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PARKINSON DISEASE EXAMINATION
USING WALK DISTURBANCES CHARACTERISTICS

This study is based on clinical observations of patient motor-disturbances, measured by PSW (Parotec System for Windows) pedobarographic recorder [1]. The gait regular asymmetry in a data spectrum has been noticed as an independent factor from disease duration and severity. In majority of analysed cases a gravity centre of the body moves towards a left limb, into a heel region. A trajectory of foot gravity centre elongation, its irregularity, a floor-contact time and impulse values increase is also visible. Predominantly on more affected limb. These diagnosis factors allow concluding that the PSW recorder could successfully be used for recognition and quantification of the motor disturbances, illustrating the Parkinson disease progress.

1. INTRODUCTION

The PSW recorder is a computer aided measuring equipment that allows collecting data concerning a patient way of walking [1]. The PSW equipment provides the user with a source records that consist of static and dynamic data. The static part of the data record is available in two-dimensional map with pressure values in points of the insole, where sensors are installed. One of characteristic features shows a body gravity centre movement.

The dynamic part of the data record allows analysing current values of the pressure distribution in cycle of walk. The footprint is covered by trajectories of the pressure central point flow in first five steps, indicating the walk stability. The presented data also allows a local energy analysis using time diagrams of the pressure distribution.

The Parkinson disease (PD) is noticed as one of the more baffling and complex neurological disease. The disease classification and monitoring of its progress still remains mystery although James Parkinson, a British physician, described in 1817 the disease characteristics in paper „Essay on the Shaking Palsy".

The PD affects at least 1 from 100 people in age over 60. The Parkinson disease onsets are very irregular, with various and reach symptoms. Anyhow several classic symptoms (with various combinations) of Parkinson disease can be distinguished, as: tremor of hands, rigidity with constantly tensed muscles, patient feels stiff with temporary paralysis, reduced spontaneous

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movement or postural abnormalities with stooped posture. Other common symptoms include a shuffling gait, a mask-like face with decreasing blinking and not readable handwriting. Father progress of the disease means additional health troubles concerning speech, swallowing, sleeping, urination or constipation. Drooling, sweating and intolerance to heat may occur very often. Troubles with thinking processes, concentration, problems solving, emotional changes, frustration can also be observed.

The Parkinson disability is often classified within following levels:

I. a one-sided tremor ,rigidity of muscles, temporary paralysis or reduced spontaneous movement or postural abnormalities,

II. a two-sided tremor, rigidity of muscles, temporary paralysis or reduced spontaneous movement or postural abnormalities,

III. first symptoms of deteriorating balance also still fully independent,

IV. help for daily living activities,

V. unless assisted and confined to wheelchair or bed.

Among many symptoms of PD several walking irregularities can be distinguished, as short-stepped or shuffling gaits – mainly in initiating movement.

Parkinson disease also effects postural stability, observed as a tendency of losing body balance. The PD is noticed when certain nerve cells (neurones) of a midbrain area (called the *substantia nigra*) die or become impaired. These neurones produce a vital substance called dopamine. The dopamine is the chemical messenger responsible for signals transmission between the *substantia nigra*s It is also known as a "black substance" and the next "relay station" of the brain, the *corpus striatum* that is responsible for smooth, co-ordinated function of the body's muscles and movement.

Even experienced neurologists are unable to make proper recognition of an early level of the Parkinson disease. If tremor is the only symptom of PD, the physician may need to observe the patient actions for more then several months.

Idiopathic Parkinson's disease is the likely diagnosis when tremor, bradykinesia, rigidity and balance problems predominate, when the course of the disease is slow with disability increasing after 10 - 20 years and the patient has a good response to levodopa. Brain converts the levodopa into dopamine, which is stored in neurones (cells) untill it is needed for body movement.

2. THE PARKINSON DISEASE RECOGNITION

This study shows the parkinsonian patients examination ability by PSW options. Our investigations were carried out for the PD recognition by patient motor disturbances analysis.

A sample set of 23 adult patients with recognised PD in ambulatory and in hospital has been selected for this study. The selection criteria excluded cases with acute musculo skeletal injures, several dementia cases (difficulties in understanding of verbal instruction), vestibule or visual affection and local foot pathologies.

The patients of the selected group were in age from 46 to 78 years. The example static data has been presented in Fig.1. The 63-years old female with PD and not visible gait disturbances found during clinical investigations.

Two domains of the disease have been then extracted: group A (of 15) concerning a left-lateral domination, group B (of 8) with right-lateral domination of the disease. Majority of them had moderate stage of the Parkinson disease involved responsibly into antiparkinsonian therapy. For 7 cases severe difficulties of motor activity were noticed. To the control group for this experiment 12 healthy adults have been selected.
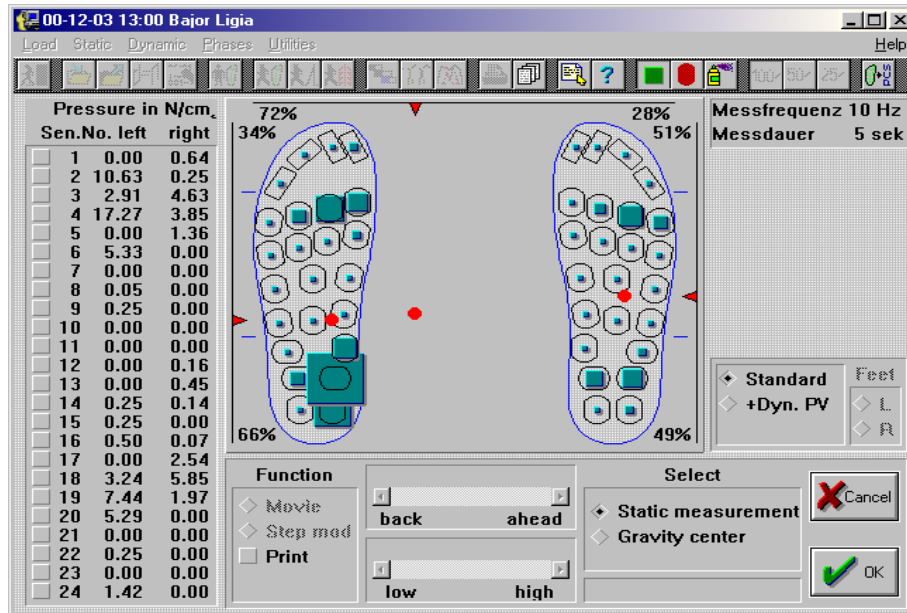

Fig.1. Early Parkinson disease (I), with left-sided lateralisation.

In each case a present neurological status has been recognised then a full examination has been carried out, both by traditional techniques and by PSW interfaces analysis. The diagnosis results, including the control group, have been matched together.

As a result of these investigations several regularities have been found:
– the gait disturbances are asymmetrical independently from duration or severity of the disease, in all cases,
– in an interface of a static data a readable movement of a body weight and a body gravity centre is visible,
– the gravity centre moves towards the left side of a foot, frequently into a heel region (for 78% of all PD patients),
– these regularities are not the same for affected limbs,
– for left-lateral dominance of the disease (15 cases) majority of them (13 cases - 86,6%) move a body weight into a left heel region, for 2 cases (13,4%) a body weight concentrates on a right heel (Fig.1),
– for group of right–lateral dominance of the disease (8 cases) 4 of them (50%) move a body weight on a left heel region, 3 of them (37,5%) on left forefoot, for 1 patient (12,5%) on right wheel.

The gravity centre trajectories

A length of foot gravity centre trajectories and their shape show severe alterations that depended on predominant side and severity of the disease.

In left lateralisation of PD in 10 subjects (66,6%) elongation of trajectories on more affected limb has been noticed. Anyhow in cases of right lateralisation of the PD the same factors of the diagnosis have been observed for 5 (62,5%) patients.

In early stage of the PD the difference between trajectory lengths of foot gravity centre movement on primary affected limb and on the other side were moderate , but in cases of severe PD this difference was significantly visible (for extreme cases, as in figure bellow, this increased above 100%).
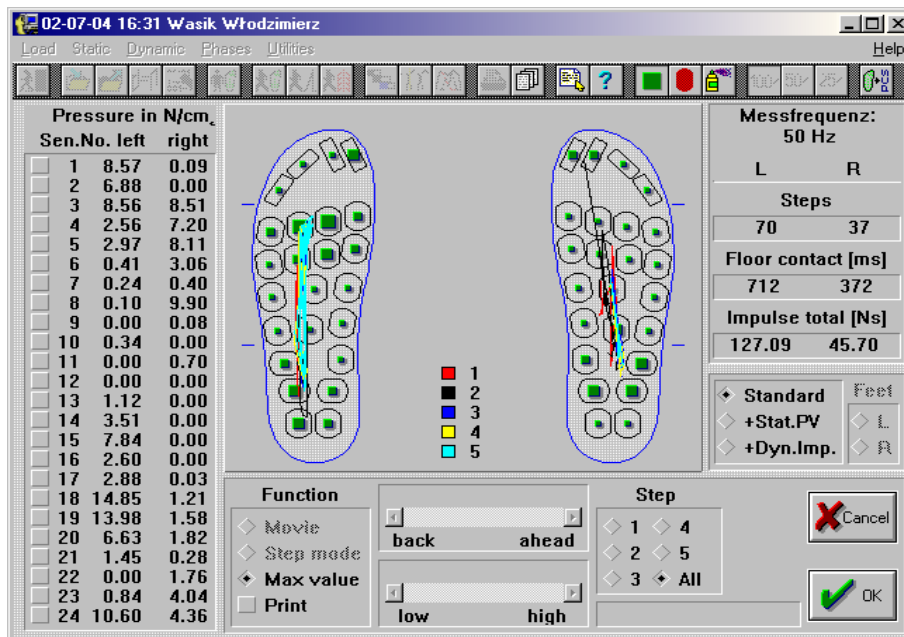

Fig.2. 67-years old male with serious severity of left- lateral PD (stage IV):

Floor contact and impulse values analyses

Besides the measures for presented above abnormalities, majority of them indicate a floor contact increase, represented by time and impulse (the absorbed energy) values.

For 11 cases (73,3%) of left-lateral PD the impulse values increase has been noticed within a left limb. For 4 cases (26,7%) this increase concerned a right limb area. For the same groups the time values of floor contact increased on left limb, in 80% (12 patients) cases and only 6,7% (for one case) on a right side have been notoced. For 2 another cases (13,3%) a floor contact time had the same value on both sides.

For 5 cases (62,5%) of the right–lateral PD the impulse value increased within a right limb was significant. For 1 case (12,5%) the impulse value was the same on both limbs. Finally in 2 cases (25%) the increase of impulse value appeared on a left limb.

For 4 cases (50%) of the right lateral PD the floor contact was significantly bigger on a right limb but for 4 other cases of the right lateral PD this floor contact increase was observed on a left limb.
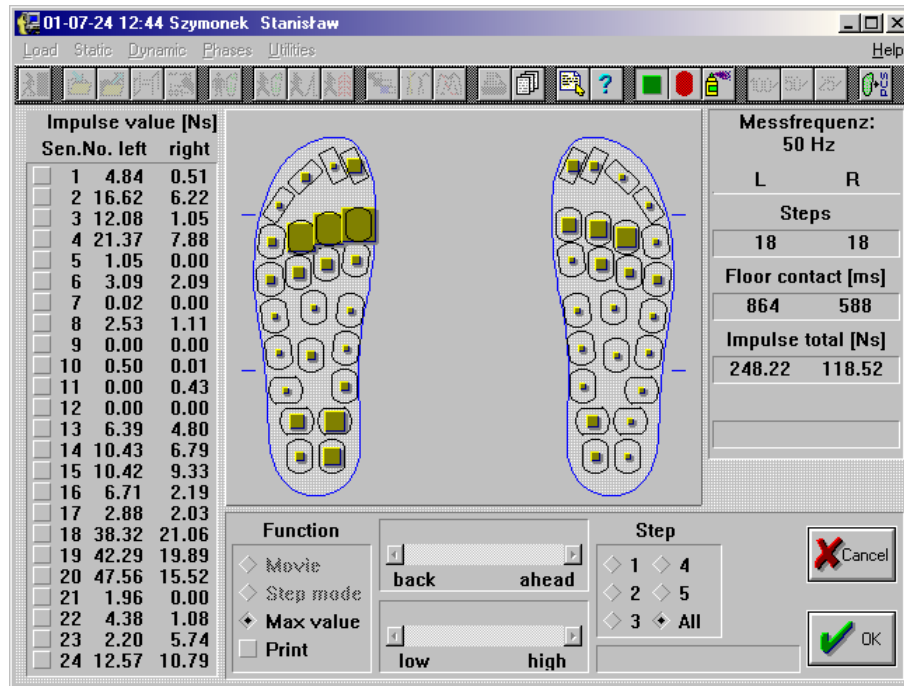
Fig.3. 69- years old male with moderate phase of left-lateral PD

The stage III example has been illustrated by a Fig 3, where significantly increased the floor contact time value. Also the impulse values were bigger on the left limb.

The walk abnormality level

The walk phases have been analysed for both groups, with a left- and right-dominated PD. The analysis results have been presented in table 2.

	Start phase	Support phase	Push off phase	Overlap phase
Higher	9	7	5	10
Lower	2	7	10	4
Similar	4	1	-	1

Tab.1. The phase comparison of a left lateral PD with an opposite limb

	Start phase	Support phase	Push off phase	Overlap phase
Higher	4	2	7	2
Lower	4	6	1	6
Similar	-	-	-	-

Tab.2. The phase values comparison of a right lateral PD with an opposite limb (number of patients)
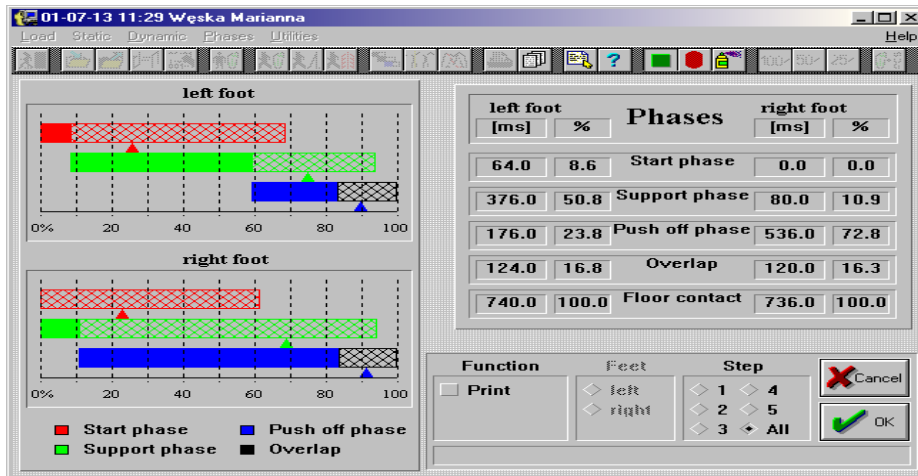

Fig.4. 67-years old female with left lateral dominated PD (stage III):

On a right foot the Start Phase = 0, with elongate time of overlap on start/Support phases. Very short is also a push off phase, with a stage on left limb.

3. CONCLUSIONS AND DISCUSSIONS

The described clinical experiments allow us estimating the PSW options as positive measures for several neurological diseases classification. A way of walking of the patient suffering from the PD can be specified by the available measures. They describe many specific abnormalities as it was discussed above.

It is well established that first symptoms of PD are observed only on one side of a footprint, usually as an upper limb tremor.

In a more critical PDs, clinical symptoms were observed on both sides of the body but the lateralisation is still visible. It corresponds to a one body-side load movement mentioned by the PSW options. We also noticed that the walk disturbances are asymmetrical, independently from duration or severity of the disease for all data records. This phenomenon concerns undoubtedly the PD but its complete explanation is still obscure.

Based on PSW records we indicated characteristic features of walk abnormalities that are observed for patients suffering from PD, among them:

– asymmetrical lateralisation of walk disturbances (100%),
– majority of patients with shifted body weight towards a left limb (78 %) usually in heel region independently from more affected side,
– elongation and irregularity of trajectories for foot gravity centre movement for more affected limb (65,2%), with more remarkable differences in lengths of the trajectories in cases with severe symptoms of PD,
– increase of a unilaterally floor contact and a time with impulse values increase usually for affected limb (65,2%),
– The time increase of start and support phases, slightly bigger then the define norms. (for more affected limb - 57%).

The PSW equipment can be used for recognition and for quantification of the motor disorders. The comparison concerns a pattern, physiological cases with abnormal cases. It is obvious that the PSW data records contain more data that it is used for quantitative diagnosis.

In previous studies we analysed motor disturbances using PSW in cases of acute sciatic neuralgia and hemiparetic patients. At first glance those result compared with PD observations showed superficial similarity (unilateral or predominate lateralisation and focussing most of gait abnormalities usually on an affected limb).

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