APA-Analyse 9.11.2014

SPSS: All\_Klein\_data\_gemittelt\_15.sav enthält die Daten von denen die outlier korrigiert wurden, mit korrekten Variablenlabels.

Main questions:

* Do APA-parameters change with age?
* Are APA-Parameters different in self-initiated and externally initiated steps?
* Are step-parameters and APA parameters correlated?
* Can freezing-of-gait be explained by reduced or absent APAs?

Introduction

Anticipatory postural adjustments (APAs) consist of muscular synergies to prepare the body to either react on an upcoming event that may challenge postural equilibrium or to allow for taking a step. Only this second type of APA will be considered in this paper. Before taking a step, the swing foot must be cleared off the ground and the body must be enabled to fall forward. This is achieved by a transient shift of the weight of the body towards the stepping foot and then back to the stance foot which bears the weight of the body during the step. Here we use the terms APA1 and APA2 for these two phases corresponding to the 'imbalance phase' and the 'unloading phase' as denominated/called/designated by Crenna et al., ([Crenna et al. 2006](#_ENREF_2)). The end of the APA1 phase was labelled 'release' by Halliday et al. and shown to correspond to the 'heel-off' instance of the swing foot ([Halliday et al. 1998](#_ENREF_5)). Simultaneously with this lateral weight shift, body weight is shifted to the heels (by actively lifting the forefoot) where after the body begins to fall forward. APAs can be recorded with electromyography from leg muscles ([Crenna and Frigo 1991](#_ENREF_3)) or by a force plate on which the subject stands and which registers the center of pressure (COP) as an indication of the weight shifting maneuvers actively performed by the subject. Also, accelerometry has been successfully used for this purpose ([Mancini et al. 2009](#_ENREF_12)). Muscular synergies leading to postural shifts can be interpreted as activity of units consisting of several synergistically acting muscles, thereby reducing the number of variables the CNS has to control ([Krishnamoorthy et al. 2003](#_ENREF_11)). Since APAs are discussed as a contributing factor to start hesitation and gait problems in Parkinson's disease (PD) ([Nutt et al. 2011](#_ENREF_13)) and automated motor sequences are reduced in PD (as for instance arm-swing movements), much interest was concentrated on APAs in PD recently. Because APAs are in time between the challenge to maintain equilibrium during stance and a regular gait pattern, and the freezing of gait phenomenon is most likely to appear at this moment, trembling in place, as seen in severely affected PD patients, has been considered as a failure to inhibit APAs (perform multiple APAs) and has been considered as one of the pathomechanisms of the freezing phenomenon ([Jacobs et al. 2009b](#_ENREF_9)). PD patients generally show a longer APA duration (as expected in a bradykinetic state) and show a reduced capability of adjusting APAs in relation to a wider initial stance as compared to healthy subjects ([Rocchi et al. 2006](#_ENREF_14))*.* The reduction of APA measures in PD is partially compensated by administration of levodopa ([Rocchi et al. 2006](#_ENREF_14)).

Systematic studies on the influence of the task on APA parameters and on the changes of APAs during age are lacking. Also, it is not clear whether step size may have a direct impact (influence?) on APA parameters. However, knowledge of these factors is necessary to fully understand APA changes in subjects with gait pathologies. In this study we addressed the influence step initiation mode (self-initiated or externally triggered) and age on several APA measures in a large group of healthy subjects. Furthermore, the relationship between APA measures and step parameters was investigated. Additionally, as APAs are altered in Parkinsonism, we studied whether PD patients and PD patients with the freezing phenomenon have different APAs which is aiming at answering whether the freezing phenomenon may be elicited by absent or reduced APAs.

**Methods**

Raw data consisted of the data sets of 1594 steps (84 subjects, 8-10 steps in 2 conditions). Averaged data were two data sets per person corresponding to two conditions (self-initiated and externally elicited step). Statistics were performed with SPSS22 (Microsoft) on averaged data. Correlations and corresponding p-values were computed with the Matlab procedure 'corr' on the raw data (as mentioned below). For descriptive purposes, the raw data and the averaged data were analyzed. For statistics, variables were checked for normal distribution with the Matlab routine 'jbtest', and, if necessary, transformed using the Box-Cox-power transformation by applying appropriate exponents to the variable.

Subjects

Hier fehlt noch viel, die genaue Charkterisierung der Gruppe, UPDRS, ON/Off, welche Skalen angewendet wurden …

## Data acquisition and analyses

Annika, diesen Abschnitt bitte mal überarbeiten, ich hab ihn einfach von Brecl-Jakobs-Dystonie-paper übernommen) APAs were recorded on a treadmill (FDM-T, Zebris medical GmbH, Isny, Germany) which was stationary during all tests. Force applied by the feet to the belt was measured by an array of pressure sensitive sensors underneath the belt (each 8.5 x 8.5 mm, 100 Hz sampling rate). Subjects were asked to stand comfortably on both feet at their preferred foot distance. They were instructed to silently count till three at their own pace after receiving the “ready” command and then make one or two comfortable steps forward. This was repeated 20 times. In patients, APAs were recorded with and without stimulation. The minimum time span between change of stimulation condition and test was 1 h. To avoid the effect of learning/training on performance on the tests the sequence of ON and OFF conditions was fully randomized from patient to patient. In addition to the instrumented measurements, three clinical scale assessments were performed: Toronto Western Spasmodic Torticollis Rating Scale (TWSTRS), Falls Efficacy Scale International (FES-I) and Freezing of gait questionnaire (FOG-Q). Patients were asked whether balance changed after the implantation (better/unchanged/worsened) and whether they had fallen during the last six months (yes/no).

Dieser Abschintt sollte ok sein: The centre of pressure (CoP) of each foot and the CoP of both feet were calculated by software supplied by the treadmill manufacturer (Figure 1A, B). From these data, Matlab algorithms (Figure 1C, D) computed the following outcome parameters: begin of APA was defined at the moment when CoP velocity of both feet (x or y) was above 1.5mm/10ms. This proved to be very reliable and could be corrected manually if necessary. End of APA was at the begin of the first step (toe off of swing foot). From these instances, APA duration was calculated. This epoch was divided into APA1 (imbalance phase, CoP shift toward the swing foot) and APA2 (unloading phase, lateral displacement of the CoP towards stance foot) ([Crenna et al. 2006](#_ENREF_2)). Peak APA in medio-lateral direction (max APA m-l) was marked and denoted as separation point between APA1 and APA2 (Fig 1D). To standardize the foot distance, all medio-lateral CoP data were scaled with a factor (20/foot distance in cm). Peak APA in a-p (max APA a-p) direction was marked as well. The length of the APA CoP-path (APA CoP length) as well as the peak APA velocity was computed by calculation of the euclidic distance between adjacent CoP points and referencing this to Δt. Additionally 1st step duration and 1st step length associated with APA were calculated

**Results**

Correlation APA with age and trigger mode, healthy subjects (n=60)

Step length, step velocity, APA duration, lateral and ant-post APA were investigated for their possible correlation with age. The only significant correlation was found between age and duration of APA1 during externally elicited steps (r = -0.33, p = 0.01). Thus, in this group, older subjects showed a shorter APA1 duration, but age had no significant influence on any other APA parameter and neither on step length or step velocity.

The step-trigger mode (external trigger or self-initiated step) had a significant influence on several parameters (T-tests for dependent means; all p values < 0.01): externally triggered steps were longer, faster and had shorter duration as compared to self-initiated steps. APA duration, APA1-duration as well as APA2 duration were shorter with externally triggered steps but lateral APA excursions as well as ant-post APA excursions were larger in this instance (Table 1).

Correlation between step length and APA parameters, all subjects

To investigate the correlation between step length and APA parameters, we analyzed the raw data (single steps). Step length showed no significant correlation with lateral APA (during the APA1 phase) in healthy subjects in externally triggered steps, but a low negative significant correlation was seen with internally elicited steps, meaning that smaller lateral APA excursions were seen before large steps (Figure APA Grafik). In both PD groups larger steps caused larger lateral APAs in the externally triggered condition only (Figure APA Grafik). Concerning ant-post APAs, the picture was clearer: in the externally triggered condition larger steps were preceded by larger posterior APA excursions in all groups (Figure APA Grafik) but this was not generally seen with self-initiated steps. The velocity of the APA1 component was significantly correlated with step length in externally triggered steps in all groups (Figure APA Grafik). APA duration showed no correlation with step length in healthy subjects but was shorter with larger steps (r = -0.3, p < 0.001) in both PD groups (data not shown).

Comparison between groups

The following analyses included all groups despite difference in age since an influence of age was not detected in the data of the healthy subjects.

ANOVAs with factors 'group' (Control, PD, PD w Freezing) and 'trigger' (self-initiated vs. externally triggered, 'trigger' as a repeated measure) were computed for step and APA-values. Detailed statistics are presented in Table 2. All parameters showed a significant difference caused by ‘trigger’, and this applied to (pertained to) all groups in a similar fashion since interactions between ‘trigger’ and ‘group’ was never significant. As it might be expected, the first step was longer and its velocity was higher in healthy subjects as compared to freezers, but these parameters were not different between Cont and PD and neither between PD and FZ. This pattern was seen in almost all statistical tests, i.e. Cont and FZ had significantly different APA duration, APA velocity, length of the COP-trace during the APA-epoch (longer in Cont) and length of lateral APA excursions (longer in Cont). Freezers and PD patients showed different values only in a few parameters: the duration of APA2 was much longer in FZ, (see Table 1) and the maximum velocity of APA1 was less in the FZ group as compared to the PD group. Remarkably, the extent of the APA excursion in anterior-posterior direction was not significantly different between the three groups.

Correlation between clinical scores and APA data

The scores of three clinical rating scales (UPDRS III, Hoehn&Yahr, FOG questionnaire) were correlated (Pearson’s correlation coefficient) with several APA and step parameters of the patients (PD patients and freezers, n=26). The UPDRS III scores were significantly correlated with the length of the COP trace in externally triggered steps (r = -0.54, p = 0.005) meaning that more severely affected patients had smaller COP excursions during the APA phase. The Hoehn&Yahr score was significantly correlated with the APA duration in externally triggered steps (r = 0.4; p = 0.43). The FOG score was correlated with maximum velocity during the APA-1 phase in self- initiated steps (r = -0.39; p = 0.047) meaning that patients with a higher freezing score had a lower peak COP velocity during the APA-1 phase.

Variability of APA curves within subjects.

For each subject, the coefficient of variation (CV) for the 8-10 COP curves during the APA phase in 2 conditions (self-initiated step, externally triggered step) was computed for lateral as well as ant-post COP displacement according to (Winter Biomechanics, John Wiley 2009). To allow for a comparison of these curves they were resampled so that each curve consisted of 50 data points by applying a MATLAB spline interpolation algorithm. The resulting values (Table XX) were analysed with an ANOVA for repeated measures with factors ‘group’ and ‘trigger’. The CV for lateral sway was significantly influenced by ‘group’ (F=4, p= 0.024) but not ‘trigger’ (p=0.065). Post hoc tests showed that the control group had a significantly smaller CV of the lateral sway as compared to the freezers.

CV of ant-post sway was very much reduced in the ext. trigger condition as compared to the self-paced steps for both Cont and PD but only slightly reduced in the FZ group. A clear significant effect of ‘trigger was seen (F = 14; p = 0.001) but ‘group’ was not significant.

Discussion

The main results of our study are: Externally elicited steps are larger (on average 5%) than self-triggered steps and show a clear difference in several APA parameters: APAs are of shorter duration but the COP excursions are larger in ant-post as well as in lateral direction. Thus, APAs before an externally elicited step seem to be more precisely coordinated as APAs preceding a self-initiated step. It seems as if the external command is capable to elicit a faster and more efficient initialization of the first step. The biomechanical explanation for this observation is probably very simple: to quickly initiate a step it is mandatory to shift the weight far back to the heels and very lateral towards the swing foot (during APA1) so that the body quickly will fall into the desired direction. An EMG analysis of self-initiated and externally triggered stepping involving healthy subjects and PD patient was reported ([Hiraoka et al. 2006](#_ENREF_7)). The authors found that the EMG burst of the tibialis anterior muscle of the swing foot was much higher in externally elicited movements and this was true for both groups, but PD patients had overall reduced tibialis anterior muscle activity. When steps of different velocity were required (after an external command) the magnitude of the M. tibials ant. activation as well as the amount of posterior COP shift depended on the velocity of the steps they had to make (slow/natural/fast) ([Crenna and Frigo 1991](#_ENREF_3)). Therefore, APA measures clearly correlate with the timing of a step and this mechanism of intentionally generating larger and faster APAs after the imperative stimulus was preserved in our data in both PD patients with and without the freezing phenomenon. Also, the scaling of the APA velocity according to step size is well preserved in both patient groups in this condition (Figure APA Grafik).

The second main result of our study is that APA measures do not (or only very weakly) correlate with step length (Figure APA Grafik). This weak dependence of APA parameters on step length in externally elicited and the absent dependence in self-initiated steps (correlation coeff. < 0.2) is surprising if one assumes that longer steps need 'larger' APAs. However, this is not generally the case and may be explained by the fact that once a step is initiated step length depends on the time at which the swing foot hits the ground and thus mostly on the velocity of the swing foot (assuming comparable falling velocity of the body). This supports the notion that timing of a step is the main factor influencing all parameters of the APA.

Are APAs affected by age?

When APAs are generated in preparation of an externally applied stimulus affecting postural stability, advanced age significantly delays their begin, reduces their amplitude and increases the intensity of compensatory postural adjustments as a reaction to the perturbance ([Woollacott and Manchester 1993](#_ENREF_16); [Kanekar and Aruin 2014](#_ENREF_10)). The effect of age on APAs as a preparation for a step has not yet been systematically investigated in larger groups. A comparison between APA parameters and step size in young and elderly healthy subjects showed that A/P displacement of the COP was significantly reduced in the elderly but other parameters were not and the authors concluded that "There is a trend for the variables to be smaller, slower and less forceful when comparing the young to the elderly …" ([Halliday et al. 1998](#_ENREF_5)). Our data confirm this appraisal because we found that age had no significant influence on any APA parameter with the exception of one parameter (duration of APA1).

Are APAs different in PD? In our study, no differences were found in the ant-post sway between groups but lateral sway was reduced in both PD groups (significantly only between Cont vs. FZ). This pattern is similar to a study investigating untreated PD patients in an early stage of the disease ([Mancini et al. 2009](#_ENREF_12)), however these authors saw significantly reduced lateral sway also in untreated early-stage PD patients. Lateral sway was also reduced in moderately affected PD patients in the study by Jacobs et al, whereas the APA timing was normal. ([Jacobs et al. 2009a](#_ENREF_8))

Freezing: zitieren ([Fling et al. 2013](#_ENREF_4)) Freezers had significantly reduced right hemisphere pedunculopontine nucleus fibre tract volume compared with healthy controls. This observation is supportive with the notion freezers may have a frontal lobe disconnection from subcortical structures critical for gait which interferes with automatic as well as cognitively controlled motor processes ([Vandenbossche et al. 2012](#_ENREF_15)).

This observation leads to two assumptions: First, in PD, APA abnormalities are related not to the disease itself but to the progression state and second; the freezing phenomenon cannot be explained by reduced APAs because freezers and non-freezers had no significantly different APAs. It seems that the motor program for eliciting APAs is preserved in these patients, but is performed less extensive (bradykinetic) and the problem lies in the initiation of the step ([Jacobs et al. 2009b](#_ENREF_9)). In fact, in their study the Parkinsonian patients showed well preserved or even faster APAs in response to an equilibrium-challenging stimulus.

Ich denke, dass man knee-trembling auch anders interpretieren könnte, nämlich als Schritte mit zu geringer Amplitude, denn wer macht schon Kniebewegungen während normaler APAs?

Der Rest sind Textschnipsel, noch nicht vollständig sortiert

MATLA B (MathWorks, Natick, MA)

Subthalamic stimulation can significantly accelerate the sequence of APAs as well as augment lateral and posterior COP shifts before the first step ([Crenna et al. 2006](#_ENREF_2)), in addition to an improvement of step size and step velocity. Stimulation of the substantia nigra pars reticulata (SNr) via the most ventral contacts of the subthalamic electrode can improve axial symptoms and the breaking mechanism at the end of a step but fail to increase step size (Chastan Brain 2009). However, STN or Globus pallidus internus surgery itself reduced lateral APA excursions and increase APA duration before a step in the majority, but not in all patients, as shown in an investigation comparing pre-OP and post-OP APA-measures (Rocchi, Neurosurgery 2006). Noch lesen : Liu, McIntyre, Gait&Posture 2006.

A comparison between moderately and severely affected PD patients used the distance between COP and Center of Mass (COM) as measure of (in)stability and found that thîs distance was reduced in the severely affected patients only in the stepping phase (possibly due to a reduced ability to equilibtare the body during such postural challenges) ([Hass et al. 2005](#_ENREF_6)). (Keine sehr wichtige Arbeit, hier wurden auch keine APAs gemessen).

Dopaminergic medication is able to improve force applied by the patient during the APA phase similarly to an external 'go' signal ([Burleigh-Jacobs et al. 1997](#_ENREF_1)).

A comparison between APAs elicited by external vs. internal triggering has not yet been reported (noch mal nachsehen ob das stimmt). External triggering may involve the 'go' signal only or additional commands concerning the leg to start with ([Crenna et al. 2006](#_ENREF_2))

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Figure . 1. Step initiation. A: ant-post position of CoP, right foot (green), left foot (red) and both feet (blue). The right foot takes the first step. APA-onset is marked with vertical bar and denotes the begin of the backward excursion of the COP in A. Step onset and step end are marked with arrows. B: medio-lateral position of CoP, colours as in A. Vertical bar denotes the APA-begin, here the lateral excursion of the COP towards the swing foot. This phase is called APA 1. C: CoP in x-y axis, colours as in A.The blue trace shows the CoP of both feet as it moves from the center towards the swing foor (APA 1), and then to the stance foot. D: CoP trace during APA in medio-lateral direction in red. The peak of the red curve (marked with a cross) denotes maximum COP excursion towards the swing foot and is called 'Max APA lateral'. This is the end of the APA 1- phase. The green trace shows the CoP path in ant-post direction. To initiate a step, the weight is shifted actively to the heels, which is seen in a posterior excursion of the curve. The cross denotes 'Max APA ant-post'.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  | **Duration** | **Length** | **Velocity** | **Duration** | **Duration** | **Duration** | **Maximum** | **Maximum** |
|  |  |  | **Age** | **1st step (ms)** | **1st step**  **(mm)** | **1st step**  **(mm/s)** | **APA (ms)** | **APA1 (ms)** | **APA2 (ms)** | **APA r-l**  **(mm)** | **APA a-p**  **(mm)** |
| **Control** | external trigger | Mean | 55.62 | 407 | 543 | 1336 | 556 | 275 | 281 | 46 | -41 |
| StdDev | 10.00 | 71 | 141 | 316 | 101 | 54 | 62 | 10 | 26 |
| self initiated | Mean |  | 495 | 519 | 1063 | 729 | 310 | 440 | 32 | -17 |
| StdDev |  | 82 | 130 | 246 | 132 | 56 | 134 | 11 | 19 |
| **PD** | external trigger | Mean | 63.60 | 377 | 469 | 1258 | 574 | 294 | 280 | 43 | -44 |
| StdDev | 14.10 | 44 | 119 | 357 | 108 | 56 | 59 | 9 | 33 |
| self initiated | Mean |  | 470 | 437 | 954 | 750 | 322 | 437 | 24 | -19 |
| StdDev |  | 49 | 163 | 372 | 151 | 43 | 109 | 7 | 15 |
| **PD/Freezers** | external trigger | Mean | 65.69 | 382 | 422 | 1019 | 682 | 327 | 355 | 35 | -23 |
| StdDev | 9.27 | 103 | 155 | 331 | 126 | 73 | 92 | 12 | 24 |
| self initiated | Mean |  | 449 | 349 | 759 | 898 | 342 | 557 | 20 | -9 |
| StdDev |  | 142 | 132 | 203 | 156 | 46 | 131 | 5 | 22 |

Table 1: APA descriptive Statistics

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  | Post-hoc tests | | |
|  | Effect of trigger | Group vs trigge | Effect of group | Cont vs PD | PD vs FZ | Cont vs FZ |
| Length 1st step | F:9.4; p=0.003 | n.s. | F:9.3, p>0.001 | n.s. | n.s. | p<0.001 |
| Duration 1st step | F:39; p<0.001 | n.s. | n.s. |  |  |  |
| Velocity 1st step | F:68; p<0.001 | n.s. | F:9.1, p>0.001 | n.s. | n.s. | p<0.001 |
| Duration APA | F:71; p<0.001 | n.s. | F:9.6; p<0.001 | n.s. | n.s. | p=0.045 |
| Duration APA 1 | F:6.2; p=0.015 | n.s. | F:4.5, p=0.014 | n.s. | n.s. (p=0.06) | p=0.04 |
| Duration APA 2 | F:103; p<0.001 | n.s. | F:7.5; p=0.001 | n.s. | p=0.03 | p=0.001 |
| Max APA lateral | F:105; p<0.001 | n.s. | F:14.4; p<0.001 | n.s. | n.s | p=0.001 |
| Max APA ant-post | F:43; p<0.001 | n.s. | n.s. |  |  |  |
| Max velocity APA 1 | F:147; p<0.001 | n.s. | F:12.4; p<0.001 | n.s. | p=0.047 | p=0.001 |
| Max velocity APA 2 | F:122; p<0.001 | n.s. | F:13; p<0.001 | p=0.01 | n.s. | p<0.001 |
| Length APA COP | F:90; p<0.001 | n.s. | F:16; p<0.001 | p=0.01 | n.s. | p<0.001 |

Table 2: APA statistics

**self initiated and externallly triggered**

([Burleigh-Jacobs et al. 1997](#_ENREF_1))

([Jacobs et al. 2009a](#_ENREF_8))

**self initiated**:

([Mancini et al. 2009](#_ENREF_12))

(Rocchi Neurosci Letters 2006)

(Rocchi Neurosurgery 2012)

**Externally triggered:**

([Crenna et al. 2006](#_ENREF_2))

([Halliday et al. 1998](#_ENREF_5))

Chastan: Effects of nigral stimulation…; Brain 2009

**APA in freezers;**

([Jacobs et al. 2009b](#_ENREF_9))

**APA in PD:**

([Jacobs et al. 2009a](#_ENREF_8))

(Rocchi Neurosci Letters 2006)

age-related changes:

Carpinella I, Crenna P, Calabrese E, et al. Locomotor

function in the early stage of Parkinson\_s disease. IEEE

Trans Neural Syst Rehabil Eng 2007; 15: 543–551.

Halliday SE, Winter DA, Frank JS, Patla AE, Prince F.

The initiation of gait in young, elderly, and Parkinson\_s

disease subjects. Gait Posture 1998; 8: 8–14.

Falls:

Almost 50% of falls occur during walking, in particular during

the initiation and termination of gait (Ashley et al., 1977;

Masud and Morris, 2001).

Anatomie:

Effects of nigral stimulation on locomotion and postural stability in patients with Parkinson’s disease

N. Chastan,1,2,3 G. W. M. Westby,1 J. Yelnik,2,4 E. Bardinet,5,6 M. C. Do,7,8 Y. Agid1,2 and M. L. Welter1,4 Brain 2009

However, to our knowledge, the SNr has never been deliberately

examined as a target for axial symptoms in Parkinson’s disease

patients (Bejjani et al., 1999; Caire et al., 2006). This paper

reports the effects of high frequency SNr stimulation on locomotion

and balance control during the gait initiation process, particularly

the ability to brake the CG fall during stepping which

reflects postural control during gait, in seven Parkinsonian patients

operated for bilateral STN stimulation with electrode contacts

located within the SNr.

Bejjani BP, Damier P, Arnulf I, Thivard L, Bonnet AM, Dormont D, et al.

Transient acute depression induced by high-frequency deep-brain stimulation.

N Engl J Med 1999; 340: 1476–80.

Bejjani BP, Dormont D, Pidoux B, Yelnik J, Damier P, Arnulf I, et al.

Bilateral subthalamic stimulation for Parkinson’s disease by using

three-dimensional stereotactic magnetic resonance imaging and electrophysiological

guidance. J Neurosurg 2000a; 92: 615–25.

Bejjani BP, Gervais D, Arnulf I, Papadopoulos S, Demeret S, Bonnet AM,

et al. Axial parkinsonian symptoms can be improved: the role of

levodopa and bilateral subthalamic stimulation. J Neurol Neurosurg

Psychiatry 2000b; 68: 595–600.

Caire F, Derost P, Coste J, Bonny JM, Durif F, Frenoux E, et al.

Subthalamic deep brain stimulation for severe idiopathic Parkinson’s

disease. Location study of the effective contacts. Neurochirurgie

2006; 52: 15–25.

([Fling et al. 2013](#_ENREF_4)) Asymmetric pedunculopontine network Wichtiges aktuelle paper

suchen:

Mov Disord. 1997 Mar;12(2):206-15.

Step initiation in Parkinson's disease: influence of levodopa and external sensory triggers.

Burleigh-Jacobs A1, Horak FB, Nutt JG, Obeso JA.

Cohen R, Nomura M, Klein K, Fleming M, Mancini M, Nutt JG, et al.

Inhibitory deficits are associated with freezing of gait in Parkinson’s

disease. 2nd Joint World Congress of the International Society for

Posture and Gait Research and Gait and Mental function, 2013.

Start hesitation in PD is associated with diminished and

prolonged preparatory CoP displacements as well as reduced

step length and velocity, compared to age-matched control subjects

[2,6,11,24].

A. Burleigh-Jacobs, F.B. Horak, J.G. Nutt, J.A. Obeso, Step initiation in

Parkinson’s disease: influence of levodopa and external sensory triggers,

Mov. Disord. 12 (1997) 206–215.

P. Crenna, C. Frigo, P. Giovannini, I. Piccolo, The initiation of gait in

Parkinson’s disease, in: A. Berardelli, M. Benecke, M. Manfredi, C.D.

Marsden (Eds.), Motor Disturbances II, Academic Press, London, 1990,

pp. 161–173. (nicht zu finden!!)

N. Gantchev, F. Viallet, R. Aurenty, J. Massion, Impairment of posturokinetic

co-ordination during initiation of forward oriented stepping movements

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R. Rosin, H. Topka, J. Dichgans, Gait initiation in Parkinson’s disease,

Mov. Disord. 12 (1997) 682–690.

Both the preparatory and stepping phases of

step initiation are improved by levodopa medication [2].

[2] A. Burleigh-Jacobs, F.B. Horak, J.G. Nutt, J.A. Obeso, Step initiation in

Parkinson’s disease: influence of levodopa and external sensory triggers,

Mov. Disord. 12 (1997) 206–215.

Mov Disord. 1994 Mar;9(2):139-46.

The initiation of normal walking.

Elble RJ1, Moody C, Leffler K, Sinha R.

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in patients with Parkinson’s disease. **Gait Posture 23:**

492–498, 2006

Lesen:

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S. Patchay,Y. Gahery,Effect of asymmetrical limb loading on early postural adjustments associated with gait initiation in young healthy adults, Gait Posture 18 (2003) 85–94.

**Postural responses to ext. perturbations DBS can be reduced:**

St George RJ, Carlson-Kuhta P, Burchiel KJ, Hogarth P, Frank

N, Horak FB: The effects of subthalamic and pallidal deep

brain stimulation on postural responses in patients with Parkinson

disease. Laboratory investigation. **J Neurosurg 116:**

1347–1356, 2012

16. Follett KA, Weaver FM, Stern M, Hur K, Harris CL, Luo P,

et al: Pallidal versus subthalamic deep-brain stimulation for

Parkinson’s disease. **N Engl J Med 362:**2077–2091, 2010

Rocchi Neurosurgery 2012

40. Schepens B, Drew T: Strategies for the integration of posture

and movement during reaching in the cat. **J Neurophysiol 90:**

3066–3086, 2003 (Postural reactions to ext. perturbations are reduced in STN but not in GPI stimulation)

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Bloem BR, Hausdorff JM, Visser JE, Giladi N: Falls and

freezing of gait in Parkinson’s disease: a review of two interconnected,

episodic phenomena. **Mov Disord 19:**871–884, 2004

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Lewis: Parkinsonism and Related Disorders 15 (2009) 333–338

However, as already stated this feature of PD does

not necessarily correlate with FOG suggesting the involvement of

additional non-dopaminergic pathways and/or structures. One

such structure is the PPN and clinicopathological studies undertaken

in PD patients have identified that cellular loss within the

PPN can be correlated with disease progression and gait disturbance

[34–36].

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Exponenten der Box-Cox-Transformation (0- natürlicher Logarithmus)

1 1.000000 File

2 1.000000 Dist re-li Fuss (mm)

3 1.000000 Startsignal (ms)

4 1.000000 Schritte Startbein

5 1.000000 Schritte 2. Bein

6 1.000000 Startbein li=1;re=2

7 1.000000 Start 1. Schr. (ms)

8 1.000000 Dauer 1. Schr. (ms)

9 1.000000 Laenge 1. Schritt (mm)

10 1.000000 mtl Geschw 1. Schritt (mm/s)

11 1.000000 Dauer 2. Schritt (ms)

12 3.000000 Laenge 2. Schritt(mm)

13 1.000000 mtl Geschw 2. Schritt (mm/s)

14 0.000000 Dauer APA (ms)

15 0.000000 Dauer APA1 (ms)

16 -0.500000 Dauer APA2 (ms)

17 1.000000 Max APA rl (mm)

18 1.000000 Max APA ap(mm)

19 1.000000 Max APA post(mm)

20 1.000000 Max APA ant(mm)

21 0.500000 Max Vel APA1 (mm/s)

22 0.500000 Max Vel APA2 (mm/s)

23 0.500000 Laenge APA-COP (mm)

24 2.000000 Body weight on sw foot start

25 2.000000 Body weight on sw foot release

26 1.000000 a\_e

27 1.000000 Subj\_Number

28 1.000000 repeat

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