standardized gait tests from real-world inertial sensor data in parkinson's disease. *IEEE Trans Neural Syst Rehabil Eng*. 2021;29:2103–11. doi:10.1109/TNSRE.2021.3119390.
11. Yang S, Li Q. Inertial sensor-based methods in walking speed estimation: A systematic review. *Sensors*. 2012;12(5):6102–6116.
12. Caramia C, Torricelli D, Schmid M, Munoz-Gonzalez A, Gonzalez-Vargas J, Grandas F, et al. Imu-based classification of parkin- son's disease from gait: A sensitivity analysis on sensor location and feature selection. *IEEE J Biomed Health Inform*. 2018;22(6):1765–74.
13. Trabassi D, Serrao M, Varrecchia T, Ranavolo A, Coppola G, De Icco R, et al. Machine learning approach to support the detection of parkinson's disease in imu-based gait analysis. *Sensors*. 2022;22(10):3700. doi:10.3390/s22103700.
14. Raffegeau TE, Krehbiel LM, Kang N, Thijs FJ, Altmann LJ, Cauraugh JH, et al. A meta-analysis: Parkinson's disease and dual-task walking. *Parkinsonism Relat Disord*. 2019;62:28–35. doi:10.1016/j.parkreldis.2018.12.01.
15. Brown LA, De Bruin N, Doan JB, Suchowersky O, Hu B. Novel challenges to gait in parkinson's disease: the effect of concurrent music in single-and dual-task contexts. *Arch Physical Med Rehabil*. 2009;90(9):1578–83.
16. Lord S, Rochester L, Hetherington V, Allcock LM, Burn D. Executive dysfunction and attention contribute to gait interference in 'off'state parkinson's disease. *Gait Posture*. 2010;31(2):169–74.
17. Penko AL, Streicher MC, Koop MM, Dey T, Rosenfeldt AB, Bazyk AS, et al. Dual-task Interference Disrupts Parkinson's Gait Across Multiple Cognitive Domains. *Neuroscience*. 2018;379:375–82. doi:10.1016/j.neuroscience.2018.03.021.
18. Mellone S, Mancini M, King LA, Horak FB, Chiari L. The quality of turning in parkinson's disease: a compensatory strategy to prevent postural instability? *J Neuroeng Rehabil*. 2016;13:39. doi:10.1186/s12984-016-0147-4.
19. Mitchell T, Conradsson D, Paquette C. Gait and trunk kinematics during prolonged turning in parkinson's disease with freezing of gait. *Parkinsonism Relat Disord*. 2019;64:188–93. doi:10.1016/j.parkreldis.2019.04.011.
20. Yang Y, Chen L, Pang J, Huang X, Meng L, Ming D, et al. Validation of a spatiotemporal gait model using inertial measurement units for early-stage parkinson's disease detection during turns. *IEEE Trans Biomed Eng*. 2022;69(12):3591–600.
21. Bock O. Dual-task costs while walking increase in old age for some, but not for other tasks: an experimental study of healthy young and elderly persons. *J Neuroeng Rehabil*. 2008;5(1):27. doi:10.1186/1743-0003-5-27.
22. Raffegeau TE, Krehbiel LM, Kang N, Thijs FJ, Altmann LJ, Cauraugh JH, et al. A meta-analysis: Parkinson's disease and dual-task walking. *Parkinsonism Relat Disord*. 2019;62:28–35. doi:10.1016/j.parkreldis.2018.12.012.
23. Sarasso E, Gardoni A, Piramide N, Volonte MA, Canu E, Tettamanti A, et al. Dual-task clinical and functional mri correlates in parkinson's disease with postural instability and gait disorders. *Parkinsonism Relat Disord*. 2021;91:88–95. doi:10.1016/j.parkreldis.2021.09.003.

24. Wu T, Hallett M, Chan P. Motor automaticity in parkinson's disease. *Neurobiol Dis*. 2015;82:226–34. doi:10.1016/j.nbd.2015.06.014.
25. Penko L, Streicher MC, Koop MM, Dey T, Rosenfeldt AB, Bazyk S, et al. Dual-task interference disrupts parkinson's gait across multiple cognitive domains. *Neuroscience*. 2018;379:375–82. doi:10.1016/j.neuroscience.2018.03.021.

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