Compensation Strategies for Gait Impairments in Parkinson Disease
A Review

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➕ Video

IMPORTANCE Patients with Parkinson disease can use a wide variety of strategies to compensate for their gait impairments. Examples include walking while rhythmically bouncing a ball, crossing the legs when walking, or stepping over an inverted cane. An overview and classification of the many available compensation strategies may contribute to understanding their underlying mechanisms and developing focused rehabilitation techniques. Moreover, a comprehensive summary of compensation strategies may help patients by allowing them to select a strategy that best matches their needs and preferences and health care professionals by permitting them to incorporate these into their therapeutic arsenal. To create this overview, this narrative review discusses collected video recordings of patients who spontaneously informed clinicians about the use of self-invented tricks and aids to improve their mobility.

OBSERVATIONS Fifty-nine unique compensation strategies were identified from approximately several hundred videos. Here, these observed strategies are classified into 7 main categories for elaboration on their possible underlying mechanisms. The overarching working mechanisms involve an allocation of attention to gait, the introduction of goal directedness, and the use of motor programs that are less automatized than those used for normal walking.

CONCLUSIONS AND RELEVANCE Overall, these compensation strategies seem to appeal to processes that refer to earlier phases of the motor learning process rather than to a reliance on final consolidation. This review discusses the implications of the various compensation strategies for the management of gait impairment in Parkinson disease.

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Gait disorders in Parkinson disease (PD) are among the most disabling symptoms of the disease because they significantly limit mobility and often result in falls and fall-associated injuries. Gait impairments in PD range from a reduced gait speed and smaller stride length to freezing of gait (FOG), which is characterized by sudden, relatively brief episodes of inability to produce effective forward stepping.[1,2] The pathophysiology underlying gait impairments in PD and FOG in particular is complex and involves dysfunction of several supraspinal structures in the locomotor network, including the basal ganglia.[2] The degree of basal ganglia dysfunction in an individual with PD is not equally distributed across the various components of the basal ganglia; the loss of dopaminergic innervation and therefore dysfunction is greatest in the posterior putamen,[3] a region that is associated with the control of automatized (or habitual) behavior.[4] In contrast, dopaminergic innervation to the rostromedial striatum, a region that is primarily involved in the production of goal-directed movements, is relatively spared.[4] Translated to gait, this means that patients with PD

may experience difficulties walking in an automatic manner (ie, without consciously paying attention to it). As a consequence, patients must progressively rely on a goal-directed control of their gait. This goal-directed control of movements is possible in the presence of a clear external stimulus because patients find it difficult to internally generate movements (ie, producing identical movements in the absence of an external cue).[5]

In addition to basal ganglia dysfunction, disturbances in other parts of the locomotor network, including cortical regions (eg, frontal cortices involved in executive functions), midbrain locomotor regions, and brain stem structures, contribute to gait disturbances in PD as well.[2,6] This implies that patients not only manifest a reduced automaticity of walking but also experience other problems, such as difficulties to produce adequate postural adjustments necessary for walking in a safe and efficient manner. Also, cognitive deficits influence gait dysfunction and the regularity of walking.[7] In addition, cognitive dysfunction may also hamper an efficient switching from habitual to goal-directed gait control.[8]

Table 1. Classification of Compensation Strategies for Gait Impairments in Parkinson Disease and Their Possible Working Mechanism

Compensation Strategy	Principal Mechanism	Phenomenology
Restoring walking		
Using external cues	External stimuli provide a movement reference or target, which introduces goal-directed behavior and may initiate cortically generated movements by bypassing automatic motor control. Rhythmicity and sensory cues might be valuable. Sensory cues may theoretically also assist in filtering information and prioritizing tasks, especially during response selection under conflict (improving executive attention).	Using auditory cues, typically rhythmic; single or rhythmic, 2-dimensional or 3-dimensional visual cues; or somatosensory cues, often rhythmic
Using internal cues	Acts as single cue or trigger for start, not as a continuous cue. Helps to achieve focused attention toward specific components of gait, to shift automatic motor control into a goal-directed one.	Focusing on predetermined components of gait; mental arithmetic or self-prompting
Changing balance requirements	Facilitates ability to make lateral weight shifts, thereby easing the swing phase of the unloaded leg, particularly in gait initiation, turning, or approaching.	Narrowing the base of support; shifting weight in place prior to stepping; making wider turns; using walking aids or supported walking
Altering the mental state	Enhancing general alertness and arousal. This may help to shift automatic motor control to a goal-directed one.	Limiting anxiety or fear of falling; increasing motivation; experiencing kinesia paradoxa
Motor imagery or action observation	Both processes involve activation of the mirror neuron system, simulate the real action, and can be considered as offline operations of the motor system. It might help to generate cortically generated movement more directly.	NA
New walking pattern	Using alternate motor programs less overlearned and less dependent on automatized generation by the basal ganglia, since walking difficulty might be a task-specific problem.	Changing the straight gait pattern (eg, scissoring, skating movements, knee lifting); using other forms of locomotion (eg, jumping, running, backward walking)
Alternatives to normal walking		
Other forms of using the legs to move forward	Examples include bicycling, ice skating, and crawling.	NA
Mixed methods	Variable combination of other mechanisms.	NA

Abbreviation: NA, not applicable.

Patients with PD often spontaneously use a variety of strategies to compensate for their suboptimal control of locomotion. Examples include walking while rhythmically bouncing a ball, crossing the legs when walking, or counting while they are walking. Such strategies are aimed both at maintaining an optimal gait pattern (preventing gait decline) and regaining a more normal gait pattern once an episode of FOG has occurred. Several compensation strategies have been described in the literature,[9-13] typically on an anecdotal basis, but a comprehensive overview and classification of available strategies is currently lacking, to our knowledge. Such an overview is important, because analyzing common traits of compensation strategies may contribute to understanding their underlying mechanisms and developing focused rehabilitation techniques. Moreover, a comprehensive summary of compensation strategies may serve as a source of inspiration for patients, allowing them to select a strategy that best matches their personal needs and preferences and health care professionals to now incorporate this repertoire into their therapeutic arsenal. Finally, we see this article as something of a tribute to the patients' impressive creativity, resilience, and intrinsic motivation to cope with their disease.

Methods

To provide an overview of the available compensation strategies for gait impairments in individuals with PD, we collected video recordings of patients who had spontaneously informed us about the use of self-invented tricks and aids to improve their mobility. Specifically, we asked them to bring home videos showing the strategies they were using to walk indoors or outdoors. In some cases, additional videos were recorded during the patients' visits in the consulting room or hospital. Moreover, we searched our personal video databases for videos of patients with PD who used compensation strategies to overcome their gait deficits. Finally, we performed a literature search of PubMed to identify further anecdotal examples, using the following search terms: *gait*, *Parkinson*, *parkinsonism*, *treatment*, *compensation*, and *cueing*. Over a period of 4 years, we collected 59 unique compensation strategies from several hundred videos (without counting all videos retrieved and viewed). We stopped our search strategy when we felt that data saturation had been reached.

Many strategies appeared to resort to 1 of several basic compensation mechanisms. Using the available literature and our clinical experience, we reached agreement on a classification scheme for compensation strategies for gait deficits in patients with PD (**Table 1**). This classification scheme entails 7 main categories of compensation strategies, which are thought to have a different underlying working mechanism. After constructing the classification scheme during a face-to-face discussion, we subsequently reached consensus during a series of teleconferences on classification of each collected video into these predefined compensation categories (**Table 2**). Here, we will elaborate on the observed strategies and possible underlying working mechanisms and their implication for the management of gait impairments in individuals with PD.

Classification of Compensation Strategies

External Cueing

The first main compensation strategy involves cueing. External cues are perhaps the most commonly known compensation strategy for gait impairments in individuals with PD, and this is reflected by the large number of videos that we collected that all showed some form of external cueing. We collected 26 unique strategies (44% of all 59 strategies) involving a form of external cueing (Table 2). External cues refer to meaningful auditory, proprioceptive, or visual stimuli that

Table 2. Video-Illustrated Compensation Strategies and Possible Underlying Mechanisms

Compensation Strategy	Possible Underlying Mechanism[a]
Walking while rhythmically bouncing a basketball or tennis ball	Auditory cues, somatosensory cues, other forms of locomotion
Boulder hopping (jumping from stone to stone)	Visual cues, other forms of locomotion
Stepping over an inverted cane	Visual cues
Pressing temples with index fingers[b]	Somatosensory cues, focusing on predetermined components of gait, and motor imagery or action observation
Moving forward as if ice skating[b]	Change of the straight gait pattern
Lifting the knees very high	Change of the straight gait pattern
Holding the belt with both hands	Somatosensory cues
Improvement of gait when fencing	Increasing motivation, kinesia paradoxa, other forms of locomotion
Walking with a weight in each hand	Somatosensory cues
Upholding a football	Visual cues, other forms of locomotion
Jumping	Other forms of locomotion
Moving forward using a walk-bicycle	Walking aids or supported walking
Ice skating	Other forms of using the legs to move forward
Walking on a painted staircase illusion	Visual cues
Kicking a cane or a stick	Visual cues, change of the straight gait pattern
Walking sideways[b]	Other forms of locomotion
Making movements as if being a toreador	Increasing motivation, kinesia paradoxa, other forms of locomotion
Stepping over a laser beam projected via a belt, stick, or shoes	Visual cues
Cycling[b]	Other forms of using the legs to move forward
Walking at the rhythm of a metronome[b]	Auditory cues
Crossing the legs when walking	Change of the straight gait pattern
Walking with very large steps	Change of the straight gait pattern
Walking at the rhythm of music	Auditory cues
2-Dimensional visual cues placed in a regular pattern on the floor	Visual cues
3-Dimensional visual cues placed in a regular pattern on the floor[b]	Visual cues
Walking in water	Changing balance requirements
Watching another person walking before gait initiation in real life or via smartglasses	Motor imagery or action observation
Improvement of gait when playing badminton	Other forms of locomotion
Moving forward while dancing	Auditory cues, other forms of locomotion
Making wider turns	Changing balance requirements
Kicking a ball attached with a cord to the patients hand	Visual cues, change of the straight gait pattern
Jumping and running while playing basketball	Visual cues, increasing motivation, other forms of locomotion
Starting gait after having brought the arms behind the back	Focusing on predetermined components of gait
Feeling stable with cutaneous vibrations	Somatosensory cues
Improvement of freezing of gait under rhythmic paresthesias induced by spinal cord stimulation	Somatosensory cues
Walking with weights on the shoes	Somatosensory cues

(continued)

Table 2. Video-Illustrated Compensation Strategies and Possible Underlying Mechanisms (continued)

Compensation Strategy	Possible Underlying Mechanism[a]
Walking along a narrow beam	Visual cues, narrowing the base of support, increasing motivation, change of the straight gait pattern
Mounting and descending a ladder	Somatosensory cues, other forms of locomotion
Running[b]	Other forms of locomotion
Riding a scooter[b]	Other forms of using the legs to move forward
Roller skating	Other forms of using the legs to move forward
Walking upstairs	Visual cues, other forms of locomotion
Walking downstairs	Visual cues, other forms of locomotion
Walking on stilts	Other forms of locomotion
Kicking an object that is sliding forward on the floor	Visual cues, change of the straight gait pattern
Gliding feet on a smooth floor	Change of the straight gait pattern
Jumping forward with propping both arms upon handrails	Other forms of locomotion
Making sidestep before stepping forward	Change of the straight gait pattern
Walking after lifting body weight while sitting on the floor	Increasing motivation
Walking after tensing trunk muscles by bending backward	Focusing on predetermined components of gait, increasing motivation
Walking after tensing lower limbs	Focusing on predetermined components of gait, increasing motivation
Walking backward	Other forms of locomotion
Stepping over someone else's foot to initiate walking	Visual cues
Stepping over own foot to initiate walking	Visual cues, focusing on predetermined components of gait, narrowing the base of support, change of the straight gait pattern
Weight shifting in place before gait initiation	Weight shifts in place prior to stepping
Turning with medial shift of base of support by lifting the arm	Narrowing the base of support, change of the straight gait pattern
Making a heel strike at every count[b]	Focusing on predetermined components of gait
Turning while thinking about better weight shift	Focusing on predetermined components of gait

[a] Terms used in the Category column occur in Table 1.

[b] See **Video**.

invigorate and facilitate motor sequences.[14] These external stimuli provide a movement reference or target that is most likely predictive in nature.[15] Examples include walking at the rhythm of a metronome,[1] stepping over 2-dimensional or 3-dimensional visual cues placed in a regular pattern on the floor,[11] and stepping over a laser beam (projected via a walker, belt, stick, or shoe). The beneficial effects of external cueing are endorsed by a review on external cueing that included studies with FOG as primary or secondary outcome.[16] In 6 of 10 studies, online auditory or visual cueing applied during ongoing gait reduced FOG in patients in the off-medication state. The 4 negative studies were conducted while patients were on-medication, suggesting that cues were either not effective when patients used their dopaminergic medication or, most likely, that the statistical power was too low in this disease state to

be able to detect a meaningful change. The response to cueing usually depends on the type of external cue; spatial (visual) cues correct and regulate the scaling and amplitude generation during walking, whereas temporal (auditory) cues facilitate gait timing and interlimb coordination.[17,18]

The mechanisms underlying external cueing might be 2-fold. First, external cues introduce goal-directed behavior, which circumnavigate those parts of the basal ganglia that are involved in automatized motor control and rely on regions of the basal ganglia that are less severely affected by loss of dopaminergic innervation.[4] Goal-directed control of movements in PD generally improves in the presence of external stimuli,[5] which might explain why external cues are so often used.[19,20] The exact neural networks involved in restored response generation using external stimuli have to be unraveled by future studies, but compensation might involve the cerebellum, the superior parietal cortex, and dorsal premotor cortex, besides the rostromedial striatum involved in goal-directed behavior.[21,22] A second working mechanism might be that cues assist in filtering information and prioritizing a stimulus, especially during response selection under conflict (which is often the case in the complex real-life world). Control of gait is not just dependent on motor circuitries but also on intact executive function, which is regulated by the frontostriatal circuitry. Patients with PD who experience FOG often display executive dysfunction, resulting in difficulties in response selection under conflict.[20] External cues might compensate for this deficit and improve executive attention a hypothesis that is supported by the robust finding that auditory cueing is beneficial during dual tasking.[23,24]

Internal Cueing

Patients can also use internal cues to compensate for their gait impairments.[13] In keeping with the concept that gait impairments in PD are partly owing to an automaticity deficit, behavioral strategies are needed to shift patients' automatic motor control to a goal-directed one.[4] Rather than being guided by external input, patients can also use internal cues to orient or focus attention toward gait by using specific self-prompting instructions[13,25] or concentrating on predetermined components of gait (eg, making a heel strike at every count [Video]). Orienting is thought to involve prefrontal areas (frontal eye fields) and parietal areas.[26] Obviously, these compensation strategies are not visible on videos, but patients frequently report to use these internal compensation strategies.[13]

Some patients also use tricks that help them to allocate their attention to gait, and these tricks can be seen on a video. Examples include a patient that pressed his index fingers against his temples before gait initiation,[9] a patient that started gait after having brought his arms behind his back, and a patient that tensed his trunk muscles by bending backward before starting to walk.

Motor Imagery and Action Observation

Motor imagery and action observation are compensation strategies that at first sight seem to be a form of internal cueing. However, both processes differ from internal cueing as they stimulate, to some degree, the real action including all its components.[27,28] They can be considered as offline operations of the motor system, which is not the case during internal cueing. During action observation, a patient observes someone else walking, whereas during motor imagery, the patient rehearses and imagines to carry out the full mo-

tor act (in this case walking) in the absence of overt motor output.[29] Motor imagery and action observation likely compensate for reduced automaticity by mental simulation[30] or visualization of the action of gait without its actual execution. Both compensation strategies imply activation of the mirror neuron system[31] and involve the supplementary motor area, the dorsal premotor cortex, the supramarginal gyrus, and the superior parietal lobe.[32] However, there are also several nonoverlapping regions involved, which indicate that motor imagery and action observation are clearly distinct phenomena. For example, motor imagery has been associated with activation of the ventral premotor cortex, whereas action observation has been associated with additional activation located in the temporal pathways.[33]

Altering the Mental State

Alteration of the mental state is another compensation strategy that might help shift to a goal-directed mode of control. In extreme forms, this is observed during paradoxical kinesia, which is defined as the sudden transient ability of patients with PD to perform a task they were previously unable to perform, usually when facing an immediate threat.[34] A classic example is the patients' marked improvement of gait directly after an earthquake.[35] Obviously, paradoxical kinesia cannot be used as a compensation strategy on a daily basis. However, improvements of gait impairments owing to increased motivation might have a similar working mechanism, involving an enhancement of alertness or arousal. Importantly, altering the mental state does not have the same working mechanism as internal cueing; internal cueing is thought to achieve focused attention toward specific aspects of gait, whereas an alteration of the mental state results in a more generic increase in attention. This alerting role of attention is thought to involve activation of the noradrenergic network in thalamic, frontal, and parietal areas[26] and cholinergic corticopetal networks.[36] With respect to paradoxical kinesia, it has also been suggested that the working mechanism could involve a burst of dopamine release from basal ganglia reserves, thus restoring automaticity and self-initiation of movements.[34] Alternatively, paradoxical kinesia may, at least some of the time, also be because of a shift to external control (for example, when throwing a ball at a patient, who then can suddenly lift the arms).

Changing the Balance Requirements

Another compensation strategy involves a change of balance requirements during gait. In contrast with the compensation strategies described above, most of these motor strategies do not target a change of the neural circuits involved in the production of gait, but rather adapt walking such that the postural demands are reduced. This is needed as patients with PD and especially those with FOG can have difficulties to make an appropriate lateral weight shift onto the stance leg preceding a step to unload the stepping leg. Such anticipatory postural adjustments have been identified during gait initiation using force plates and are frequently too small in patients with PD.[37-39] However, small anticipatory postural adjustments are presumably not the cause of FOG, because these postural adjustments have been reported to be larger during trials of individuals with FOG compared with trials of individuals without FOG.[39] More likely, patients may have difficulties integrating the weight shift with the ensuing step, possibly resulting in FOG with alternating trembling of the legs.[40,41] Reduced postural adjustments have been at-

tributed to reduced brain activity in the supplementary motor area,[42,43] whereas difficulties in integrating postural adjustments with subsequent steps might be owing to dysfunction at the level of the pedunculopontine nucleus and pontomedullary reticular formation.[44,45] Several strategies compensate for dysfunction of these structures by reducing the need to make a lateral weight shift or by facilitating the integration between postural adjustments and steps. We collected 7 unique compensation strategies that involved a change of the balance requirements. One common applied strategy is to make wider rather than narrow turns, which presumably facilitates the integration between weight shifts and steps compared with the more delicate integration when making a narrow turn. Another example is the use of a walk-bicycle, which is a specific bicycle without pedals and a low seat that allows stepping movements without the need for generating postural adjustments.[46] In fact, 1 of various explanations why many patients with FOG can still ride a bicycle with considerably fewer difficulties is also associated with this weight shifting, which is not needed when patients are seated on their buttocks.[47]

Adapting a New Bipedal Locomotor Pattern or Using Alternatives for Walking

Another category of compensation strategies is the adoption of a new walking pattern. A new walking pattern uses alternative motor programs that are less overlearned than those involved in normal walking and therefore less dependent on automatic generation by the basal ganglia. Usually, these movements are not completely new but have been learned previously; associated motor programs have been consolidated but refer to earlier phases of the motor learning process rather than to a reliance on final consolidation. We have collected 28 unique videos of patients who had altered their normal walking pattern. Examples include patients who lift their knees very high or walk as if they are ice skating (**Video**). In addition to these relatively small adaptions, we have also observed large adaptations of the normal walking pattern, such as a patient who was unable to walk forward but could walk backward, and patients who showed an improved gait pattern when walking sideways (a so-called crab walk; **Video**) or running (**Video**). Running and walking sideways or backward is presumably less overlearned than normal walking. This hypothesis is supported by observations in patients with dystonia, another movement disorder involving dysfunction of the basal ganglia,[48] in which abnormal postures are often observed during walking but not running or walking backward.[49]

Other Forms of Using the Legs to Move Forward

Yet another compensation category, one that is somehow associated with the adaption of a new walking pattern, involves other forms of using the legs to move forward. An already classic illustration is the preserved ability of many patients to ride a bicycle (**Video**),[10] which appears to be a common phenomenon in countries where cycling is prevalent.[50] Others examples are patients who are able to ice skate or ride a scooter (**Video**) without any problems, despite impairments during walking. For an extensive discussion of all possible mechanisms underlying the preserved ability to cycle in patients with PD, we refer to a viewpoint article by Snijders et al.[47] One possibility is that the motor system is organized according to tasks, and some of these tasks, such as walking, are affected by PD, whereas others, such as ice skating or riding a bicycle, are not affected. This

might be associated with the prior amount of learning, suggesting that cycling and ice skating are less overlearned than walking. Another hypothesis is that during these alternative movements, a different control mode of repetitive cycles is required, which is driven by external cueing (bicycling) or attentional control (ice skating). As mentioned, there is less need to create lateral weight shifts during cycling than walking. Moreover, the pedals are usually coupled, which restores the symmetry of leg movements in this typically asymmetric disease. In contrast, during real or mimicked ice skating, large lateral weight shifts are essential to prevent a fall. This explicit urge to make a large lateral weight shift to prevent a fall might explain why some patients are inclined to use this strategy.

Combination of Compensation Strategies

Nineteen videos may have involved a combination of the aforementioned working mechanisms. One example is a patient who showed a significant improvement of his gait pattern when rhythmically bouncing a ball (**Video**). Rhythmically bouncing ball could act as a rhythmical auditory or somatosensory cue, but it may also trigger an alternative motor program that is less overlearned and therefore less dependent on automatic generation by the basal ganglia. Another commonly applied strategy is to purposely walk with a narrow base of support, which is typically seen in many patients with PD.[51] One may argue that this requires smaller postural adjustments compared with gait with a normal-to-wide stance width. However, it might also require alternative motor programs that are less overlearned than those involved in normal walking or involve a combination of both mechanisms. A final example of combined compensation strategies is the marked improvement of gait when climbing a staircase (**Video**). In the various videos that we collected, it seems that this is mainly beneficial when there is a large contrast between the separate steps of the stairway,[12] suggesting that the stairs serve as a 3-dimensional visual cue. However, another plausible explanation is that that climbing stairs involves a motor program that is less overlearned than normal walking. In addition, stairs could force patients to produce a more effective lateral weight shift to avoid stumbling.

Conclusions and Future Directions

The collected variety of compensation strategies highlights the enormous inventiveness of patients and their caregivers and underscores the need to collaborate with them to refine current treatment approaches. Overarching working mechanisms of compensation strategies seem to involve an allocation of attention to gait, the introduction of goal directedness, and the use of motor programs that are less overlearned than those used in normal walking. Overall, these strategies seem to appeal to processes that refer to earlier phases of the motor learning process rather than to a reliance on final consolidation.

An additional overarching working mechanism of all compensation strategies might be the reduction of anxiety. There is an increasing line of evidence that shows that anxiety is associated with FOG,[52-55] although it is still debated whether it plays a causal or modifying role. Several patients spontaneously reported that use of a compensation strategy reduced their fear to freeze, as it provided them with a backup plan. One example is a patient who showed a marked improvement of his gait pattern when walking with laser shoes,[56] although he actually did not look at the projected laser beams. When debriefed about this,

he told us that he indeed did not look at the cues for most of the time, but that he simply felt more comfortable having the laser shoes with him just in case.

Importantly, compensation strategies do not have the same effect in each individual patient and can sometimes also exaggerate gait impairments. This suggests that each supraspinal structure involved in the locomotion network is not affected to the same extent in each patient and the reduced neural reserve in patients with gait impairments creates a thin line between compensation-induced benefits as well as disturbances.[57] Translated to clinical practice, this implies that all patients with PD should be educated about the available compensation strategies, and that, together with an experienced therapist, the optimal compensation strategies for that specific individual should be identified. Such evaluations should not be limited to 1 occasion but must be repeated if the chosen strategies lose their effectiveness over time.

The reason for a possible reduction or loss of effectiveness of a particular compensation strategy might be 2-fold. First, the neural circuitry involved in the compensation strategy may also become affected by the underlying process of neurodegeneration. Second, when used frequently, compensation strategies can lose their efficacy when they become increasingly automated themselves, but this interesting hypothesis needs to be addressed by future studies.

This framework needs to be confirmed by future studies that further explore the underlying working mechanisms. Future work is also needed to improve the application of compensation strategies in daily life. A challenge is to now deliver external cueing safely and on demand in a user-friendly and effective manner in the patient's own natural environment. This requires the development of wearable sensors that can signal when gait deteriorates.[58] Recent work on such wearables is promising, but refinement is needed.[59] Moreover, recent technological advances improve the ability to provide external cueing in daily-life situations.[60,61] Examples include wearable minicomputers in the form of smart glasses to provide rhythmic visual cueing or augmented visual cues on top of the patient's visual field.[60,62] Another example is the laser shoe, which consists of a shoe equipped with a transverse line–generating laser mounted on the front tip, presenting horizontal lines to step over.[56,63] Different technological advancements may extend the use of other compensation strategies to daily life as well. Examples include the walk-bicycle[46] and smart glasses showing footages of someone walking, allowing action observation. Another example is the CuPiD system (University of Bologna), in which inertial measurement units combined with a smartphone application provide patients auditory real-time feedback on their gait-performance.[64] A challenge is to translate these new technological advancements into daily clinical practice, determine their clinical efficacy, and provide them to patients in combination with more conventional compensation strategies.

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