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Housing accessibility problems for people with Parkinson's disease

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Abstract

Objectives: Promoting accessible housing for all citizens is high on the political agenda. Knowledge is however limited regarding housing accessibility problems for people with Parkinson's disease (PD). The objectives were to investigate housing accessibility problems among people with PD at different stages of disease severity, and to analyze the potential impact of improved functional ability on accessibility problems.

Materials & Methods: The study included 253 participants with PD (61% men; mean age 70 years). Disease severity was assessed by the Hoehn and Yahr (HY) I-V stages: HY I, n=50; II, n=73, III, n=66; IV-V, n=64. Using the Housing Enabler (HE) instrument, accessibility problems were investigated by combining assessments of the person's functional capacity with assessments of physical barriers in the housing environment into a person-environment fit measure (HE-score). To analyze potential impact of improved functional ability on housing accessibility problems, data simulation was applied.

Results: HE-scores differed significantly ($p<0.001$) in relation to HY stages. Overall balance problems explained 22% and walking devices 17% of the HE-scores, whereas environmental barriers contributed to a lesser extent. The environmental barriers generating the most HE-scores were "no grab bar at shower/bath/toilet" and "wall-mounted cupboards and shelves placed high". A simulation of improved balance significantly ($p<0.001$) lowered the HE-scores in all HY stages.

Conclusions: The results suggest that actions targeting balance problems and dependence on walking devices have the greatest potential for reducing housing accessibility problems in people with PD. The study also details environmental barriers that need specific attention when providing housing adaptation services.

Keywords: Accessibility; Assistive Devices; Housing; Parkinson’s Disease; Physical barriers; Postural Balance.

Introduction

The proportion of people ageing with disabilities is increasing.[1-3] Due to a strong aging-in-place policy in many countries[4], a large proportion of older people with disabilities live in ordinary housing. This situation places demands on the ordinary housing stock to provide adequate conditions for people with disabilities. That is, conditions that enable people with disabilities to perform activities of daily living according to their needs and wishes.[5] Achieving accessible housing for all is high on the political agenda.[6] The global disability action plan for 2014-2021 underlines the importance of identifying and eliminating accessibility problems in buildings as a matter of justice and equality.[7] To understand the complexity of accessibility problems for older people it is then important to take into account different diagnostic groups with specific needs. As recently highlighted[8], there is limited knowledge regarding accessibility problems in people with Parkinson's disease (PD).

Accessibility is a function between the demands of the physical environment (E) and the person´s functional capacity (P)[9], i.e. an aspect of Person-Environment (P-E) fit. It is theoretically supported by the Ecological Model of Ageing, according to which a balance between the person's capacity and the demands of the environment can be achieved by changing one or the other or both.[10] Accessibility problems emerge when environmental demands exceed the functional capacity of the individual; for instance, stairs without handrails may create severe problems for individuals with poor balance. Exploring accessibility problems in specific diagnose groups such as PD, may deepen the understanding of how accessibility problems are generated. In a previous study accessibility problems were explored in a sample of very old single-living people in urban environments[11]; it compared 20 individuals with self-reported PD with matched controls.[12] Though the study had notable limitations it delivered interesting results. For instance, the environmental barriers that generated the most problems seemed to be more often located to the exterior surroundings for people with self-reported PD compared to controls. Evidently, to present results valid for the PD population, larger studies with samples with a confirmed PD diagnosis and varied housing and living conditions are imperative. Moreover, as functional capacity changes during the disease course, it is of clinical interest to examine how accessibility problems relate to disease severity.

Housing accessibility problems are commonly addressed by individual housing adaptations. Considering accessibility as a matter of P-E fit however, part of the strategy to reduce accessibility problems could be to improve the individual's functional capacity and ability, such as balance, stamina and coordination of movements. Physical therapy for people with PD often addresses gait, mobility and balance[13], abilities potentially important to counteract accessibility problems and thus to facilitate activities of daily living. However, to the best of our knowledge there are no previous studies on the potential of physiotherapeutic interventions to reduce accessibility problems among people with PD. It would therefore be of interest, both from a clinical and a policy perspective, to explore which features of the individual's capacity as well as in the environment generate accessibility problems. Such knowledge would inform the development of efficient strategies for the reduction of housing accessibility problems for people with PD.

The overall aim of this study was to investigate housing accessibility problems among people with PD at different stages of disease severity, and specifically to determine which functional limitations and environmental barriers contribute the most to housing accessibility problems for people with PD. Focusing on the person component of accessibility, a related aim was to analyze the potential impact of improved functional ability on accessibility problems.

Material & methods

This study was based on baseline data of a larger longitudinal project in Sweden; "Home and Health in People Ageing with PD". For details of data collections and procedures such as a complete list of instruments used, see the study protocol.[14]

Participants and recruitment

At baseline, a sample of 653 participants (recruited from three hospitals in Skåne, Sweden) met the inclusion criterion of being diagnosed with PD (G20.9, according to ICD-10) for at least one year. Out of these, 216 individuals were excluded according to the following criteria: difficulties in understanding/speaking Swedish (n=10), severe cognitive difficulties (n=91), living outside Skåne (n=58) or other reasons (n=57), for example, hallucinations or a recent stroke. That is, a potential participant was excluded if not deemed to be able to give informed consent or partake in the majority of the data collection. Among the remaining 437 individuals who were invited to participate 157 declined, 22 were unreachable, two had their PD diagnosis revised and one was excluded due to extensive missing data. For the present study, two additional participants were excluded due to missing data on accessibility problems. Consequently, the final sample size was 253 (61% men) participants; their mean (SD, min-max) age was 70 (9.2, 45-93) years. The median (q1-q3, min-max) PD duration was 8 (5-13, 1-43) years.

(Table 1 in here)

The Home and Health in People Ageing with PD project[14] was approved by the Regional Ethical Review Board (No. 2012/558) in Lund, Sweden. All participants provided written informed consent.

Procedure- data collections

The data collection included a self-administered postal survey followed by a subsequent home visit that involved interview-administered questions and questionnaires, observations and clinical assessments. The home visits were scheduled at a time point of the day when the participants reported usually to be feeling their best (i.e., being in the "on state" due to PD medication). If the participant became too tired or unwell (i.e., became increasingly "off"), the assessments were completed on another day but in close conjunction (which happened in eight cases). The data collection was administered by two project assistants (reg. occupational therapists) that had undergone specific training. The current study involves data on accessibility problems (P-E fit), disease severity and descriptive information.

The Housing Enabler Instrument- accessibility problems

Accessibility problems were assessed according to the Housing Enabler (HE).[15] First introduced in 1996, the HE has subsequently been thoroughly evaluated and optimized and is extensively used in ageing research. Sufficient inter-rater reliability of the HE has been demonstrated in several studies, and the validity has been successively strengthened during 20 years of research.[16] At present, the instrument is available in Swedish, Danish, English and Finnish. In addition, the rating forms are available in German, Icelandic, Hungarian, Latvian, Russian and Portuguese. Translation procedures to other languages have included reliability studies as well as adaptation to the building regulations and standards for housing design in other countries.[17-19]

Based on the notion of P-E fit[10], the HE takes into account that functional limitations constitute an important component of accessibility problems. Environmental barriers are objectively assessed based on national standards for housing design and juxtaposed with the individual profile of functional limitations. The HE is administered in three steps:

Step 1 (P component): Interview and observation of functional limitations (12 items) and dependence on mobility devices (2 items), see Table 3. All items are dichotomously assessed (Present=1/Not present=0). Step 1 renders a profile of functional limitations/dependence on mobility devices and generates a sum score (min-max, 0-14). According to the manual[15], the data collector administers a combination of interview and observation, that is, observations of the person while performing activities in the home environment. If the person states that his/her functional limitations vary over time, since the housing environment should be accessible at any point in time the rating should reflect the "worst-case-scenario".

Step 2 (E component): Observation and dichotomous assessment (Present=1/Not present=0) of 161 environmental barriers indoors in the home (n=87), at entrances (n=46) and in the immediate exterior surroundings (n=28). This step implies no involvement of the participant. Step 2 provides a detailed account of the type of environmental barriers present and also generates a sum score (min-max, 0-161).

Step 3 (P×E interaction): Based on the first two steps, the magnitude and character of the accessibility problems in each case is calculated. The P and E components are combined using a scoring matrix with predefined severity ratings 0-4 (0=No problem, 1=Potential problem, 2=Problem, 3=Severe problem, 4=Impossibility). The severity ratings are summed to a total accessibility problem score (HE-score) as well as sub-scores for each of the 14 items of the P component and for each of the 161 items of the E component. The total score predicts the magnitude of accessibility problems to arise in a specific case (higher scores mean more accessibility problems). The sub-scores denote how much each item of the P and E components, respectively, contribute to the total score. In cases with no functional limitations/dependence on mobility devices, the scores are 0. The theoretical maximum for the total score is 1,844. Min-max values for the 14 sub-scores of the P component are 0-292 and for the 161 sub-scores of the E component 0-35.

Hoehn and Yahr - disease severity

Disease severity was assessed (in "on state") according to Hoehn and Yahr (HY).[20] The HY includes five stages: HY I (unilateral involvement, usually with minimal or no functional disability); HY II (bilateral involvement without impairment of balance); HY III (unilateral or bilateral + postural instability); HY IV (severely disabled; still able to walk or stand unassisted); and HY V (confined to bed or wheelchair unless aided). In the present study, HY stages IV (n=57) and V (n=7) were merged for reasons of distribution.

Descriptive information

Descriptive variables included: age; sex; PD-duration; education; living area (rural/urban); type of housing (one-family/multi-family); previous housing adaptations (No/Yes); activities of daily living (PD Activities of Daily Living Scale, PADLS)[21]; motor symptoms (Unified PD Rating Scale, UPDRS part III)[22]; dyskinesia (UPDRS part IV, items 32-34)[22]; fluctuations (UPDRS part IV, items 36-39)[22]; cognitive functioning (Montreal Cognitive Assessment, MoCA)[23]; history of falls past 6 months (No/Yes), freezing of gait (FOG Questionnaire[24], self-administered version[25], item 3) and total number of non-motor symptoms (Non-motor Symptoms Questionnaire for PD, NMS Quest).[26] At the home visit, the participants also selfrated their current mobility as either Good (“on”); Good, but hyperkinetic; or Bad (“off”). Descriptive information is provided in Table 1.

Statistical analysis

Group differences between HY stages with regard to number of functional limitations/dependence on mobility devices, number of environmental barriers and accessibility problems were analyzed by means of the Kruskal-Wallis test and/or the Mann-Whitney U-test for ordinal variables. Where significant differences were found, post-hoc analyses were conducted.

To determine which functional limitations and environmental barriers contributed the most to housing accessibility problems, average sub-scores for each item of the P component (i.e., 14 sub-scores) and of the E component (i.e., 161 sub-scores) were computed. The sub-scores for the P and E components were sorted in descending order for the total sample and for the HY stages, in order to produce ranking lists. The relative shares of the total accessibility score for each item were also calculated. Given the large number of environmental barrier items (n=161), the results presented for the E component are based on the ‘‘top 10’’ barriers. The order of the items in the ranking lists for the HY stages was qualitatively compared, using the total sample as reference.

In a subsequent step, we applied a simulation to analyze the potential effect of improved functional ability on the manifestation of accessibility problems. That is, in each case we assumed that the functional limitation that contributed the most to accessibility problems (i.e. in this sample) was sufficiently improved not to be assessed as present. We then re-calculated the scores and compared the results of the simulated scenario with the authentic data scenario. The differences in scores between the two scenarios were analyzed with Wilcoxon signed rank test, while the ranking lists were qualitatively compared.

All computations were conducted using IBM SPSS Statistics 22 for Windows (IBM Corporation, Armonk, NY, U.S.). Results with p-values<0.05 were considered statistically significant, unless Bonferroni correction was applied. The corrected significance level was lowered to 0.05/6=0.0083 (i.e., six post-hoc pairwise tests were conducted for each group difference found).

Results

P, E components and accessibility problems (HE-scores) in relation to the severity of PD

The median (q1-q3) HE-scores ranged from 122 (56-198) in HY stage I to 328 (240-384) in HY stages IV-V (Table 2). HE-scores differed significantly (p<0.001) according to HY stages. Post hoc comparisons (Bonferroni corrected) showed statistically significant differences between all HY stages except between stages I and II. The number of functional limitations/dependence on mobility devices differed significantly (Bonferroni corrected post-hoc comparisons) between the HY stages, except between stages I - II and stages I - III. Although the number of environmental barriers differed in relation to HY stages, subsequent comparisons (Bonferroni corrected) showed no statistically significant difference.

(Table 2 in here)

Functional limitations and environmental barriers contributing most to accessibility problems

In the total sample, the top two items of the P component that contributed the most to the magnitude of accessibility problems were poor balance (explained 22% of the total HE-score) followed by dependence on walking devices (explained 17%), see Table 3. An average HE-score of 43.0 related to poor balance whereas an average score of 33.0 related to walking devices.

The top three environmental barriers that generated most accessibility problems were: “No grab bar at shower/bath and/or toilet” (average HE-score = 7.3); “Wall-mounted cupboards and shelves placed high (kitchen)” (average = 7.0); and “Stairs the only route (entrance)” (average = 6.3), see Table 4.

(Tables 3 and 4 in here)

Poor balance was the functional limitation that generated the most accessibility problems in HY stages I, II and III. It was followed by limitations of stamina in HY I, whereas the second functional limitation in rank order was fine motor skills in HY II-III. In HY IV-V, dependence on walking devices generated the most accessibility problems, followed by poor balance.

The top three environmental barriers were the same in HY stages I-III as in the total sample although the ranking order differed. That is, for those in HY IV-V, “Stairs the only route (entrance)” was exchanged to “Refuse bin difficult to reach (exterior surroundings)”.

Simulation of improved balance

In the total sample, the simulation of improved balance (i.e. poor balance was the functional limitation that contributed the most to accessibility problems) lowered the magnitude of accessibility problems substantially: the median (q1-q3) HE-score decreased from 186 (96-276) to 129 (62-212). Moreover, it lowered the median HE-score substantially in all HY stages: stage I from 122 to 87; stage II from 127 to 95; stage III from 181 to 121, and in stage IV-V from 328 to 286 (Table 5). The reduction in HE-scores was significant in all HY stages ($p<0.001$).

In the total sample, the top three environmental barriers remained the same after simulating improved balance, but the magnitude of problems generated by each of them decreased substantially. When comparing different levels of disease severity, HY I and II stand out; more barriers were replaced by barriers that cause lesser accessibility problems (see Tables 4 and 5).

(Table 5 in here)

Discussion

The main finding of this study is that the P component of P-E fit contributes more to housing accessibility problems among people with PD than the E component does. Balance problems contribute the most, followed by dependence on walking devices. Moreover, simulation of improved balance showed significant lowering of housing accessibility problems in all HY stages. These findings suggest that interventions targeting functional capacity have the greatest potential for reducing housing accessibility problems in people with PD.

A cardinal feature of PD is balance problems, and it contributed the most (22%) to housing accessibility problems. Not surprisingly, accessibility problems became more prominent in HY stage III, which per definition includes postural instability.[20] Less expectedly, poor balance contributed the most to accessibility problems already in HY stages I and II, even though HY stages I-II do not include balance impairment or postural instability. There are several reasons that might explain this. First, the HE item definition of poor balance incorporates dizziness, which is an aspect not included in HY. Second, the HE assessment should reflect the worst case scenario in cases where the participant reported fluctuations. Third, for a more comprehensive assessment of balance problems, participants were observed while performing activities in their homes. Moreover, while observing the participants the data collectors had access to data on a broad variety of aspects in the current study (for details, see the study protocol)[14] that could support them to make more informed assessments. For example, data regarding near falls and whether the participant reported an unsteadiness while turning, representing aspects relevant for assessing balance problems.

Though the simulation analyses showed substantial and significant decrease of the HE-scores in all HY stages, it also indicated that the impact of improved balance on accessibility problems would be more profound in HY I and II. That is, besides the decrease of the HE-scores, the barrier ranking lists in HY I and II were more markedly affected by balance improvement. Many of the barriers that originally appeared on the lists were replaced by barriers generating lesser problems. In later HY stages—characterized by more complex functional profiles—barriers can be problematic in several ways. That is, barriers generating problems in relation to poor balance (e.g., heavy doors, refuse bin/letterbox difficult to reach) often generate accessibility problems also in relation to lack of stamina, incoordination and so on. Consequently, to address just one specific functional limitation such as balance problems is most likely insufficient to resolve accessibility problems for those in later HY stages. It should also be kept in mind that in the most advanced HY stages, a balance improvement on a level that it would no longer be assessed as presence of poor balance is hardly a realistic prospect.

The present findings suggest that balance training could be instrumental in reducing or counteracting housing accessibility problems by taking action early in the disease progression, which would enhance possibilities for people with PD to remain independent and active. A systematic review of 22 RCT-studies[13] concluded that exercise interventions that specifically targeted balance dysfunction have moderate to high effect sizes on balance in people with PD. Little or no beneficial effect on balance was however shown in multi-component exercise studies in the home setting.[13] Moreover, the long-term effect is unclear and most studies included only people with PD in HY stages I-III.[13,27] Though our simulation pointed to a positive impact of improved balance, further research is needed and it remains to be demonstrated in practice whether supervised balance training will reduce housing accessibility problems in people with PD.

In terms of generating accessibility problems, the second most important item of the P component was dependence on walking devices. To the best of our knowledge, this variable has not constituted the primary outcome in intervention studies within the field of PD. However, if dependence on walking devices is seen as a proxy for walking difficulties, there is evidence for interventions that can improve gait features such as gait speed.[27] Importantly, a previous PD-study showed that among recurrent fallers many falls occurred while using a walking device.[28] This underlines the importance of addressing the need, use and safety of walking devices in people with PD, including a home environment that is optimized for safe use.

Though targeting functional capacity appears to have the greatest potential for reducing housing accessibility problems among people with PD, traditional housing adaptations are still required. As shown by Tables 4 and 5, this is true especially in later HY stages. The present study pinpoints the environmental barriers that are particularly important to consider in the home-setting and close exterior surrounding. The most prominent barriers differed however from previous explorative findings[12], which highlights the importance of replicating studies with sufficient sample sizes and to include persons with a verified PD-diagnosis.

Stairs (at entrance) were among the top environmental barriers, which corroborates a previous PD-study that identified stairs as a barrier for mobility.[29] The ability to climb stairs is affected early on during the PD course in those having the Postural Instability Gait Difficulty (PIGD) subtype of PD[30]; it is associated with fear of falling[31-32] and anxiety.[32] Moreover, 34-42 % of persons with PD avoid stairs due to the risk of falling.[33-34] This underlines the importance of considering stairs as an environmental barrier to target in housing adaptations, and that safe stairclimbing need to be practiced.

Strengths, Limitations and Future Perspectives

A strength of this study is the use of a well-established instrument that is based on the notion of P-E fit, covering a broad variety of objectively assessed environmental barriers (n=161). Furthermore, the HE is available in 10 languages, making it possible to conduct similar studies in a large number of countries. Although our results are unique within the field of PD research, we acknowledge the need for further studies in different national contexts. Moreover, longitudinal studies are needed to understand the evolution of accessibility problems in people with PD as the disease progresses.

Intervention studies with housing accessibility as an outcome could be useful to test different strategies in terms of optimizing interventions targeting the functional capacity of the individual and environmental barriers in housing and close surroundings. A methodological limitation when using the HE in such intervention studies is that the functional limitations of the P component are dichotomously assessed. That is, such assessments might not be sufficiently sensitive for research involving people with PD. Depending on the research questions, it is therefore advisable to complement the HE with assessments that address balance and gait problems in a more fine-tuned manner.

Conclusions

The present study provides new knowledge and insights that may support shaping efficient strategies for the reduction of housing accessibility problems among people with PD. The findings suggest that interventions targeting balance problems and dependence on walking devices have the greatest potential for achieving positive results. The study also details which environmental barriers that need specific attention when providing housing adaptation services, such as lack of grab bar at shower/bath/toilet, wall-mounted cupboards/shelves placed high in the kitchen, and stairs the only route to entrance.

Authors' contributions

MHN, SI and BS conceived the idea of the study; all authors (MHN, SI, JAA, BS) participated in designing the study. MHN and BS drafted the initial manuscript. BS and JAA performed the statistical analyses. In an iterative process all authors provided critical intellectual input to the evolving draft of the manuscript, and they all read and approved the final manuscript.

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Conflict of Interest

Susanne Iwarsson and Björn Slaug are the copyright holders and owners of the Housing Enabler (HE) assessment tool and software, provided as commercial products. The other authors have no competing interests.

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Table 1.

Descriptive information and sample characteristics according to PD-severity, N=253.

Characteristic	Disease severity (Hoehn and Yahr stages)				
	I n=50	II n=73	III n=66	IV-V n=64	Total sample N=253
Sex (men), n (%)	33 (66)	51 (70)	35 (53)	35 (55)	154 (61)
Age (years), mean (SD)	68 (9.6)	66 (8.8)	71 (7.6)	75 (9.0)	70 (9.2)
PD duration (years), median (q1-q3)	5 (4-8)	8 (6-11)	8 (5-13)	13 (8-16)	8 (5-13)
Education (High-school, university ≥ 11 years), n (%)	25 (50)	23 (32)	23 (35)	14 (22)	85 (34)
Living area (Urban), n (%)	12 (24)	29 (40)	23 (35)	20 (31)	84 (33)
Housing (Multi-dwelling), n (%)	19 (38)	24 (33)	32 (49)	35 (55)	110 (44)
Prior housing adaptation (yes), n (%)	7 (14)	15 (21)	20 (30)	42 (66)	84 (33)
ADL (PADLS), median (q1-q3)	2 (1-2)	2 (1-2)[5]	2 (2-2)	3 (2-4)[5]	2 (2-3)[6]
Cognitive function (MoCA), median (q1-q3)	27 (25-28)	27 (25-28)	25 (21-28)[5]	23 (18-25)[7]	26 (22-28)[8]
Motor symptoms (UPDRS III), median (q1-q3)	18 (13-24)	27 (22-34)	34 (26-39)	46 (34-56)[3]	30 (22-40)[3]
Dyskinesia (UPDRS IV, ítems 32-34), median (q1-q3)	1 (0-2)	0 (0-2)	1 (0-3)[5]	1 (0-4)	1 (0-3)[5]
Fluctuations (UPDRS IV, items 36-39), median (q1-q3)	0 (0-2)	2 (0-3)	2 (1-3)[5]	2 (1-3)	2 (0-3)[5]
History of falls past 6 months, n (%)	16 (32)	29 (40)[5]	31 (47)	37 (58)	113 (45)[5]
Total NMS (NMSQuest), median (q1-q3)	9 (5-12)[6]	8 (4-13)[9]	11 (8-15)[9]	15 (11-19)[10]	10 (6-15)[11]
FOG (FOGQsa, ítem 3; scores ≥1=FOG), n (%)	14 (28)	31 (43)[5]	42 (64)	54 (89)[2]	141 (57)[1]

PD, Parkinson's disease; PADLS, the PD Activities of Daily Living Scale; MoCA, the Montreal Cognitive Assessment; UPDRS, Unified PD Rating Scale, part III= motor examination whereas part IV= complications; NMS, non-motor symptoms; NMSQuest, Non-motor symptoms Questionnaire, FOGQsa, the self-administered Freezing of Gait Questionnaire; q1-q3, first and third quartiles. In the table, reported % is valid %. Higher scores = "worse" in all instances but MOCA, where higher scores are "better".
[1] 4 missing values; [2] 3 missing; [3] 5 missing; [4] 16 missing; [5] 1 missing; [6] 2 missing; [7] 7 missing; [8] 8 missing; [9] 9 missing; [10] 14 missing ; [11] 34 missing.
At the time of the home visit, 68% of the participants (1 missing value) reported that their mobility was good ("on") or good, but hyperkinetic.

Table 2.

Number of functional limitations/dependence on mobility devices (P component), number of environmental barriers (E component) and accessibility problems (HE-scores) in relation to different stages of disease severity (Hoehn and Yahr), N=253.

Housing Enabler (HE) Component and Scores	Disease severity (Hoehn and Yahr stages)					
	I n=50	II n=73	III n=66	IV-V n=64	Total sample N=253	P-value
No. of. functional limitations + dependence on mobility devices [a], median (q1-q3)	3 (2-4)	3 (1-4)	4 (2-6)	7 (6-8)	4 (2-6)	<0.001 [b]
No. of environmental barriers [a], median (q1-q3)	64 (57-73)	69 (64-73)	69 (61-76)	63 (56-74)	67 (59-74)	0.012 [c]
Accessibility problems (HE-scores) [a], median (q1-q3)	122 (56-198)	127 (50-195)	182 (108-258)	328 (240-384)	186 (96-276)	<0.001 [d]

[a] Assessed by means of the Housing Enabler (HE; Iwarsson & Slaug, 2010).
[b] Post-hoc pairwise group comparisons, significant differences (P-values uncorrected for multiple comparisons):
HY I vs. HY IV-V: p<0.001;
HY II vs. HY III: p=0.002;
HY II vs. HY IV-V: p<0.001;
HY III vs. HY IV-V: p<0.001.
[c] Post-hoc pairwise group comparisons showed no significant differences.
[d] Post-hoc pairwise group comparisons, significant differences (P-values uncorrected for multiple comparisons):
HY I vs. HY III: p=0.007;
HY I vs. HY IV-VI: p<0.001;
HY II vs. HY III: p=0.005;
HY II vs. HY IV-V: p<0.001;
HY III vs. HY IV-V: p<0.001.

Table 3.

Personal component of accessibility (P-E fit): ranking of functional limitations/dependence on mobility device items [a] with respect to how much they contribute to the total magnitude of accessibility problems, at different stages of Parkinson's disease severity (Hoehn and Yahr), N=253.

	Total sample (N=253)		Disease severity (Hoehn and Yahr stages)			
Functional limitation/ dependence on mobility device item	Relative contribution to HE-score, %	Rank (score)	I (n=50) Rank (score)	II (n=73) Rank (score)	III (n=66) Rank (score)	IV-V (n=64) Rank (score)
Poor balance [b]	22.0	1 (43.0)	1 (32.2)	1 (37.8)	1 (46.8)	↓ 2 (53.7)
Reliance on walking devices	16.8	2 (33.0)	↓ 6 (7.5)	↓ 5 (11.1)	↓ 3 (27.8)	↑ 1 (83.0)
Reduced fine motor skills	15.4	3 (30.2)	3 (24.6)	↑ 2 (29.6)	↑ 2 (31.9)	↓ 5 (33.5)
Incoordination	12.5	4 (24.4)	↓ 5 (13.3)	↑ 3 (21.2)	4 (24.5)	4 (36.7)
Limitations of stamina	12.4	5 (24.3)	↑ 2 (25.2)	↑ 4 (15.6)	5 (20.8)	↑ 3 (37.2)
Reduced upper extremity function	5.3	6 (10.3)	↓ 8 (5.4)	↓ 7 (5.6)	↓ 7 (9.0)	6 (20.8)
Reduced spine / lower extremity function	4.5	7 (8.8)	7 (6.9)	↓ 8 (5.4)	↑ 6 (9.6)	↓ 9 (13.2)
Visual impairment	4.5	8 (8.8)	↑ 4 (17.7)	↓ 9 (2.2)	↓ 9 (4.7)	8 (13.4)
Difficulty in moving head	3.4	9 (6.6)	9 (0.8)	↑ 6 (6.2)	↑ 8 (6.6)	↓ 10 (11.7)
Dependence on wheelchair	2.6	10 (5.2)	↓ 14 (0.0)	↓ 14 (0.0)	10 (1.2)	↑ 7 (19.3)
Difficulty interpreting information	0.5	11 (1.0)	↑ 10 (0.7)	11 (0.0)	11 (1.1)	11 (2.1)
Loss of upper extremity function	0.1	12 (0.2)	↓ 13 (0.0)	↓ 13 (0.0)	↓ 14 (0.0)	12 (0.6)
Loss of hearing	0.0	13 (0.1)	↑ 11 (0.0)	↑ 10 (0.0)	↑ 12 (0.0)	13 (0.2)

Note: Total sample used as reference. ↑ Higher ranking order than total sample; ↓ lower ranking order than total sample. [a] Assessed by means of the Housing Enabler (HE; Iwarsson & Slaug, 2010). The HE also includes the item "Blindness", not displayed as it did not occur in our sample.
[b] Poor balance refers to instability when performing everyday activities and includes risk of falling as well as dizziness.

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Table 4.

Environmental component of accessibility (P-E fit): ranking of "top 10" environmental barriers [a] with respect to how much they contribute to the total magnitude of accessibility problems, at different stages of disease severity (Hoehn and Yahr), N=253.

Environmental barrier item (part of housing)	Total sample (N=253)		Disease severity (Hoehn and Yahr stages)			
	Relative contribution to HE-score, %	Rank (score)	I (n=50) Rank (score)	II (n=73) Rank (score)	III (n=66) Rank (score)	IV-V (n=64) Rank (score)
No grab bar at shower/bath and/or toilet (hygiene area)	3.7	1 (7.3)	↓ 2 (6.1)	1 (5.8)	↓ 2 (7.6)	1 (9.6)
Wall-mounted cupboards and shelves placed high (kitchen)	3.6	2 (7.0)	↓ 3 (4.5)	↓ 3 (5.2)	↑ 1 (8.6)	2 (9.5)
Stairs the only route (entrance)	3.2	3 (6.3)	↑ 1 (6.7)	↑ 2 (5.3)	3 (6.8)	↓ 9 (6.8)
Refuse bin difficult to reach (exterior surroundings)	2.6	4 (5.1)	↓ 9 (2.7)	4 (3.9)	↓ 5 (4.8)	↑ 3 (8.8)
High thresholds and/or steps (entrance)	2.4	5 (4.8)	↑ 4 (3.3)	5 (3.3)	↓ 7 (4.2)	↑ 4 (8.3)
Storage areas can only be reached via stairs/threshold (suppl facilities)	2.3	6 (4.6)	↓ 7 (3.0)	6 (3.1)	6 (4.2)	↑ 5 (8.0)
Insufficient maneuvering spaces in relation to movable furnishings (general)	2.3	7 (4.4)	↓ 8 (2.8)	↓ 10 (2.8)	↓ 9 (4.1)	↑ 6 (7.9)
Doors that cannot be fastened in open position (entrance)	2.2	8 (4.3)	↓ >10 (2.4)	↑ 7 (3.0)	8 (4.2)	↑ 7 (7.5)
Letterbox difficult to reach (exterior surroundings)	2.2	9 (4.2)	↓ >10 (2.2)	↑ 8 (2.9)	↑ 4 (4.9)	↓ 10 (6.7)
High threshold/level difference/step (entrance)	2.1	10 (4.0)	↑ 6 (3.0)	↓ >10 (2.7)	10 (4.0)	↓ >10 (6.2)

Note: Total sample used as reference. ↑ Higher ranking order than total sample; ↓ lower ranking order than total sample. [a] Assessed by means of the Housing Enabler (HE; Iwarsson & Slaug, 2010). Due to the large number of environmental barrier items in the HE (n=161), the results are based on the ''top 10'' barriers.

Table 5.

Simulation of accessibility problems [a] based on a scenario where the functional limitation contributing most to accessibility problems (i.e. poor balance) was sufficiently improved not to be assessed as present, N=253.

	Total sample	Disease severity (Hoehn and Yahr stages)			
Environmental barrier item (part of housing)	(N=253) Rank (score)	HY I (n=50) Rank (score)	HY II (n=73) Rank (score)	HY III (n=66) Rank (score)	HY IV-V (n=64) Rank (score)
Wall-mounted cupboards and shelves placed high (kitchen)	1 (5.4)	↓3 (3.5)	1 (3.8)	1 (6.3)	1 (7.7)
No grab bar at shower/bath and/or toilet (hygiene area)	2 (5.0)	2 (4.2)	↓3 (3.6)	2 (2.0)	2 (7.3)
Stairs the only route (entrance)	3 (4.8)	↑1 (5.3)	↑2 (3.7)	3 (4.7)	↓5 (5.8)
Refuse bin difficult to reach (exterior surroundings)	4 (3.7)	↓6 (1.8)	4 (2.7)	4 (3.3)	4 (6.7)
Shelves too deep (kitchen)	5 (3.3)	↓>10 (0.9)	↓>10 (1.7)	↓6 (3.0)	↑3 (7.1)
Letterbox difficult to reach (exterior surroundings)	6 (3.0)	↓>10 (0.7)	↓>10 (1.8)	↑5 (3.3)	↓>10 (5.1)
Controls in high/inaccessible position (kitchen)	7 (2.9)	↓>10 (1.3)	↓9 (1.9)	7 (2.6)	↑6 (5.8)
Controls in high/inaccessible position (hygiene area)	8 (2.9)	↓>10 (1.3)	↓>10 (1.9)	8 (2.6)	↑7 (5.8)
Controls in high/inaccessible position (other indoor area)	9 (2.9)	↓>10 (1.3)	↓10 (1.9)	9 (2.5)	↑8 (5.7)
High thresholds and/or steps at the entrance (entrance)	10 (2.7)	10 (1.7)	↓>10 (1.6)	10 (2.7)	↑9 (5.4)
	Median (q1-q3)	Median (q1-q3)	Median (q1-q3)	Median (q1-q3)	Median (q1-q3)
Accessibility problems (HE-scores), after simulated balance improvement	129 (62-212)	87 (45-143)	95 (41-134)	121 (65-192)	286 (197-331)

Note: Total sample used as reference. ↑ Higher ranking order than total sample; ↓ lower ranking order than total sample. [a] Assessed by means of the Housing Enabler (HE; Iwarsson & Slaug, 2010). Due to the large number of environmental barrier items in the HE (n=161), the results are based on the ''top 10'' barriers.