



**EISCSA State-of-the-Art Session**  
**“Deficit related strategies in walking and running”**

**Walking disorder and related intervention strategies in Parkinson’s disease (PD)**

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In the western hemisphere Parkinson’s disease is a very prevalent neurodegenerative disorder affecting mainly people of advance age (> 60 years). Besides the well known tremor the symptomatology is characterized by a multivariate structure (rigidity, akinesia, postural and gait disorder). The treatment is primarily based on a pharmaceutical compensation (L-Dopa) of low dopamine levels resulting from neural death in the substantia nigra. In the early stage of disease L-Dopa supplementation is commonly effective to reduce most of the symptoms, especially rigidity and akinesia. However, the more the disease proceeds, the lower are effectiveness and efficiency of pharmaceutical interventions (Braak et al. 2000). Especially postural and gait disorders become stronger and more frequent and L-Dopa administration is lowly effective to treat these symptoms (Jankovic 2002, Bronte-Steward et al. 2002). This is - among other things - of crucial importance since mobility deficits like gait impairment, postural instability, and history of falls are of highest concern for the quality of life in PD (Schrag et al. 2000). Further more maintaining a critical level of mobility is necessary in order to avoid nursing at home, losing independence and social contacts. In consequence and with respect to disease progression it is fundamentally important having treatment strategies which are effective to reduce severity of locomotion deficits in PD. The walking pattern of Parkinson’s patients shows multiple pathological components; however the basic structure is intact. Common deficits are:

- reduced stride length,
- shuffling walk,
- reduced velocity,
- no or reduced arm to leg synchronization,
- forward-leaning, stooped posture and
- limited adjustment of timing and length of steps to environmental conditions.

In later stage of disease patients’ walking pattern might be characterized furthermore by difficulties in starting (freezing) or stopping (hastening) to walk, maintaining constant stride frequency and walking velocity, passing narrow walkways and performing a second task while walking (Rubinstein et al. 2002 for review, Schwed & Haas 2009 for review). Moreover falls become more frequent. With respect to this multivariate deficit structure different approaches are available to reduce walking difficulties. From a behavioral point of view one can instruct

patients to avoid difficult situations like narrow walkways, crowded places, or motor demands which require dual tasking. Furthermore it is possible to compensate motor control deficits using an external cueing strategy. It is widely argued that the PD walking pattern results from deficits within the internal cueing process by the reason of a reduced gain in the motor commands. In multiple experiments (Rubinstein et al. 2002 for review, Schwed & Haas 2009 for review) it could be shown that deficits in the internal cueing can be compensated by presenting adequate external cues (auditory, visual, tactile). Using monotonous rhythmical auditory cues – which's frequency is slightly above the stride frequency of the patient – one can achieve spontaneous improvements in various gait parameters (stride frequency, stride length, velocity). However, studies which analyzed carry-over effects and transferability of auditory cueing to everyday motor demands show heterogeneous results (Schwed & Haas 2009 for review). Principally, cueing seems more successful if it is combined with gait training.

Similar to auditory cueing gait improvements can also be achieved by visual cueing. Thus markers on the floor assist patients' gait rhythm (steps follow each other) and lead to increased stride length. However, the type of cueing was found to influence the outcome (Schwed & Haas 2009). Hence, a huge optical contrast between markers and floor has been proved being effective and the distance between these visual cues needs to be adapted to the individual stride length. Furthermore presentation of transversal lines improves locomotion whereas no positive effects became evident when using longitudinal lines.

Besides these effects also treadmill training was also found having positive influence on walking performance. However, physiological functioning is not clear. One might argue that treadmill walking presents a kind of tactile cue or/and these sensory stimulation helps to activate spinal central pattern generator (CPG) leading to an automatic and rhythmic activation of leg muscles. This mechanism works independently from supraspinal areas. Therefore, CPG activation might reduce cortical processing load which is of crucial importance for assisting continuity of gait and avoiding freezing (Schwed & Haas 2009).

Even if these methods are proved very well they cover only a small range of situations and motor demands. Every day life is however characterized by fluctuating environmental conditions which require adaptability. Thus, adequate gait training should focus these situations, too. Analogously to experiments in Multiple Sclerosis (Haas et al. 2010) it became also obvious in Parkinson's disease that a deviance-based (variable) gait training improves gait performance and day to day functions. One can speculate that the variability of training related sensory stimuli helps to break down stable pathological motor pattern. This process can be regarded as a precondition for extra- and interpolating motor commands which is a fundamental part of adapting motor behavior adequately to fluctuating external conditions.

In animal studies it was found furthermore that confrontation with an enriched environment leads to neurotrophic factor releases and neuroprotective effects, respectively (Falkenberg et al. 1992, Bezard et al. 2003, Fahert et al. 2005). However, training sessions which are related to huge stress or fatigue should be avoided as they affect neurotrophic factor expression (Smith et al. 1995). In contrast eliciting strong neuromuscular reflex-answers – e.g. downhill running – has positive effects as the release of neurotrophic factor is high (Aguiar et al. 2008). With respect to this multivariate interactive structure it is necessary to find adequate relations between training-contents, -intensities, variability, rest periods etc.

In conclusion keeping up walking ability is of highest concern for the therapy process in PD in order to avoid establishing a vicious circle, i.e. the lower the walking ability the higher the risk for

nursing at home loss of social contacts and downregulation of neurotrophic factors. Especially the latter is highly related with neurodegeneration and overall disease progression (Tillerson et al. 2001, 2002, Cohen et al. 2003, Vaynman & Gomez-Pinilla 2005). Roughly spoken using gait function is necessary in order to avoid losing brain function.

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