Perception and Use of Compensation Strategies for Gait Impairment by Persons With Parkinson Disease

Author(s):
Anouk Tosserams, MD¹, ²; Lisanne Wit, BSc²; Ingrid H.W.M. Sturkenboom, PhD³; Maarten J. Nijkrake, PT PhD³; Bastiaan R. Bloem, MD PhD¹; Jorik Nonnekes, MD PhD², ³

Corresponding Author: Anouk Tosserams, anouk.tosserams@radboudumc.nl

This is an open access article distributed under the terms of the Creative Commons Attribution License 4.0 (CC BY), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Neurology® Published Ahead of Print articles have been peer reviewed and accepted for publication. This manuscript will be published in its final form after copyediting, page composition, and review of proofs. Errors that could affect the content may be corrected during these processes.
Affiliation Information for All Authors: 1. Radboud University Medical Centre, Donders Institute for Brain, Cognition and Behaviour, Department of Neurology, Center of Expertise for Parkinson & Movement Disorders, Nijmegen, The Netherlands; 2. Radboud University Medical Centre, Donders Institute for Brain, Cognition and Behaviour, Department of Rehabilitation, Center of Expertise for Parkinson & Movement Disorders, Nijmegen, The Netherlands; 3. Sint Maartenskliniek, Department of Rehabilitation, Nijmegen, The Netherlands.

Contributions:
Anouk Tosserams: Drafting/revision of the manuscript for content, including medical writing for content; Major role in the acquisition of data; Study concept or design; Analysis or interpretation of data
Lisanne Wit: Drafting/revision of the manuscript for content, including medical writing for content; Major role in the acquisition of data; Study concept or design; Analysis or interpretation of data
Ingrid H.W.M. Sturkenboom: Drafting/revision of the manuscript for content, including medical writing for content; Study concept or design
Maarten J. Nijkrake: Drafting/revision of the manuscript for content, including medical writing for content; Study concept or design
Bastiaan R. Bloem: Drafting/revision of the manuscript for content, including medical writing for content; Study concept or design
Jorik Nonnekes: Drafting/revision of the manuscript for content, including medical writing for content; Study concept or design; Analysis or interpretation of data

Number of characters in title: 136

Abstract Word count: 282

Word count of main text: 3913

References: 31

Figures: 2

Tables: 3

Supplemental: - Appendix 1: full questionnaire - Appendix 2: author roles

Statistical Analysis performed by: Anouk Tosserams MD, Radboudumc

Search Terms: [ 324 ] Class IV, [ 165 ] Parkinson's disease/Parkinsonism, [ 242 ] All Rehabilitation

Acknowledgements: The Fox Insight Study (FI) is funded by The Michael J. Fox Foundation for Parkinson's Research. We would like to thank the Parkinson's community for participating in this study to make this research possible. The authors would also like to thank ParkinsonNEXT for facilitating the distribution of the survey in the Netherlands. The Center of Expertise for Parkinson & Movement Disorders was supported by a center of excellence grant awarded by the Parkinson Foundation.

Study Funding: This study was supported by a ZonMW Veni grant to Dr. Nonnekes (16.196.022).
Disclosures: AT, LW, MN, and IS report no disclosures; JN was supported by a ZonMW Veni (grant 16.196.022). He reports a grant from ZonMW (OffRoad grant), Michael J. Fox Foundation, Ipsen Pharmaceuticals and Gossweiler Foundation outside the submitted work; BB currently serves as Editor-in-Chief for the Journal of Parkinson’s disease, serves on the editorial board of Practical Neurology and Digital Biomarkers, has received honoraria from serving on the scientific advisory board for the Critical Path Institute, Kyowa Kirin, UCB, and Zambon, has received fees for speaking at conferences from AbbVie, Bial, GE Healthcare, Oruen, Roche, and Zambon, and has received research support from the Netherlands Organization for Scientific Research, the Michael J Fox Foundation, Nothing Impossible, Parkinson Vereniging, the Parkinson’s Foundation, Hersenstichting Nederland, Verily Life Sciences, Horizon 2020, the Topsector Life Sciences and Health, Abbvie, UCB, Yesse Technologies, and Zambon, all outside the submitted work.

eAppendix 1 --- http://links.lww.com/WNL/B492

ABSTRACT

Background: Gait impairments are common and disabling in Parkinson’s disease (PD). Applying compensation strategies helps to overcome these gait deficits. Clinical observations suggest that the efficacy of different compensation strategies varies depending on both individual patient characteristics and the context in which the strategies are applied. This has never been investigated systematically, hampering the ability of clinicians to provide a more personalized approach to gait rehabilitation.

Objective: We had three aims: (1) to evaluate patients’ awareness and actual use of compensation categories for gait impairments in PD; (2) to investigate the patient-rated efficacy of the various compensation strategies, and whether this efficacy depends on the context in which the strategies are applied; and (3) to explore differences in the efficacy between subgroups based on sex, age, disease duration, freezing status, and ability to perform a dual task.

Methods: A survey was conducted among 4,324 adults with PD and self-reported disabling gait impairments.

Results: The main findings are: (1) compensation strategies for gait impairments are commonly used by persons with PD, but their awareness of the full spectrum of available strategies is limited; (2) the patient-rated efficacy of compensation strategies is high, but varies depending on the context in which they are applied; and (3) compensation strategies are useful for all types of PD patients, but the efficacy of the different strategies varies per person.
Conclusions: The choice of compensation strategies for gait impairment in PD should be tailored to the individual patient, as well as to the context in which the strategy needs to be applied.

Classification of Evidence: This data provides Class IV evidence that compensation strategies are an effective treatment for gait impairment in Parkinson’s disease patients with gait impairment.
1. INTRODUCTION

Gait impairments are common and are reckoned among the most disabling symptoms of Parkinson’s disease (PD). They often give rise to falls and fall-related injuries, decreased functional mobility, independence and quality of life.\textsuperscript{1-3} Gait disturbances in PD can be continuously present (i.e. smaller step length, slower gait speed or higher gait variability), or –as the disease progresses– become more episodic in nature (e.g. bouts of festination or freezing of gait (FOG)).\textsuperscript{4,5} Episodic gait deficits such as FOG may occur when the patient initiates gait, turns, attempts to cross a narrow space (e.g. passing a doorway), when the patient is anxious, or when the patient performs a concurrent task while walking (e.g. talking or carrying a tray).\textsuperscript{6-8}

Dopaminergic treatment alone is seldomly satisfactory in ameliorating these disabling gait impairments, especially with increasing disease duration.\textsuperscript{9,10} Remarkably, patients often spontaneously invent creative ‘detours’ to overcome their walking difficulties, in order to remain mobile and independent. These so-called compensation strategies can be very diverse; examples include walking paced by the rhythm of a metronome or by imaginary counting, mimicking the gait of another person, resorting to an adapted walking pattern (e.g. walking backwards, or by lifting up the knees high), or by using alternative ways to move forwards, such as roller skating. A wide range of different compensation strategies has been reported, typically in the form of anecdotal case reports, describing a typically self-invented solution that apparently worked very well for that particular individual.\textsuperscript{11-13} Recently, a comprehensive overview of compensation strategies to overcome gait impairments has been published, where a conceptual framework of seven separate overarching categories of compensation strategies was proposed, based on their suspected underlying working mechanisms (Table 1).\textsuperscript{14}

Clinical observations suggest that a certain compensation strategy may be highly effective in one person, but may have no effect, or even aggravate gait disability in another person. Furthermore, even within one individual, a specific strategy may have different effects depending on the context in which it is applied (e.g. when preparing food in the kitchen vs. when walking outside).\textsuperscript{15-17} To date this has not been systematically investigated, hampering the ability of healthcare professionals to provide a more tailored, personalized approach to gait rehabilitation for persons with PD. Consequently, in current daily practice, the search for appropriate compensation strategies for a given person with PD remains a time-consuming trial-and-error process. Moreover, individual patients are rarely offered an opportunity to systematically try out the multiple different variants of compensation strategies until they find a specific one that suits their needs and abilities best.
To address this issue, we conducted an international web-based survey among persons with PD experiencing gait impairments. The aim of this study was threefold: (1) to evaluate the participants’ awareness and use of the various compensation categories for gait impairments in PD; (2) to investigate the patient-rated efficacy of compensation strategies, and whether this depends on the context in which the strategies are applied; and (3) to explore whether different patient subgroups (defined by sex, age, disease duration, freezing status, and ability to perform a dual task) might respond differently to certain types of compensation strategies.

2. METHODS

2.1 Study design

The primary research questions comprised: (1) To what extend do participants know and use the seven categories of compensation strategies for gait impairments in PD?; (2) What is the patient-rated efficacy of compensation strategies, and does this differ depending on the context in which the strategies are applied?; and (3) Do different subgroups of participants (defined by sex, age, disease duration, freezing status, and ability to perform a dual task) respond differently to certain categories of compensation strategies? (Class IV evidence).

A web-based survey was distributed among 6,700 participants within the Fox Insight cohort, as well as 1,573 Dutch participants via ParkinsonNEXT (NL). Fox Insight is a longitudinal, virtual, patient-centered observational study on PD led by the Michael J Fox Foundation. Data used in the preparation of this article were obtained from the Fox Insight database (https://foxinsight-info.michaeljfox.org/insight/explore/insight.jsp) on June 1st 2020. For up-to-date information on the study, visit https://foxinsight-info.michaeljfox.org/insight/explore/insight.jsp. ParkinsonNEXT (www.parkinsonnext.nl) is an online platform that aims to unite patients, researchers and clinicians wanting to contribute to research and innovation in PD or parkinsonism. The online survey was accessible from March – June 2020. Respondents above the age of 18 years with a self-reported diagnosis of PD and self-reported disabling gait impairments were included in the analyses.

The survey consisted of three parts (eAppendix 1). The first part asked about sex, age, time since PD diagnosis and the presence and severity of gait impairments. Moreover, the presence and severity of freezing of gait (FOG) was assessed using the New Freezing of Gait Questionnaire (NFOG-Q). They were also asked about their fall history over the preceding 12 months. The second part of the survey addressed the seven main...
categories of compensation strategies (Table 1). One-by-one, each specific category was explained, and illustrated by several practical examples. Participants were then queried whether they were aware of the category of strategies, whether they had ever applied a strategy belonging to that category, and—if so—how application of this strategy had affected their gait in a variety of contexts. These contexts included: gait initiation, turning, stopping, passing a doorway, walking in narrow spaces, walking outdoors, walking in a crowded area, walking while talking, walking while carrying something, performing activities of daily living (ADL), and time-pressure situations. Respondents could indicate whether applying the strategy in that specific context: 1) improved their gait; 2) had no effect on their gait; or 3) worsened their gait. The third part of the survey examined the participants’ interest to learn more about compensation strategies for gait impairments in PD. At the end of the survey respondents were given an open-ended opportunity to share any new compensation strategies, other than the ones already presented in the overview. In all cases, the mentioned strategies fitted into one of the seven proposed categories, and were therefore migrated to the corresponding categories.

For Fox Insight respondents, data from a pre-existing Fox Insight questionnaire titled “Your cognition and daily activities” were also included in the analyses. No data on cognition were available for respondents from the ParkinsonNEXT cohort.

2.2 Data processing and -analysis

Based on the free-text entries that respondents had provided, data were verified and manually corrected by two independent researchers (AT, LW) to ensure that all recorded compensation strategies were completed under the appropriate corresponding category. All (descriptive) statistical analyses were performed in IBM SPSS 25 (SPSS, Inc., Chicago, IL, USA). Any missing values were excluded from the analyses. Independent t-tests (means) and chi-square tests (proportions) were performed to assess subgroup differences. Values of $P<0.05$ were considered to be statistically significant.

2.3 Standard Protocol Approvals, Registrations, and Patient Consents

The study was approved by the Institutional Review Board of the Radboud University Medical Center in Nijmegen, the Netherlands (Ref: 2019-5737). Written informed consent was not necessary for this work.
2.4 Data availability

Data are available to qualified investigators on request to the corresponding author.

3. RESULTS

3.1 Study population

In total, 4,987 responses were collected via Fox Insight (response rate: 74.4%), and 845 via ParkinsonNEXT (response rate: 53.7%). 1,508 persons did not report disabling gait impairments, and were therefore excluded. Characteristics of the included sample of 4,324 respondents are presented in Table 2. Differences in the main characteristics of responders versus non-responders from the ParkinsonNEXT cohort were not clinically relevant in terms of sex distribution (62.1% vs. 64.6% men), age (66.4 vs. 64.5 years), and disease duration (6.5 vs. 5.9 years since diagnosis). These data were not available for the Fox Insight sample.

Of the 4,324 persons with gait impairments who were included, 35.3% found that their walking difficulties negatively affected their ability to perform their usual daily activities. Of note, 52.4% of respondents had experienced one or more falls in the preceding 12 months, resulting in injury that had required medical attention in 385 cases.

Data from the Fox Insight questionnaire “Your cognition and daily activities” was available for 3,586 of 3,663 (97.9%) respondents from the Fox Insight cohort enrolled in the present study. The majority of these respondents had little to no difficulties performing cognitive tasks in daily life. Specifically, most respondents had little to no difficulties reading the newspaper or a magazine (88.7%), keeping track of time (e.g. using a clock) (96.1%), counting the correct amount of money when making purchases (96.8%), reading or following complex instructions (e.g. directions for a new medication) (90.9%), handling an unfamiliar problem (e.g. getting the refrigerator fixed) (88.0%), explaining how to do something involving several steps to another person (84.0%), remembering a list of four or five errands without writing it down (69.1%), using a map to tell where to go (92.1%), remembering new information like phone numbers or simple instructions (77.2%), doing more than one thing at a time (76.0%), learning to use new gadgets or machines around the house (84.2%), understanding their personal financial affairs (92.5%), maintaining or completing a train of thought (92.5%), discussing a TV show, book, movie or current events (88.5%), or remembering what day and month it is (93.8%). Less than 1% of respondents indicated that they were completely incapable of performing one or more of these daily activities.
3.2 Awareness of compensation strategies

Of all respondents, 16.7% had never heard of any of the compensation strategies before. Only a small group (3.5%) was aware of all seven categories of compensation strategies. The median number of categories that respondents were aware of was three. Apart from the use of walking aids and alternatives to walking, external cueing was the most widely known category of compensation strategies (46.9% had heard of it), followed by internal cueing (44.8%). Action observation and motor imagery was the least known category (14.3%). Dutch respondents from the ParkinsonNEXT cohort generally knew more categories of strategies (median: 4) compared to respondents from within the Fox Insight cohort (median: 3; \( p < 0.001 \)).

Most respondents had read about the strategies themselves (35.0%), had heard about it from their physical therapist (29.6%), or had invented the strategies themselves (12.5%). One in three participants (32.2%) had ever received targeted advice from a professional focused on the use of compensation strategies for gait impairments in PD. Notably, 75.2% of respondents indicated that they would be interested to learn more about the available compensation strategies.

3.3 Use of compensation strategies

Of all respondents, 22.8% had never tried any form of compensation strategies before, despite experiencing clear and sometimes disabling gait impairments. Less than 1% of respondents had tried all seven categories of compensation strategies. The median number of categories that respondents had ever tried was two. Adapting a new walking pattern was most often tried (78.4% of respondents who were aware of it had ever tried it), followed by internal cueing (76.8%). Alternatives to walking was the least tried category (28.3%).

Overall, 64.7% of respondents still used one or more compensation strategies in daily life. Compensation strategies were most often used when walking outdoors, or in time-pressure situations, and were least often applied when attempting to stop walking or cross a doorway. The median number of categories used in daily life was one. Changing the balance requirements was the most widely used category. Among the 1,729 users of this category, 429 (24.8%) respondents used walking aids only, whereas 1,300 (75.2%) also employed other balance strategies (e.g. making a volitional weight shift to initiate gait). After changing the balance requirements, internal cueing was most often applied in daily life (71.7% of respondents who had tried it continued to use it), followed by altering the mental state (70.5%). External cueing was the least used category (55.3%).
Among the respondents using compensation strategies, 12.4% reported that they had felt obliged to switch to different strategies over time. Most often, this was due to PD progression, rendering some strategies too difficult or dangerous to apply (e.g. riding a bicycle). Another illustrative example included switching from walking over lines pasted to the floor to using a specialized Parkinson’s wheeled walker that is able to project a laser line on the floor. We found no suggestion that the effect of a certain strategy tapered off over time due to habituation.

3.4 Patient-reported efficacy of compensation strategies

The patient-reported efficacy of the different categories of compensation strategies is presented in Figure 1. While most respondents reported that application of compensation strategies positively affected their gait, not every respondent seemed to benefit from every category of strategies. When the efficacy of the strategies was averaged across contexts, changing the balance requirements had the highest success rate in improving gait (76%), whereas external cueing showed the relatively lowest success rate (62%).

Importantly, the efficacy of compensation strategies varied greatly depending on the context in which they were applied (Figure 2). Internal cueing, for example, seemed highly effective during gait initiation (73% success rate), but was deemed to be less useful when attempting to stop walking (47%). Similarly, action observation and motor imagery could be a successful strategy when walking outdoors (83% success rate), but seemed to be less helpful when applied in a narrow space (55%). In general, compensation strategies were most effective when walking outdoors (84% success rate), or during gait initiation (79%). Strategies were deemed least effective during an attempt to stop walking (54% success rate) or cross a doorway (65%). While reports of negative effects of compensation strategies were relatively scarce (this occurred in around 3% of cases), paradoxical aggravation of gait deficits was occasionally reported in stress-inducing or dual-task situations, including time-pressure situations (6%), walking in narrow spaces or crowded areas (7%), and walking while talking or carrying something (7%).

3.5 Subgroup data

The awareness and use of compensation strategies for gait impairments in PD did not differ between subgroups based on sex, freezing status, age (cut-off: 65 years old), time since diagnosis (cut-off: 5 years), and the ability to perform a dual task (persons with little to no difficulties vs. persons with more severe difficulties).
There were also no differences in the reported efficacy of different strategies between these subgroups, except for a slightly higher success rate among younger patients for external cueing and adopting a new walking pattern, and among persons who had little to no difficulty dual tasking for motor imagery and action observation (Table 3).

4. DISCUSSION

A web-based survey among 4,324 persons in the Fox Insight and ParkinsonNEXT (NL) cohorts was conducted to make an inventory of patients’ perceptions of compensation strategies for gait impairments in PD. The main findings of this study were: (1) compensation strategies are commonly used by persons with PD and gait impairments, although their awareness of the full spectrum of available strategies is limited; (2) the patient-rated efficacy of compensation strategies is high, but varies depending on the context in which they are applied; and (3) the efficacy of compensation strategies varies per person, emphasizing the need for a more personalized approach to gait rehabilitation in PD. We will next discuss these findings in further detail.

First, considering the severity of walking difficulties that respondents expressed, we consider the awareness of the full spectrum of compensation strategies among persons with PD to be rather limited. The median number of known categories was three out of seven, and a striking one in five patients had no prior awareness of any of the compensation strategies for gait impairments. About half of the respondents had acquired this knowledge themselves, through reading or personal experience. Notably, only one in three patients had ever received targeted advice from a professional, focused specifically on strategies to overcome gait impairments. Moreover, only 1% of patients had tried strategies from all seven categories available. A previous study among healthcare professionals in the Netherlands demonstrated that only 23% of PD healthcare professionals (i.e. physiotherapists, occupational therapists) apply all seven categories of compensation strategies in clinical practice when working with PD patients experiencing gait impairments, due to the lack of specific knowledge and skills in this field. Considering that PD care in the Netherlands is organized in a high-standard professional network of therapists who have received dedicated PD-specific training and treat large numbers of patients (ParkinsonNet), this percentage might be an overestimation of the global knowledge and application of compensation strategies among PD healthcare professionals. This may also explain why Dutch respondents from ParkinsonNEXT knew more strategies than respondents from Fox Insight.
Regardless of the underlying explanations, it is evident that both persons with PD and PD healthcare professionals\textsuperscript{19} are interested in learning more about compensation strategies. Integrating the use of compensation strategies into educational programs, or developing a dedicated online platform about the various available strategies, might facilitate finding a suitable strategy for every person with PD who experiences gait impairments. This notion is underscored by the present findings, showing that the application of a single strategy is often insufficient, as different contexts may require different types of strategies, or because individual patients simply respond better to one specific strategy compared to another. Also, our findings show that the feasibility of a previously successful strategy may diminish over time because of progression of disability, emphasizing the need to have a broader spectrum of compensation strategies available so that a customized renewed approach can be identified for any given individual patient. In the present work we did not investigate whether knowing more compensation strategies positively affected a person’s perceived quality of life, but this could be a topic of future investigations.

Second, the overall patient-rated efficacy of compensation strategies is high across all seven categories. Interestingly, while the main body of scientific work on compensation strategies has thus far focused on external cueing – perhaps because external cueing is easily controllable in a lab setting –,\textsuperscript{21-24} it is the least effective category according to patients. Unsurprisingly, since it is the most commonly known and applied category among PD healthcare professionals,\textsuperscript{19} the existence of external cueing was widely known among respondents. Yet, only few patients actually applied external cues in their daily lives. In contrast, strategies changing the balance requirements and altering the mental state were deemed to be most effective, and were accordingly most often used. These categories may be more accessible and feasible for persons with PD, as they typically do not require specific devices (e.g. laser shoes, a metronome) or adaptations to the environment (e.g. 2- or 3D patterns on the floor). They may also be preferred because they are relatively less noticeable to bystanders, avoiding stigmatization or feelings of embarrassment.\textsuperscript{25,26} As such, our findings reinforce the notion that all categories of compensation - and not just external cueing – deserve further systematic investigation.

Importantly, the effects of compensation strategies vary depending on the context in which they were applied, underlining the importance of a tailored approach to gait rehabilitation. We were struck by the relatively modest effect of compensations strategies during attempts to stop walking. More work is needed to clarify
why gait termination is less influenced by applying compensation strategies, and what alternative strategies could be developed to ameliorate this.

Another notable finding was that some respondents experienced a negative effect of compensation strategies during stress-inducing or dual-task situations. In PD, gait deficits are generally exacerbated while performing dual tasks, because the need to concentrate on executing the concurrent task interferes with the patient’s ability to focus purposefully on gait.\textsuperscript{27-29} Compensation strategies are believed to aid in prioritizing tasks, and in allocating attention to gait.\textsuperscript{14} However, the introduction of an additional task—namely, the application of a compensation strategy—might exceed the attentional resources in certain individuals, causing a paradoxical aggravation of walking difficulties, instead of an improvement.\textsuperscript{17} This is also reflected in the present study, by the slightly higher efficacy ratings of respondents with little to no difficulties dual tasking, compared to respondents with more difficulties dual tasking.

Third, the efficacy of compensation strategies varies per person. Exploratory subgroup examinations based on age, sex, freezing status and disease duration, however, did not demonstrate truly remarkable differences in the patient-rated efficacy of the different categories of compensation strategies. In general, compensation strategies seem to be useful in all types of PD patients, and further work is needed to investigate optimal predictors of the effects of the different types of strategies for individual patients. Ideally this would be investigated in a prospective clinical trial, in which a clinician could also examine the severity of gait impairments present, and the efficacy of the different strategies could be quantified using more objective measures (e.g. improvement of spatiotemporal gait parameters, including gait variability).

Our study was not without shortcomings, and some of our findings should be interpreted with caution. Participants of both cohorts may well have been a selected and rather proactive sample of the overall PD population. Although the response rate was high for a survey study, particularly in the Fox Insight cohort, respondents may have been the most informed or motivated persons with PD. In addition, we were unable to retrieve information on the main characteristics of non-responders from within the Fox Insight sample. The self-reported nature of the survey is further reason for caution, for example because the extent of the gait disability could not be confirmed by an independent neurological examination. As PD diagnosis is also self-reported, we cannot exclude the possibility that some patients in fact had a form of atypical parkinsonism, which may respond in a different way to compensation strategies than PD. At the same time, it is quite
possible that persons with atypical parkinsonism will also benefit from compensation strategies, and such compensation may be particularly important for these patients as medication is generally much less effective in improving their gait impairments. Another limitation of our study is the lack of objective information about the respondents’ cognitive status, as cognitive deficits may impede the ability to use particular categories of compensation strategies.\textsuperscript{17,30} It is possible that a certain degree of cognitive reserve is imperative to be able to compensate for gait impairments.\textsuperscript{31} The potential effect of impaired cognition might be particularly relevant for compensation strategies that are inherently cognitive tasks, such as internal cueing (e.g., counting while walking). Further studies should aim to include a more heterogeneous study population in terms of cognitive status, and include more objective measures of cognition (e.g., the Mini Mental State Examination or Montreal Cognitive Assessment) to gain more insight into the interplay between cognition and the ability to compensate for gait impairment in PD.

In conclusion, the present findings support the application of compensation strategies for gait impairments in PD, and emphasize that a one-size-fits-all approach to gait rehabilitation is inappropriate. Persons with PD should be—and wish to be—more thoroughly informed about the range of available strategies. Importantly, the choice of compensation strategies should be tailored to the individual patient, as well as to the contexts in which the strategies need to be applied. Further prospective studies are vital to further crystallize these findings, and eventually incorporate them into evidence-based protocols, thus paving the way towards a more personalized approach to gait rehabilitation in PD.
REFERENCES


**TABLES**

**Table 1. Proposed categorization of compensation strategies by Nonnekes et al. (JAMA Neurology 2019)**

<table>
<thead>
<tr>
<th>Compensation category</th>
<th>Description</th>
<th>Phenomenology†</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. External cueing</td>
<td>Typically rhythmic external stimuli, that may be auditory, somatosensory, or visual.</td>
<td>Walking to the beat of a metronome; wearing vibrating socks; stepping over lines.</td>
</tr>
<tr>
<td></td>
<td>Internal cueing</td>
<td>Focusing attention on (predetermined components of) gait.</td>
</tr>
<tr>
<td>---</td>
<td>----------------</td>
<td>--------------------------------------------------------</td>
</tr>
<tr>
<td>3.</td>
<td>Changing the balance requirements</td>
<td>Facilitating the ability to make lateral weight shifts.</td>
</tr>
<tr>
<td>4.</td>
<td>Altering the mental state</td>
<td>Enhancing general alertness and arousal, leading to increased motivation or relaxation.</td>
</tr>
<tr>
<td>5.</td>
<td>Action observation and motor imagery</td>
<td>NA</td>
</tr>
<tr>
<td>6.</td>
<td>Adapting a new walking pattern</td>
<td>Changing the straight gait pattern, or using other forms of locomotion.</td>
</tr>
<tr>
<td>7.</td>
<td>Other forms of using the legs to move forward</td>
<td>NA</td>
</tr>
</tbody>
</table>

NA = not applicable.

*A more comprehensive list of examples is provided in previous work by Nonnekes et al. (JAMA Neurology 2019).*

14
Table 2. Characteristics of included respondents

<table>
<thead>
<tr>
<th></th>
<th>Total cohort</th>
<th>Fox Insight</th>
<th>ParkinsonNEXT (NL)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Respondents (n)</td>
<td>4324</td>
<td>3663</td>
<td>661</td>
<td></td>
</tr>
<tr>
<td>Men (n (%))</td>
<td>2387 (55.3)</td>
<td>1960 (53.6)</td>
<td>427 (64.6)</td>
<td>&lt;0.001a</td>
</tr>
<tr>
<td>Age (years)</td>
<td>67.8 ± 9.0</td>
<td>68.0 ± 9.0</td>
<td>66.4 ± 8.6</td>
<td>&lt;0.001a</td>
</tr>
<tr>
<td>Time since diagnosis (years)</td>
<td>6.7 ± 5.3</td>
<td>6.7 ± 5.4</td>
<td>6.5 ± 4.6</td>
<td>0.51</td>
</tr>
<tr>
<td>Respondents with FOG (n (%))</td>
<td>1851 (42.8)</td>
<td>1652 (45.1)</td>
<td>199 (30.1)</td>
<td>&lt;0.001a</td>
</tr>
<tr>
<td>NFOG-Q score&lt;sup&gt;b&lt;/sup&gt; (median [range])</td>
<td>17 [1-28]</td>
<td>17 [1-24]</td>
<td>17 [5-28]</td>
<td>0.03&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Values are represented as mean ± SD, unless otherwise specified. NL = Netherlands; FOG = Freezing of gait; NFOG-Q = New Freezing of Gait Questionnaire (score range 0-28).<sup>18</sup>

<sup>a</sup> Statistically significant difference between Fox Insight cohort and ParkinsonNEXT cohort, as determined by independent samples t-test (means) or chi-square test (proportions).

<sup>b</sup> Among respondents with freezing of gait, defined by a non-zero NFOG-Q score.
Table 3. Subgroup-reported efficacy (% positive effect) of different compensation strategies for gait impairments in PD

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Men</th>
<th>Women</th>
<th>FOG+</th>
<th>FOG-</th>
<th>&lt;65yrs old</th>
<th>&gt;65yrs old</th>
<th>&lt;5yrs since PD diagnosis</th>
<th>&gt;5yrs since PD diagnosis</th>
<th>No/little difficulties dual tasking</th>
<th>More difficulties dual tasking</th>
</tr>
</thead>
<tbody>
<tr>
<td>External cueing (n=560)</td>
<td>60.2</td>
<td>63.2</td>
<td>62.4</td>
<td>58.9</td>
<td>66.4&lt;sup&gt;b&lt;/sup&gt;</td>
<td>59.4&lt;sup&gt;b&lt;/sup&gt;</td>
<td>63.0</td>
<td>61.6</td>
<td>63.3</td>
<td>59.7</td>
</tr>
<tr>
<td>Internal cueing (n=861)</td>
<td>67.0</td>
<td>68.6</td>
<td>67.8</td>
<td>66.6</td>
<td>71.9</td>
<td>65.7</td>
<td>68.5</td>
<td>67.4</td>
<td>69.5</td>
<td>68.3</td>
</tr>
<tr>
<td>Changing the balance requirements (n=1208)</td>
<td>73.4</td>
<td>79.3</td>
<td>76.6</td>
<td>75.1</td>
<td>76.7</td>
<td>75.9</td>
<td>77.1</td>
<td>75.4</td>
<td>78.2</td>
<td>74.6</td>
</tr>
<tr>
<td>Altering the mental state (n=833)</td>
<td>72.7</td>
<td>76.1</td>
<td>75.9</td>
<td>71.4</td>
<td>73.5</td>
<td>74.6</td>
<td>73.6</td>
<td>74.5</td>
<td>76.3</td>
<td>72.5</td>
</tr>
<tr>
<td>Action observation and motor imagery (n=242)</td>
<td>65.8</td>
<td>60.0</td>
<td>61.8</td>
<td>65.5</td>
<td>66.9&lt;sup&gt;c&lt;/sup&gt;</td>
<td>62.0</td>
<td>66.8</td>
<td>60.9</td>
<td>69.4&lt;sup&gt;d&lt;/sup&gt;</td>
<td>58.8&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Adapting a new walking pattern (n=760)</td>
<td>66.5</td>
<td>67.8</td>
<td>67.6</td>
<td>66.0</td>
<td>71.9&lt;sup&gt;c&lt;/sup&gt;</td>
<td>65.2&lt;sup&gt;c&lt;/sup&gt;</td>
<td>69.5</td>
<td>66.0</td>
<td>69.6</td>
<td>68.0</td>
</tr>
</tbody>
</table>

Sample sizes represent the number of respondents who indicated to have ever tried that specific category of strategies. Values represent the percentage of respondents experiencing a positive effect averaged across all contexts to provide an overall indication of efficacy. Comparative analyses were performed using a chi-square test. FOG+ = freezers; FOG- = non-freezers.

<sup>a</sup> Based on the Fox Insight questionnaire “Your cognition and daily activities”: how much difficulty do you experience doing more than one thing at a time?

<sup>b</sup> \( p=0.04 \)

<sup>c</sup> \( p=0.05 \)

<sup>d</sup> \( p=0.01 \)

Copyright © 2021 The Author(s). Published by Wolters Kluwer Health, Inc. on behalf of the American Academy of Neurology.
Figure 1. Overall patient-reported efficacy of different compensation strategies for gait impairments in PD

Sample size represents the number of respondents who indicated they had ever tried that specific category of strategies. Values represent the percentage of respondents experiencing a positive effect averaged across all contexts to provide an overall indication of efficacy.

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Positive effect (%)</th>
<th>No effect/negative effect (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Changing the balance requirements (n = 1,208)</td>
<td>76</td>
<td>20 4</td>
</tr>
<tr>
<td>Altering the mental state (n = 833)</td>
<td>74</td>
<td>23 2</td>
</tr>
<tr>
<td>Internal cueing (n = 861)</td>
<td>68</td>
<td>27 5</td>
</tr>
<tr>
<td>Adapting a new walking pattern (n = 760)</td>
<td>67</td>
<td>28 5</td>
</tr>
<tr>
<td>Action observation and motor imagery (n = 242)</td>
<td>64</td>
<td>31 6</td>
</tr>
<tr>
<td>External cueing (n = 560)</td>
<td>62</td>
<td>33 6</td>
</tr>
</tbody>
</table>

Figure 2. Patient-reported efficacy (% indicating a positive effect) of different compensation strategies for gait impairments in PD, depending on the context in which they were applied.

Values represent the percentage of users experiencing a positive effect on gait impairments while applying a specific strategy in a specific context.
## When initiating or altering gait

<table>
<thead>
<tr>
<th></th>
<th>External cueing (n = 560)</th>
<th>Internal cueing (n = 861)</th>
<th>Changing the balance requirements (n = 1,208)</th>
<th>Altering the mental state (n = 833)</th>
<th>Action observation and motor imagery (n = 242)</th>
<th>Adapting a new walking pattern (n = 760)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gait initiation</td>
<td>67</td>
<td>73</td>
<td>88</td>
<td>84</td>
<td>69</td>
<td>70</td>
</tr>
<tr>
<td>Stopping</td>
<td>43</td>
<td>47</td>
<td>59</td>
<td>59</td>
<td>52</td>
<td>46</td>
</tr>
<tr>
<td>Turning</td>
<td>66</td>
<td>71</td>
<td>86</td>
<td>74</td>
<td>74</td>
<td>66</td>
</tr>
</tbody>
</table>

## In stress-inducing or dual-task situations

<table>
<thead>
<tr>
<th></th>
<th>External cueing (n = 560)</th>
<th>Internal cueing (n = 861)</th>
<th>Changing the balance requirements (n = 1,208)</th>
<th>Altering the mental state (n = 833)</th>
<th>Action observation and motor imagery (n = 242)</th>
<th>Adapting a new walking pattern (n = 760)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time-pressure situation</td>
<td>60</td>
<td>70</td>
<td>74</td>
<td>77</td>
<td>64</td>
<td>69</td>
</tr>
<tr>
<td>Activity of daily living</td>
<td>58</td>
<td>63</td>
<td>79</td>
<td>79</td>
<td>60</td>
<td>65</td>
</tr>
<tr>
<td>While carrying something</td>
<td>63</td>
<td>72</td>
<td>77</td>
<td>79</td>
<td>63</td>
<td>68</td>
</tr>
<tr>
<td>While talking</td>
<td>59</td>
<td>66</td>
<td>69</td>
<td>68</td>
<td>65</td>
<td>70</td>
</tr>
</tbody>
</table>

## When adapting to the environment

<table>
<thead>
<tr>
<th></th>
<th>External cueing (n = 560)</th>
<th>Internal cueing (n = 861)</th>
<th>Changing the balance requirements (n = 1,208)</th>
<th>Altering the mental state (n = 833)</th>
<th>Action observation and motor imagery (n = 242)</th>
<th>Adapting a new walking pattern (n = 760)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passing a doorway</td>
<td>62</td>
<td>64</td>
<td>69</td>
<td>64</td>
<td>58</td>
<td>64</td>
</tr>
<tr>
<td>In a narrow space</td>
<td>60</td>
<td>66</td>
<td>75</td>
<td>74</td>
<td>55</td>
<td>64</td>
</tr>
<tr>
<td>In a crowd</td>
<td>60</td>
<td>68</td>
<td>77</td>
<td>77</td>
<td>60</td>
<td>67</td>
</tr>
<tr>
<td>Outdoors</td>
<td>79</td>
<td>86</td>
<td>84</td>
<td>81</td>
<td>84</td>
<td>85</td>
</tr>
</tbody>
</table>
Perception and Use of Compensation Strategies for Gait Impairment by Persons With Parkinson Disease
Anouk Tosserams, Lisanne Wit, Ingrid H.W.M. Sturkenboom, et al.
Neurology published online September 8, 2021
DOI 10.1212/WNL.0000000000012633

This information is current as of September 8, 2021

Updated Information & Services
including high resolution figures, can be found at:
http://n.neurology.org/content/early/2021/09/08/WNL.0000000000012633.full

Subspecialty Collections
This article, along with others on similar topics, appears in the following collection(s):
All Rehabilitation
http://n.neurology.org/cgi/collection/all_rehabilitation
Class IV
http://n.neurology.org/cgi/collection/class_iv
Parkinson's disease/Parkinsonism
http://n.neurology.org/cgi/collection/parkinsons_disease_parkinsonism

Permissions & Licensing
Information about reproducing this article in parts (figures,tables) or in its entirety can be found online at:
http://www.neurology.org/about/about_the_journal#permissions

Reprints
Information about ordering reprints can be found online:
http://n.neurology.org/subscribers/advertise

Neurology® is the official journal of the American Academy of Neurology. Published continuously since 1951, it is now a weekly with 48 issues per year. Copyright Copyright © 2021 The Author(s). Published by Wolters Kluwer Health, Inc. on behalf of the American Academy of Neurology. All rights reserved. Print ISSN: 0028-3878. Online ISSN: 1526-632X.