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Determinants of patient-reported functional mobility in people with Parkinson's disease: A systematic review☆

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ABSTRACT

Background: Information on determinants of patient-reported functional mobility is lacking but would inform the planning of healthcare, resources and strategies to promote functional mobility in people with Parkinson's disease (PD).
Research question: To identify the determinants of patient-reported functional mobility of people with PD.
Methods: Eligible: Randomized Controlled Trials, cohort, case-control, or cross-sectional analyses in people PD without date or setting restrictions, published in English, German, or French. Excluded: instruments with under 50 % of items measuring mobility. On August 9th 2023 we last searched Medline, CINAHL and PsychInfo. We assessed risk of bias using the mixed-methods appraisal tool. Results were synthesized by tabulating the determinants by outcomes and study designs.
Results: Eleven studies published 2012–2023 were included (most in Swedish outpatient settings). Samples ranged from 9 to 255 participants. Follow-up varied from 1.5 to 36 months with attrition of 15–42 %. Heterogenic study designs complicated results synthesis. However, determinants related to environment seem to associate the strongest with patient-reported functional mobility, although determinants related to body structures and functions were most investigated. We identified disease duration, the ability to drive, caregiving, sex, age, cognitive impairment, postural instability and social participation as determinants of patient-reported functional mobility.
Discussion: Methodological quality of the studies was limited. No study reported an a priori power calculation. Three studies controlled for confounders. The included studies lack representativeness of the population of people living with PD. Standardized sets of outcomes could enable more systematic research synthesis.
Conclusions: Future research should focus on activities, participation and environmental factors and improve methodological quality.

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1. Introduction

Parkinson's disease (PD) is a highly complex neurodegenerative disorder, resulting in a wide variety of motor and non-motor symptoms, negatively impacting physical function and quality of life [1–3]. In their narrative reviews, Tosserams, de Vries, Bloem and Nonnekes [1], Bouca-Machado, Maetzler and Ferreira [4] illustrated that reduced functional mobility has important consequences for the participation of people with PD at home, at work, or within the community. Functional mobility is defined as moving independently and safely in different environments in order to accomplish functional activities or tasks and to participate in activities of daily living (ADL) at home, work and in the community [4]. To measure functional mobility in these different settings, a patient-reported measure (i.e., a report of the status of a patient's health condition that comes directly from the patient without interpretation of the patient's response by a clinician or anyone else" [5]) is a practical, less costly and invasive measurement approach than the administration of objective, physical performance tests. Notably, such Patient-Reported Outcome Measures (PROMs) provide patients' perspectives and are often the outcomes of most importance to patients [6]. Moreover, patient-reported functional mobility takes into account subjective and underlying factors that might not be captured by objective measurements alone. Thus, it provides insight into functional mobility in daily life and acknowledges that each patient's experience of mobility is unique. Finally, understanding determinants associated with functional mobility from the perspective of people with PD enables healthcare providers to tailor interventions to the needs of people with PD by addressing the aspects that matter most to them. While recent longitudinal analyses by Lindh-Rengifo, Jonasson, Ullen, Mattsson-Carlgren and Nilsson [7] indicated perceived balance while dual-tasking and global cognitive functioning could predict patient-reported functional mobility, comprehensive overviews of the determinants of patient-reported functional mobility are unfortunately lacking. Such analyses could help direct future research and lend insight into the determinants associated with functional mobility as experienced and reported by the people living with the disease.

Consequently, our objective was to systematically review the literature to answer the following question: What are the determinants of patient-reported functional mobility of people with typical PD? We intentionally refrained from distinguishing a priori between exposures (determinants with a causal role for functional mobility) and factors co-occurring or associated with functional mobility to allow for a broad overview.

2. Methods

The review was carried out according to the Joanna Briggs Institute reviewers' manual [9]. In writing this review we adhered to the PRISMA 2020 reporting guideline [10]. A completed PRISMA checklist is included as supplement 1. The review protocol is publicly available in the OSF-registry (https://osf.io/8ugb7) [11]. A table in the supplement documents five deviations from the protocol.

2.1. Eligibility criteria

We included studies assessing determinants of patient-reported functional mobility in randomized controlled trials (RCTs), cohort, case-control, or analytical cross-sectional study designs in people with typical PD or Parkinson's disease dementia (PDD) without date, setting or culture restrictions, published in English, German, or French language. Studies with less than 50 % of items measuring mobility as an activity or function, according to the ICF definitions, were excluded. In- and exclusion criteria are presented in Table 1. Further definitions and information regarding these criteria can be found in the protocol [11].

2.2. Information sources and search strategy and selection process

We developed literature search strategies using medical subject

Table 1
In- and exclusion criteria.

	Components		Inclusion	Exclusion
Content	P	Population	People with typical PD or PDD	People with atypical PD or other diseases
	E	Exposure	Modifiable and non-modifiable determinants	-
	O	Outcome	**Patient-reported mobility measured as with at least 50 % of the items as an activity** Activity is defined as "The execution of a task or action by an individual" [12]: • Changing basic body position (D410) • Transferring oneself (D420) • Lifting and carrying objects (D430) • Walking (D450) • Going up and down stairs (D451) • Moving around in different locations (D460), using equipment (D465) using transportation (D470) • Driving (D475) **Instruments assessing mobility as an activity** • Life Space Assessment (LSA) • Walk-12 G	**Mobility measured as body function** Function Is defined as "The physiological functions of body systems (including psychological functions)" [12]: • Clinically based tests, physiological tests • Performance measure • Gait quantification methods [13] • No patient-reported instruments • Clinician or caregiver reported instruments, observations • Instruments measuring following activities • Maintaining body position (D415) • Moving objects with lower extremities (D435) • Hand and arm use (D445) • Fine hand use (D430), fine foot use (D446) • Moving around by means other than walking (D455) • Riding animals for transportation (D480)
Form	**Types of evidence sources**		**Studies assessing the statistical association of one or several factors with the defined outcome** • Randomized controlled trials • Prospective and retrospective cohort studies • Case-control studies • Analytical cross-sectional studies	• Commentaries • Conference abstracts • Descriptive study designs (case reports, case series) • Editorials, letters • Study protocols • Instrument validation studies
	Publication		No restrictions	No restrictions
	Timeframe		No restrictions	No restrictions
	Language		English, German, French	Other languages
	Setting		No restrictions	No restrictions
	Culture		No restrictions	No restrictions

Note. Codes, e.g., D410, according to the ICF-classification included.

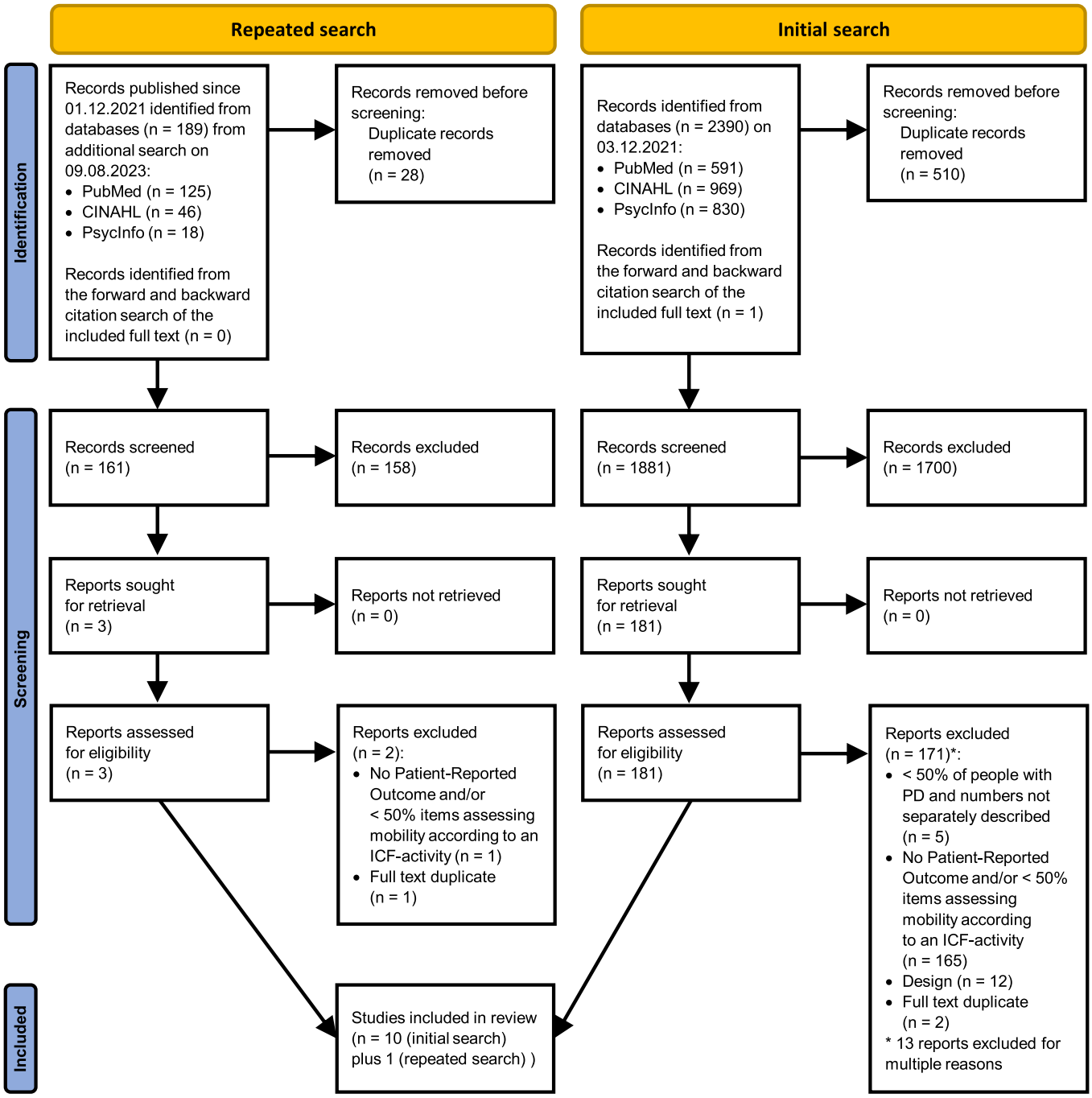

Fig. 1. PRISMA flowchart.

headings (MeSH) and text words related to functional mobility. The full search strategies for all databases can be found in the supplement. On 3rd of December 2021 we searched Medline (PubMed interface, 1946 onwards), CINAHL (EBSCO host interface, 1976 onwards), and PsycINFO (EBSCO host interface, 1894 onwards). We applied the Joanna Briggs Institute (JBI) three-step search strategy in consultation with an information specialist and Health Sciences Librarian with expertise in systematic review searching to locate etiology and risk data [8,14,15]. We performed a manual backward citation search (using reference lists) and a forward citation search on 31st of May 2022 in the Web of Science database (Clarivate interface, 1900 onwards). We repeated the search on August 9th 2023 to ensure a current representation of the literature. We included papers regardless of the peer review practice of the journal. Title / abstract screening and full-text screening were independently performed by two reviewers. Any disagreements were solved by discussion and consensus. The software CADIMA [16] and EndNote (version 9.3.3, Clarivate, UK) were used for the management and documentation of the results.

2.3. Data collection process and items

Data was collected by one reviewer according to an excel template of the standardized data extraction instrument provided by Moola, Munn, Tufanaru, Aromataris, Sears, Sfetcu, Currie, Lisy, Qureshi, Mattis and Mu [8], supplemented by the STROBE reporting guideline checklist. A second reviewer checked the completed data extraction forms. Regarding the outcome of patient-reported functional mobility, data of instruments were included if at least 50 % of the items assessed the

Table 2
Study characteristics – cohort study.

Citation (Year)	Objectives	Country Setting	Baseline sample size N Female n (%)	Follow-up sample size n (%)	Follow-up (months) Attrition n (%)	Age mean (SD)	Disease Stage (H&Y) median (q1 - q4)	Years since diagnosis median (q1 - q4)	(MDS) UPDRS III median (q1 - q4)	Cognition mean (SD)	Functional mobility mean (SD)	Functional mobility as primary outcome	Functional mobility mean (SD)	Determinants included in the study
Lindh-Rengifo, Jonasson, Ullen, Mattsson-Carlgren and Nilsson [7] (2021)	To investigate how perceived walking difficulties evolve over a 3-year period in people with PD To identify predictive factors of perceived walking difficulties.	Sweden Outpatient	255 49 (19 %)	148 (58 %)	36 107 (42 %)	67.9 (8.92)	2 (2–3)	8 (5–11)	UPDRS: 28 (NR)	MoCA: 25.7 (3.1)	Walk-12 G 14.8 (10.8)	✓	Walk-12 G 14.8 (10.8)	Body structures and functions: Perceived balance problem while dual tasking, Global Cognition (MoCA), Pain, Postural instability, Fatigue (NHP Energy), Worse lower extremity function, Personal: Age, Activities and participation: Walk-12 G Baseline

Note. NR = Not reported; Hoehn and Yahr (H&Y) range: 0–5, higher = worse.
Movement Disorders Society Unified Parkinson's Disease Rating Scale part III (MDS-UPDRS III) range: 0–132, higher = worse.
Unified Parkinson's Disease Rating Scale part III (UPDRS III) range: 0–108, higher = worse.
Montreal Cognitive Assessment (MoCA) range: 0–30, higher = better.
Mini Mental State Examination (MMSE) range: 0–30, higher = better.
Walk-12 G range: 0–42, higher = worse.
University of Alabama at Birmingham Life Space Assessment (UAB LSA) range: 0–120, higher = better.

component of patient-reported mobility in the form of activity (e.g., an execution of a task or action by an individual). The protocol [11] provides definitions and examples of included items according to the ICF [12]. In addition, data was sought for relevant study details (i.e., sample size, study inclusion and exclusion criteria, years of follow-up, information related to missing data, recruitment procedures, statistical technique(s), study outcome and determinant measurements, as well as effect sizes, p-values, and confidence intervals). In case of missing information for this relevant study details reviewers contacted authors of primary sources or reviews for further information.

2.4. Study risk and reporting bias assessment

Due to the heterogeneity of study designs, we used the mixed-methods appraisal tool (MMAT) for risk of bias assessment [17] instead of the Joanna Briggs Institute critical appraisal tools [8] mentioned in our preregistration. Neither assessments of meta-bias(es) (e.g., publication bias across studies, selective reporting within studies), nor of the strength of the body of evidence (e.g., Grading of Recommendations, Assessment, Development and Evaluations (GRADE)) were performed.

2.5. Effect measures and synthesis methods

In the absence of the authors reply, numbers were extracted using the WebPlotDigitizer [18]. To calculate Cohen's d and their 95 % CIs with the meta-analysis effect size calculator [19], we used the reported pre- and post-intervention mean values for Harrison, Earhart, Leventhal, Quinn and Pietro [20], while for Leavy, Joseph, Löfgren, Johansson, Hagströmer and Franzén [21] we used the reported between-group differences of changes from baseline and standard deviation. Finally, from Olsson, Franzén and Johansson [22], we used the pre- / post-intervention mean values and standard error values. As confidence intervals were not reported for almost all studies reporting standardized regression coefficients [7,23,24], the missing 95 % CIs in the studies of Lindh-Rengifo, Jonasson, Ullen, Mattsson-Carlgren and Nilsson [7] and Rantakokko, Iwarsson, Slaug and Nilsson [23] were calculated by the equation: *upper or lower CI* $*$ *standardised beta*/*beta*, while for the study of Ryder-Burbidge, Wieler, Nykiforuk and Jones [24] we applied the equation *standardised beta* $+$ *or* $-$ $(1.96 * standard\ error)$. No calculations for Dutra, Soares, Artigas, Pereira, Krimberg, Ovando, Schuh and de Mello Rieder [25] were possible due to missing information. Due to obvious variation in outcomes, study designs and determinants, no heterogeneity and subgroup analyses were performed. However, we tabulated the determinants by outcomes and study designs to promote comparability.

3. Results

3.1. Study selection

After searching three databases, a total of 2390 records were identified, with one additional article identified through forward citation searching. After removing 510 duplicates and examining 1881 titles and abstracts, 181 potentially relevant articles were retained. We assessed the full text of 181 articles and 10 were finally included in the systematic review [7,20–24,26–29]. While most articles (165 / 171) did not examine patient-reported outcome measures (PROMs) and/or less than 50 % of their items assessed mobility, some articles (13 / 171) were excluded due to multiple reasons. Finally, data for only two outcome measures fulfilling the in- and exclusion criteria were included: Walk-12 G [30] and the UAB Life-Space Assessment [31,32]. While the higher the Walk-12 G, the worse the functional mobility, the opposite is true for the UAB Life-Space Assessment. The repeated literature search in August 2023 identified one additional study published since December 1st 2021 [25]. The PRISMA flowchart in Fig. 1 illustrates the

Table 3
Study characteristics – controlled trial and pre-post study design.

Citation (Year)	Objectives	Country Setting	Baseline sample size N Female n (%)	Follow-up sample size n/N (%)	Follow-up (months) Attrition n/N (%)	Age mean (SD)	Disease stage (H&Y) n (%) per stage	Years since diagnosis mean (SD)	(MDS) UPDRS III mean (SD)	Cognition Median (Range)	Functional mobility mean (SD)	Functional mobility as primary outcome	Determinants included in the study
Controlled trial study design													
[21] (2020)	To assess the clinical effectiveness of the adapted HiBalance program on balance control and gait among people with PD.	Sweden Reha-bilitation	117 I: 33/61 (54 %) C: 22/56 (39 %)	99 (85 %)	10 19 (16 %)	I: 70 (8.5) C: 70 (6.5)	I: H&Y 2: 28/61 (46 %) I: H&Y 3: 33/61 (54 %) C: H&Y 2: 20/56 (36 %) C: H&Y 3: 36/56 (64 %)	I: 6.6 (5.1) C: 8.0 (5.8)	NR	NA	Walk-12 G: I: 15.5 (7.5) C: 12 (7.3)	×	Activities and participation: HiBalance program Body structures and functions: TMT-B
Pre-post study design													
[26] (2014)	To assess the impact of STN DBS on life-space mobility and Quality of Life	Canada Hospital	20 7 (35 %)	20 (100 %)	NA 0 (0 %)	57.2 (7.7)	NR	11.3 (3.7)	UPDRS: 18.5 (11)	NR	UAB LSA: NR	✓	Environment: Subthalamic Stimulation
[20] (2020)	To determine the effectiveness of a targeted dance intervention to improve walking speed for people with PD by increasing motor motivation.	USA Out-patient	10_a 3 (30 %)	11/14 (79 %)	1.5 3/14 (21 %)	69 (8)	H&Y 2: 6 (60 %) H&Y 2.5: 3 (30 %) H&Y 3: 1 (10 %)	6 (3)	MDS-UPDRS: 29 (12)	MMSE: 28 (26–29)	UAB LSA: 68 (35)	×	Activities and participation: Contemporary dance
[22] (2020)	To investigate feasibility and effect of table tennis training on balance control and physical function in people with PD.	Sweden Out-patient	9 4 (44 %)	8 (89 %)	2.5 2 (22 %)	66.9 (5.5)	H&Y 2: 8 (89 %) H&Y 2.5: 1 (11 %)	8.6 (4.9)	UPDRS: 23 (11)	NR	Walk-12 G: 10.9 (2.3)	×	Activities and participation: Table Tennis

Note. NR = Not reported, NA = Not applicable, I = Intervention, C = Control, Hoehn and Yahr (H&Y) range: 0–5, higher = worse.
Movement Disorders Society Unified Parkinson's Disease Rating Scale part III (MDS-UPDRS III) range: 0–132, higher = worse.
Unified Parkinson's Disease Rating Scale part III (UPDRS III) range: 0–108, higher = worse.
Montreal Cognitive Assessment (MoCA) range: 0–30, higher = better.
Mini Mental State Examination (MMSE) range: 0–30, higher = better.
Walk-12 G range: 0–42, higher = worse.
University of Alabama at Birmingham Life Space Assessment (UAB LSA) range: 0–120, higher = better [a] = *participants* included *in final analyses*.

Table 4
Study characteristics – cross-sectional study design.

Citation (Year)	Objectives	Country Setting	Sample size N Female n (%)	Age mean (SD)	Disease Stage (H&Y) n (%) per stage	Years since diagnosis mean (SD) or median (q1 - q4)	(MDS) UPDRS III mean (SD)	Cognition mean (SD) or median (q1 - q4)	Functional mobility (FM) mean (SD) or median (q1 - q4)	Functional mobility as primary outcome	Determinants included in the study
[27] (2018)	To investigate the relationship between patient-reported walking difficulties (Walk- 12 G) and performance-based walking in laboratory and free-living conditions.	Sweden Outpatient	49 28 (57 %)	75 (5.9)	HY 2: 22 (45 %) HY 3: 27 (55 %)	6 (3–9)	UPDRS: 40 (10.9)	MMSE: 28 (27–29)	Walk-12 G: 12 (7–20)	×	Activities and participation: Habitual walking - Steps per day in free-living conditions
[28] (2012)	To explore the potential contributions of motor, non-motor, and demographic factors, as well as complications of drug therapy, on fear of falling among people with PD.	Sweden Hospital	154 62 (40 %)	70 (9.1)	NR	6 (5.4)	NR	NR	Walk-12 G: 13 (6–23)	×	Body structures and functions: Fear of falling (FES)
[23] (2019)	To describe life-space mobility and explore associations of motor and non-motor symptoms with life-space mobility in people with people with PD.	Sweden Outpatient	164 58 (35 %)	71.6 (8.9)	H&Y 1: 10 (6 %) H&Y 2: 69 (42 %) H&Y 3: 37 (23 %) H&Y 4: 39 (24 %) H&Y 5: 10 (7 %)	NR	UPDRS: 31.4 (16.7)	MoCA: 25.1 (4.0)	UAB LSA: 72.3 (28.8)	✓	Activities and participation: Walk-12 G, Timed Up and Go Body structures and functions: UPDRS III, Freezing of Gait (FOGQ), Depression (GDS-15), Pain, Fatigue (NHP Energy), Global cognition (MoCA)
[24] (2022)	To explore individual, social and environmental factors that impact life-space mobility in PD.	Canada Outpatient	113 45 (40 %)	71.2 (9.0)	NR	NR	NR	NR	UAB LSA: 64.2 (25.8)	✓	Personal: Age, Sex Environmental: No driver's license, Receiving caregiving, No extra money in the house, Activities and participation: Social participation index Health Conditions: Respiratory condition
[29] (2021)	To determine the extent to which walking activity might contribute to total life-space mobility.	NR	69 29 (42 %)	67.5 (8.7)	H&Y 2: 27 (39 %) H&Y 2.5: 30 (43 %) H&Y 3: 12 (17 %)	NR	NR	NA	UAB LSA: Mean: 92 IQR: 42.25	✓	Activities and participation: Daily walking activity (StepWatch 4 Activity Monitor)
[25] 2023	To explore the relationship between life space mobility, self-efficacy, and balance.	Brasil Hospital	88 40 (45.5 %)	63.2 (10.5)	H&Y 1: 15 (17.0 %) H&Y 2: 42 (47.7 %) H&Y 3: 21 (23.9 %) H&Y 4: 10 (11.9 %)	9.0 (6.0)	MDS-UPDRS: 85.1 (31.2 %)	MoCA: 26.0 (23.0–35.0)	UAB LSA: 65.2 (22.8)	✓	Personal: Age, Sex Body structures and functions: MDS-UPDRS, Global cognition (MoCA), Depression (BDI-II) Health Conditions: Disease duration, Motor subtypes

Note. NR = Not reported, NA = Not applicable, Hoehn and Yahr (H&Y) range: 0–5, higher = worse.
Movement Disorders Society Unified Parkinson's Disease Rating Scale part III (MDS-UPDRS III) range: 0–132, higher = worse.
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Montreal Cognitive Assessment (MoCA) range: 0–30, higher = better.
Mini Mental State Examination (MMSE) range: 0–30, higher = better.
Walk-12 G range: 0–42, higher = worse.
University of Alabama at Birmingham Life Space Assessment (UAB LSA) range: 0–120, higher = better.

Table 5
Overview of investigated potential determinants of patient-reported functional mobility.

ICF categories [34]	Investigated determinant	Sources
Health condition		
	Respiratory condition	[24]
	Disease duration	[25]
	Motor subtype	[25]
Body functions and structures		
Body functions are the physiological functions of body systems (including psychological functions).	MDS-UPDRS	[25]
Body structures are anatomical parts of the body such as organs, limbs and their components.	**Motor symptoms**	
	Clinician-assessed motor symptoms (MDS-UPDRS III)	[23]
	Freezing of Gait	[23]
	Perceived balance problem while dual tasking	[7]
	Postural instability	[7]
	Worse lower extremity function	[7]
	Non-motor symptoms	
	Depression	[23,25]
	Fatigue	[7,23]
	Fear of falling	[28]
	Global cognitive cognition	[7,23, 25]
	Pain	[7,23]
	TMT-B	[21]
Activities and participation		
Activity is the execution of a task or action by an individual.	Contemporary dance	[20]
Participation is involvement in a life situation	HiBalance program	[21]
	Social participation	[24]
	Steps per day in free-living conditions	[27,29]
	Table tennis	[22]
	Timed up and Go	[23]
Environmental factors		
Environmental factors make up the physical, social and attitudinal environment in which people live and conduct their lives.	No driver's license	[24]
	No extra money in the house	[24]
	Receiving caregiving	[24]
	Subthalamic stimulation	[26]
Personal factors		
Personal factors are the particular background of an individual's life and living, and comprise features of the individual that are not part of a health condition or health states. These factors may include gender, race, age, other health conditions, fitness, lifestyle, habits, upbringing, coping styles, social background, education, profession, past and current experience (past life events and concurrent events), overall behavior pattern and character style, individual psychological assets and other characteristics, all or any of which may play a role in disability at any level.	Age	[7,24, 25]
	Sex	[24,25]

process of source selection and the reasons for exclusion. We excluded the cross-sectional study by Kader, Ullen, Iwarsson, Odin and Nilsson [33] as they analyzed the baseline data of the longitudinal study by Lindh-Rengifo, Jonasson, Ullen, Mattsson-Carlgren and Nilsson [7].

3.2. Study characteristics

Tables 2–4 provide an overview of the included studies and their characteristics. Details of the excluded full text sources as well as their exclusion criteria can be found on the project page (https://osf.io/jcqzr/).

3.3. Study design, outcomes, and determinants assessment

A total of eleven studies, including one controlled trial [21], three pre-post studies [20,22,26], one prospective cohort study [7] and five cross-sectional studies [23–25,27–29] published between 2012 and 2022, were included in this review. Most (6/11) were conducted in

Table 6
Summary of the methods and results of the included controlled trials and pre-post study designs.

Citation (Year)	Examined intervention	Functional mobility mean (SD)	Statistical analysis	Effect measure	Effect size (Confidence interval (95 %)	p-value	Sample size	Power calculation reported
UAB LSA								
[26] (2014)	Subthalamic Stimulation	Pre-Post change: 9.8	Paired t-tests	d	NR	> 0.05	20	×
[20] (2020)	Contemporary dance	Pre-Post change: 3	Paired t-tests	d	0.09 (−0.9269, 0.7454)	0.66	11	×
Walk-12 G								
[21] (2020)	HiBalance program	C: Change: 1.72 (8.38) I: Change: 2.75 (6.78)	ANOVA	d	0.112 (−0.251, 0.475)	0.887	99	×
[22] (2020)	Table tennis	Pre-Post change: − 2.6	Wilcoxon rank-sum test	d	0.373 (−0.684, 1.430)	0.462	8	×

Note. NR = Not reported, I = Intervention, C = Control.

Table 7
Summary of the methods and results of the included prospective cohorts and cross-sectional study designs – Outcome: Walk-12 G.

Citation (Year)	ICF-category	Examined determinants	Instruments	Patient Reported Determinant	Discrete determinant	Statistical analysis	Effect	Effect size (Confidence interval (95 %))	p-value	Sample size	Power calculation reported
[28] (2012)	S&F	Fear of falling[2]	FES	✓	✓	Spearman's rank correlation	ρ	0.82 (NA)	< 0.001	154	×
[27] (2018)	A&P	Objective daily habitual walking - Steps per day in free-living conditions[1]	Actigraph GT3X+ accelerometer	× Gait quantification methods	✓	Spearman's rank correlation	ρ	0.46 (NA)	0.001	49	×
[21] (2020)	S&F	Cognitive flexibility in shifting attention between 2 competing tasks[2]	TMT-B	× Performance test	✓	Multiple Regression	NR	NR	NR	99	×
[7][a] (2021)	S&F	Perceived balance problem while dual tasking	One question	✓	×	Multiple Regression	β	0.18 (0.063, 0.297)	0.003	148	×
	P	Age	Years	× Interview	✓			0.172 (0.066, 0.277)	0.002		
	S&F	Cognition[1]	MoCA	× Performance test	✓			-0.107 (−0.209, −0.004)	0.041		
	S&F	Fatigue	1 of 3 questions of the NHP Energy subscale	✓	✓[d]			0.101 (−0.011, 0.213)	0.076		
	S&F	Pain	One question	× Interview	×			0.100 (−0.003, 0.204)	0.058		
	S&F	Postural instability	One item	× Clinician assessed	×			0.091 (−0.007, 0.189)	0.070		
	S&F	Objective worse lower extremity function[2]	Five chair stands test ≥ 16.0 s	× Observation	✓[d]			-0.088 (−0.192, 0.017)	0.099		

Note. A&P = Activities and Participation, E = Environmental, HC = Health Conditions, P = Personal, S&F = Body structures and functions, B = regression coefficient, β = standardized regression coefficient, [a]95 % Stand. CI = upper or lower CI x standard. beta / beta, [b] Stand. Beta = beta + /- (1.96 *standard error), NA = Not applicable, NR = Not reported, [d] = dichotomized.

Table 8
Summary and results of the included prospective cohorts and cross-sectional study designs – Outcome: UAB LSA.

First author and citation (Year)	ICF-category	Examined determinants	Instruments	Patient Reported Determinant	Discrete determinant	Statistical analysis	Effect	Effect size (Confidence interval (95 %)	p-value	Sample size	Power calculation reported
[23][a] (2019)	A&P	Patient-reported walking difficulties	Walk-12 G[2]	✓	✓	Multiple Regression	β	-0.19 (−0.582, 0.202)	0.036	122	✓
	S&F	Pain	"Are you bothered by pain?"	× Interview	×			-0.13 (−6.951, 6.691)	0.054		
	A&P	Objective functional mobility	TUG[2]	× Observation	✓			-0.12 (−0.375, 0.135)	0.139		
	S&F	Depression	GDS-15[2]	× Interview	✓			-0.10 (−1.256, 1.056)	0.161		
	S&F	Motor symptoms	MDS-UPDRS III[2]	× Clinician assessed	✓			0.08 -0.292, 0.452	0.409		
	S&F	Cognition	MoCA[1]	× Performance test	✓			-0.06 (−1.020, 0.900)	0.45		
	S&F	Fatigue	1 of 3 questions of the NHP Energy subscale	✓	✓[d]			-0.04 (−7.468, 7.388)	0.631		
	S&F	Freezing of Gait	FOGQsa item 3. Score ≥ 1 = yes	✓	✓[d]			0.02 (−6.644, 6.684)	0.784		
[24][b] (2022)	E	No driver's license	NR	× Interview	×	Multiple Regression	β	-0.40 (−0.547, −0.071)	≤ 0.05	113	NR
	A&P	Social participation	Social participation index[1]	✓	✓			0.36 (0.225, 0.495)	≤ 0.05		
	E	Receiving caregiving	NR	× Interview	×			-0.24 (−0.372, −0.102)	≤ 0.05		
	E	No extra money in the house	NR	NR	×			-0.22 (−0.358, −0.084)	≤ 0.05		
	P	Sex	NR	NR	×			-0.17 (−0.479, 0.134)	≤ 0.05		
	P	Age	Years	NR	×			-0.10 (−0.180, −0.020)	≤ 0.05		
	HC	Respiratory condition	NR	✓	×			NR	NR		
[29] (2021)	A&P	Objective daily walking activity	StepWatch 4 Activity Monitor	× Gait quantification methods	✓	Simple regression	B	0.002 (0.000, 0.003)	0.07	69	NR
[25] (2023)	S & F	Balance confidence	ABC Scale[1]	✓	✓[d]	Pearson's or Spearman's rank correlation	r / ρ	0.51 (NR)	NR	88	✓
	S & F	Balance	Mini-BESTest[1]	× Performance test	✓[d]	Pearson's correlation	r	0.42 (NR)	NR		
	P	Age	Years	× Interview	×	Pearson's or Spearman's rank correlation	r / ρ	-0.27 (NR)	NR		
	S & F	Cognition	MoCA[2]	× Performance test	✓[d]	Pearson's or Spearman's rank correlation	r / ρ	0.29 (NR)	NR		
	S & F	Motor- and non-motor symptoms	MDS-UPDRS[2]	× Clinician assessed	✓[d]	Pearson's or Spearman's rank correlation	r / ρ	0.28 (NR)	NR		
	S & F	Depression	BDI-II[2]	✓	✓[d]	Pearson's or Spearman's	r / ρ	0.34 (NR)	NR		

(*continued on next page*)

Table 8 (*continued*)

First author and citation (Year)	ICF-category	Examined determinants	Instruments	Patient Reported Determinant	Discrete determinant	Statistical analysis	Effect	Effect size (Confidence interval (95 %)	p-value	Sample size	Power calculation reported
	HC	Disease duration	NR	× Interview	×	rank correlation Pearson's or Spearman's rank correlation	r / ρ	0.02 (NR)	NR		
	P	Male sex	NR	× Interview	×	Chi-square test	x^2	NR	0.51		
	HC	Motor subtype	NR	× Interview	×	Chi-square test	x^2	7.54 (NR)	0.006		

Note. NA = Not applicable, NR = Not reported, A&P = Activities and Participation, E = Environmental, HC = Health Conditions, P = Personal, S&F = Body structures and functions, ABC scale = Activities-Specific Balance Confidence Scale, B = regression coefficient, β = standardized regression coefficient, [a]95 % Stand. CI = upper or lower CI x standard. beta / beta, [b] Stand. Beta = beta + /- (1.96 *standard error), [d] = dichotomized, ρ = Spearman's rho, x^2 = Chi-square, [1]: Higher = Better, [2]: Higher = worse.

Sweden [7,21–23,27,28] and / or in the outpatient (6/11) [7,20,22–24,27] setting. Sample size ranged from 9 [22] to 255 people with PD [7]. The follow-up of participants of longitudinal and pre-post-study designs varied between 1.5 [20] and 36 months [7] with an attrition rate of minimum 15 % [21] and maximum 42 % in the study with the longest follow-up [7]. The detailed risk of bias assessment can be found in the supplement 4.

Most studies using the Walk-12 G [30,31] to measure patient-reported functional mobility were from Sweden [7,21,22,27,28]. Compared to the definition of functional mobility by Bouca-Machado, Maetzler and Ferreira [4], the Walk-12 G [30] assesses the mobility and functionality and the UAB LSA [32] additionally measures the environment. Neither of the two instruments assess the other components of functional mobility (i.e., move safely in order to participate in ADL at home, work and in the community). The Walk-12 G mean values ranged from 11 [22] to 15 [7] while the UAB LSA mean values ranged from 64 [24] to 92 [29]. Table 5 illustrates potential determinants of patient-reported functional mobility investigated by the included studies. According to the frequency, less attention has been paid to health conditions, activities and participation as environmental and personal factors, while determinants related to body structures and functions have received most attention.

3.4. Characteristics of study participants

Mean age of the participants was between 57.2 [26] and 75.0 years [27] with a minimum of 30 % [20] and a maximum of 51 % [27] female participants. While the Hoehn and Yahr (H&Y) disease stage was not reported in 3/11 studies [24,26,28], most of the participants in the remaining studies were in a H&Y stage II (i.e., without impaired balance). As the original and the modified H&Y scale were both applied, between study comparison was limited to four determinants. The studies of Harrison, Earhart, Leventhal, Quinn and Pietro [20] and Nilsson, Hariz, Iwarsson and Hagell [28] had the patients with the lowest disease duration (mean of six years) while the participants of Daneault, Duval, Barbat-Artigas, Aubertin-Leheudre, Jodoin, Panisset and Sadikot [26] had the highest disease duration (eleven years). Although the MDS-UPDRS is the gold standard clinical research assessment tool for PD motor impairment, four out of eleven studies did not report the (MDS) UPDRS [21,24,28,29]. Similarly, only three of the eleven included studies [7,23,25] applied the MoCA, a scale recommended by the Movement Disorders Society to assess cognition in people with PD [35], while two [20,27] applied the Mini Mental State Examination (MMSE) [36]. While most studies reported mean cognition scores below the cut-off score [37] for presence of mild cognitive impairment in people with PD [7,20,23,27], this was not the case for one study [25]. The remaining six studies did not perform any cognitive assessment to detect mild cognitive impairment [21,22,24,26,28,29].

3.5. Results of individual studies

Tables 6, 7 and 8 present summary statistics, effect estimates and their precision for controlled trials and pre-post study designs, as well as for cross-sectional and prospective cohort study designs. While most determinants were addressed only by single studies [7,21,23,24,27–29], Table 9 synthesizes the association with patient-reported functional mobility of the six determinants included in more than one study. In these studies, higher age was significantly associated with worse patient-reported functional mobility. Results for global cognition and depression were not so conclusive, as negative and positive associations were found by previous research, while results were less heterogenic for pain. Results of studies assessing fatigue tend to show that fatigue is associated with worse patient-reported functional mobility. One study reported significant association of male sex with a worse outcome. Finally, by examining the standardized regression coefficients in the three studies using multiple regression [7,23,24] from high to low effect size in comparison with the ICF-categories (Tables 7 and 8), it seems that environmental factors, i.e., having a driver's license, had a stronger association (β from 0.22 to 0.40) with patient-reported functional mobility than body structures and function (β from 0.02 to 0.18). Unfortunately, only one study [24] assessed environmental factors.

4. Discussion

We systematically reviewed the literature assessing determinants of functional mobility in community-dwelling people with PD to answer the question: What are the determinants of patient-reported functional mobility of people with typical PD? Although we need to interpret these findings with caution due to the heterogeneity and the small number of studies, determinants related to environment seem to have the strongest association with patient-reported functional mobility, while determinants related to body structures and functions were most frequently investigated.

Across studies we noted a large heterogeneity of used methods and reported results. Three studies applied multiple regression and reported standardized regression coefficients [7,23,24]. Rantakokko, Iwarsson, Slaug and Nilsson [23], Ryder-Burbidge, Wieler, Nykiforuk and Jones [24], Dutra, Soares, Artigas, Pereira, Krimberg, Ovando, Schuh and de Mello Rieder [25] assessed the same primary outcome: the University of Alabama Birmingham Life-Space Assessment (UAB LSA). Most studies did not find statistical support for an association. However, environmental factors, i.e., having a driving license might have a stronger

Table 9
Associations between various types of factors and functional mobility.

Determinant	Interpretation	Author	β	CI	p-value
Age	NA	Lindh-Rengifo, Jonasson, Ullen, Mattsson-Carlgren and Nilsson [7][2]	0.172	0.066, 0.277	0.002
	NA	Dutra, Soares, Artigas, Pereira, Krimberg, Ovando, Schuh and de Mello Rieder[25][1]	-0.27	NR	NR
	NA	Ryder-Burbidge, Wieler, Nykiforuk and Jones [24][1]	-0.1	-0.180, − 0020	< 0.05
Cognition	MoCA[2]	Lindh-Rengifo, Jonasson, Ullen, Mattsson-Carlgren and Nilsson [7][2]	-0.107	-0.209, − 0.004	0.041
	MoCA[2]	Dutra, Soares, Artigas, Pereira, Krimberg, Ovando, Schuh and de Mello Rieder [25][1]	0.29	NR	NR
	MoCA[2]	Rantakokko, Iwarsson, Slaug and Nilsson [23][1]	-0.06	-1.020, 0.900	0.45
Depression	GDS-15[2]	Rantakokko, Iwarsson, Slaug and Nilsson [23][1]	-0.10	-1.256, 1.056	0.161
	BDI-II[2]	Dutra, Soares, Artigas, Pereira, Krimberg, Ovando, Schuh and de Mello Rieder [25][1]	0.340	NR	0.009
Fatigue	Fatigue = Yes	Lindh-Rengifo, Jonasson, Ullen, Mattsson-Carlgren and Nilsson [7][2]	0.101	-0.011, 0.213	0.076
	Fatigue = Yes	Rantakokko, Iwarsson, Slaug and Nilsson [23][1]	-0.04	-7.468, 7.388	0.631
Pain	Pain = Yes	Lindh-Rengifo, Jonasson, Ullen, Mattsson-Carlgren and Nilsson[7][2]	0.1	-0.003, 0.204	0.058
	Pain = Yes	Rantakokko, Iwarsson, Slaug and Nilsson[23][1]	-0.13	-6.951, 6.691	0.054
Sex	Male sex	Ryder-Burbidge, Wieler, Nykiforuk and Jones [24][1]	-0.17	-0.479, 0.134	≤ 0.05
	Male sex	Dutra, Soares, Artigas, Pereira, Krimberg, Ovando, Schuh and de Mello Rieder [25][1]	NR	NR	0.510

Note. [1]: Higher = Better, [2]: Higher = worse.

association with patient-reported functional mobility than the frequently studied body structures and function. These findings are in line with the previous results by Tosserams, de Vries, Bloem and Nonnekes [1], Bouca-Machado, Maetzler and Ferreira [4], stating we need to pay more attention to the assessment of environmental and personal factors. Moreover, our results strengthen their hypothesis that the environmental factors (ability to drive [24], caregiving [24]), the personal factors (sex [24], age [7,24]), the body function (cognitive impairment [7], postural instability [7]), and "social participation" [24] are determinants of patient-reported functional mobility. Furthermore, according to the recent review of Ramos, Duarte, Bouca-Machado, Fabbri, Mestre, Costa, Ramos and Ferreira [38], architecture and design (e.g., housing adaptations/accessibility/usability, floor surface/lights/signaled pedestrian crossings or reaching/space between objects) are associated with functional mobility. However, the included studies of that review applied qualitative study designs [39,40] or did not assess patient-reported functional mobility [41]. In comparison, while Ryder-Burbidge, Wieler, Nykiforuk and Jones [24] investigated the role of social participation and environmental determinants (e.g., having a driver's license, money, or caregiving) none of the included studies assessed environmental factors like architecture and design. In summary, determinants related to environment seem to have the strongest association with patient-reported functional mobility however based on few studies, while determinants related to body structures and functions were most frequently investigated.

The reporting of those results was not always complete. Namely, eleven risk of bias elements could not be answered due to missing information. While reporting guidelines were available [42] and are recommended by the International Committee of Medical Journal Editors [43], the more recent studies did not have a higher reporting quality than the older studies. Moreover, the methodological quality of the included studies was limited. For instance, most of the determinants were assessed by single items instead of validated questionnaires. Half of the studies had patient-reported functional mobility as the primary outcome, while this was not the case for Harrison, Earhart, Leventhal, Quinn and Pietro [20], Leavy, Joseph, Löfgren, Johansson, Hagströmer and Franzén [21], Olsson, Franzén and Johansson [22], Daneault, Duval, Barbat-Artigas, Aubertin-Leheudre, Jodoin, Panisset and Sadikot [26], Nilsson, Hariz, Iwarsson and Hagell [28]. No study reported an a priori power calculation (for one, a sample size calculation was mentioned but not with sufficient detail to determine when it was conducted [25]) and only one study reported a post-data collection sensitivity power analysis [23]. Lindh-Rengifo, Jonasson, Ullen, Mattsson-Carlgren and Nilsson [7], Rantakokko, Iwarsson, Slaug and Nilsson [23], Ryder-Burbidge, Wieler, Nykiforuk and Jones [24] were the only studies reporting controlling of confounders. Despite Leavy, Joseph, Löfgren, Johansson, Hagströmer and Franzén [21] not providing effect sizes and confidence intervals, we did not exclude the study from our review. The included studies lack representativeness of the population of people living with PD as either interventional and pre-post studies selected participants based on a defined set of rather narrow inclusion or exclusion criteria. Further, possibly biased study enrolment was not tested in the observational studies, which did not report reasons why certain eligible individuals chose not to participate. The present review process had some minor limitations. For instance, we did no grey literature search and did not include clinical trial registries for ongoing studies. Additionally, we performed no assessments of meta-bias(es) or the strength of the body evidence. Finally, due to the limited geographical distribution of the studies, our findings may not be representative of a broader global population.

Despite the limited evidence, our work shows that determinants related to participation and environment seem to have the strongest association with functional mobility, while determinants related to body structures and functions were most frequently investigated. Consequently, we recommend future research focuses less on body structures and functions and more on participation and environmental factors. Future research projects investigating patient-reported functional mobility should improve methodological quality, for example by conducting and including sample size calculations, controlling for confounders, and avoiding selective participant recruitment or convenience sampling without reporting reasons of non-participation. As we intentionally refrained from distinguishing a priori between exposures (determinants with a causal role for functional mobility) and factors co-occurring or associated with functional mobility, this could be investigated by future research. More consensus-derived standardized sets of outcomes [44] that should be measured and reported could reduce study heterogeneity and enable more systematic research synthesis in the future. Finally, our findings suggest health professionals can tailor interventions to the context of people with PD, i.e., their ability to drive [24], caregiving [24], to their personal factors, i.e., sex [24] and age [7,24] as to their cognition [7], postural stability [7] and social participation [24].

Other information

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Registration and protocol

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Anne-Marie Hanff: Conceptualization, Methodology, Formal analysis, Investigation, Writing – original draft, Writing – review & editing, Visualization, Supervision. **Claire Pauly:** Methodology, Investigation, Writing – review & editing. **Laure Pauly:** Methodology, Investigation, Writing – review & editing. **Armin Rauschenberger:** Methodology, Formal analysis, Writing – review & editing. **Anja K. Leist:** Conceptualization, Writing – review & editing. **Rejko Krüger:** Conceptualization, Resources, Writing – review & editing. **Maurice P. Zeegers:** Conceptualization, Methodology, Resources, Writing – review & editing, Supervision. **Chris McCrum:** Conceptualization, Methodology, Resources, Writing – original draft, Writing – review & editing, Supervision.

Declaration of Competing Interest

Dr Leist received renumeration from Roche for consultant activities. The other authors have no conflict of interest to report.

Data availability

The collected data supporting the conclusions of this article are available under the following OSF-link: https://osf.io/jcqzr/.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.gaitpost.2023.11.013.

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