Motion Videocapture and Treadmill to Study Postural Reactivity and Transition: Application to the condition of "Dry" Immersion in Parkinson's Disease

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Abstract—**The purpose of this study was to evaluate technical reliability of a commercially available treadmill to induce slip displacement, which is sufficient to provoke postural reactivity in subjects with Parkinson's disease (PD). These subjects underwent the program of ground-based microgravity modeled with "dry" immersion (DI). Additionally, in the same study group we assessed the function of postural transition. Both postural reactivity and transition were traced with motion videocapture technique. We found that at 1 km/hour treadmill did produce acceleration and, hence, heel strike, detectable for motion videocapture. Therefore, from the methodological point of view the study looks promising. However, this acceleration proved lesser than it is usually applied in suchlike studies. In part, this explains for the lack of significant effect of the DI program on the characteristics of postural compensation reactions in subjects with PD. Alternatively, the result could be explained by weak effect of DI on the studied postural functions. For future studies, we regard that inertial measuring units (IMU) and stronger acceleration would better fit the task to study postural reactions in subjects with PD.**

I. INTRODUCTION

Motility (the ability to move freely, independently, and easily) and *mobility* (the ability to change location or move between two locations) appear as critical abilities of any animal, including a human. The term *motion*, in the most broad sense, refers to the *state* of progression in space (antonym of *rest*), or the condition of restlessness of a very big object, e.g. the "motion of ocean". Correspondingly, the term *movement* refers to a physically moving smaller object observed from the side, for example, a hand, or in a joint.

There are varied modes of motion, of which *locomotion* is the most readily at view. As the name suggests, locomotion means the ability to actively transport one's own body to a distance larger than size of the body (self-transport), which actually means a change in its position on the surface of the Earth. In this respect, locomotion has much in common with mobility. Locomotion is comprised of walking, running, jumping (if the landing point is different from the take-off point), swimming, diving, flying, etc. Unlike locomotion, movements are not linked to body transportation, for example, manipulations, or, hand movements, such as writing, food cutting, face washing, closing buttons, etc. In some studies, such manipulative movements, opposed to the trunk "axial" ones, are defined as the "appendicular" movements [1]. Thus, unlike locomotion, movements are not associated with body movement.

In addition, there is a special muscle activity that does not require observable movements at all - the postural activity, which is based on such a phenomenon as muscle tone. Muscle tone refers to a state of weak, prolonged, isometric skeletal muscle contraction. However, muscle tone can also be defined as the ability to resist passive flexion-extension of the joint or the viscoelastic properties of muscles [2, 3]. In a sense, muscle tone (posture) is widely regarded as "movement without movement."

Vertical stance at ease, or upright stance, presents a good example of such static motor activity (task for postural *orientation in space*). Practically no movement is seen in standing-at-ease man, though the task to stand upright is not easy at all, as it requires the ability to the *body balance* in the Earth's gravitational field. Without muscle activity (muscle tone) and balancing corrective trunk and arm movements the body will quickly fall under gravity. In addition to this static balance at standing at ease, there is also the dynamic balance aimed at keeping the body in the upright position during walking or jumping, as they readily destroy the body balance. Thus, division of motor activity into locomotion and postural activity is very conditional, as postural mechanisms are "in-built" in locomotion.

To prevent falls, several classes of *proactive* and *reactive* posture mechanisms have been evolutionarily developed: 1) anticipatory posture adjustments (APA), which begin approximately 70 ms before movement to adjust the center of pressure (CoP) for body or arm movement, 2) postural reactions, which start some 100 ms *after* the onset of a perturbation was perceived by the vestibular receptors, and 3) corrective volitional reactions (>500 ms after the perturbation has taken place), which account for deliberate postural *corrective* activity [4].

Altogether, the motor activity allows motility (and, hence, mobility), targeted (purposeful) hand activity, and also prevents falls. Such a set of motor competences allowed surviving a human in the primeval, highly hazardous environment. Likewise, these competences stay important in today's urban environment, where a pedestrian, especially an elderly human, encounter perturbations like slippery surface, obstacles, and traffic. If the fall did occur, then the body balance was inefficient. In older adults, due to weaker musculature and poor motor coordination spontaneous falls also happen [5]. This, in turn, leads to direct bodily damage (injures). Also, older people are less willing to walk outdoors, what restricts their mobility. For neurological pathologies, e.g.

Parkinson's disease (PD) or dementia, falls risk is even higher [6].

Some 7 years ago, we came up with a project to study the physiological mechanisms and rehabilitation potential of the ground-based microgravity modeled with the condition of "dry" immersion (DI). We found that enhanced muscle tone (rigidity) in subjects with PD is decreased after either a program of DI sessions or a single one DI session [7]. Tremor, assessed with nonlinear parameters of surface electromyogram, clearly was decreased after a session of DI [8]. The parameters of vertical stance assessed with the PC-based stabilometry (evaluation of the CoP travel) were unchanged either after a single one DI session or a program of 7 DI sessions [9]. Additionally, we reported that the reaction time in visual-motor tasks, especially cognition-loaded ones, significantly improved after the program of DI sessions [10].

Still, such "easy" task as vertical stance seems (static body balance) to be not so representative, since the elderly and subjects with PD at initial and moderate stage of the disease are able to effectively maintain the upright position, although they demonstrate longer travel of CoP and spontaneous changes in its direction [11]. Therefore, we asked, are dynamic balance mechanisms (postural reactivity and APAs), in contrast to the static ones, improved after the program of DI sessions? As we have earlier written, "there is market pain for a time-saving (fast), not-so-precise (robust), easy-to-do (comprehensible), though still relevant, evaluation procedure of postural reactivity [12]. To proceed, we opted to test for feasibility a study apparatus assembled of available and low-cost instruments, to study the dynamic body balance in PD subjects. More specifically, we combined 1) the motor-driven treadmill as a perturbation-inducing machine, and 2) a motion videocapture instrument to trace postural reactions. The APAs were studied with a well-known TUG (Timed-Up and Go) test, namely, with its "sit-to-stand" phase.

II. RELATED WORKS

Several approaches can be found for assessing postural reactivity to external perturbations and proactive adjustments to posture transitions. The first is to disturb the subject's balance during a routine neurological examination and assess it using a rating scale. For example, the generally accepted UPDRS-III (Unified Parkinson's Disease Scale, Motor Part) has a corresponding test (item 30: "Posture stability, assessed as a reaction to a sudden strong displacement of CoP caused by backward pull, although a sophisticated version (MDS-UPDRS) is increasingly being used [13].

Another approach, best illustrated with BESTest, allows exerting the displacement of CoP with "push-and-release" test [11]. The BESTtest was further commercialized and now appears as a sophisticated PC-based instrumented method for posture and gait assessment that provides 24 informative measures in 5 domains of body balance [14]. Such-like "science-intensive" methods all the time are becoming more precise, easy-to-do, and easy to interpret. From the other side, they are still costly, and are elaborated and used in limited number of laboratories (or even single one laboratory). Perturbations could be also applied during PC-based stabilometry to digitize CoP displacement and travel [15].

In this study, we propose to induce perturbation with a regular treadmill. Treadmills are usually available in a physiological laboratory and are often used as a kind of research tool, rather than just a simulator of locomotion. For example, treadmills allow one to study the characteristics of running / walking at an external pace ("treadmill walking") as opposed to "overground walking" at an independent pace [16, 17]. In addition, several studies have successfully used the treadmill as a perturbation tool because the treadmill allows heel strikes (slip displacement) [18, 19]. The last two articles reported on the effect of low back pain on the postural reaction of the trunk to perturbation. Since PD patients have distinct abnormalities of body balance and orientation in space, it seems reasonable to study their posture reactivity and posture transition using a treadmill. Most of the studies with treadmill as perturbation inductor appear as *instrumented*, i.e. equipped with integrated force sensors and are a split-belt.

Among useful features of the treadmill, one can note reproducibility of its dynamics, i.e. its running belt starts at same velocity predetermined on the operation panel. It means that one can obtain standard displacement of the running belt. We used this feature to exert reproducible perturbations in the studied group of patients with PD who passed through a program of ground-based microgravity modeled with "dry" immersion (DI).

The sit-to-stand phase of TUG test is used to study the APAs, as it allows evaluating the preparatory postural adjustments *prior* to the movement and also some kinematic characteristics of the movement itself [20]. This phase of TUG is widely used to evaluate the effect of some anti-PD therapies, e.g. subtalamic nucleus stimulation [1] or dopaminergic therapies [21].

III. METHODS AND SUBJECTS

Subjects

Fourteen subjects volunteered to the study. Eleven subjects with PD (aged 46-67 years, 9 males, 2 females) were enrolled to the study group (with the program of DI, or the DI group). One subject underwent the program of DI four times within 3 years, and another subject - two times. Altogether, we obtained data from 14 courses of DI. Three subjects constituted the control group (without DI, or the noDI group, all males). Each subject signed the informed consent form. We used the protocol, earlier approved by the local ethic committee for the study of DI in PD subjects(statement of approval №34, 22.04.2015). The anthropologic and clinical data on the subjects is presented in Table 1. The measurements were conducted in 2017-2019.

Procedures and outcome measures

The DI procedure. The program of DI sessions was elsewhere in-detail described [7, 8, 9, 10]. In brief, the DI condition was induced with help of MEDSIM device (Center of Aviaspace Medicine and Technologies, Moscow, Russia) housed in the Laboratory of Novel Methods in Physiology (Institute of Higher Biomedical Technologies, Petrozavodsk

State University, Russia). This device appears as a bathtub filled with 2 cubic meters of periodically aerated and heated water (32°C). It is equipped with a metal, regularly perforated platform, movable up and down with a motor drive. The surface of water is covered with a water proof film or large square (3 x 4 m). That allowed making folds, wrapping, and lodging (immersing) the subject in the water volume. Only head and the upper part of thorax were left above the water (head-out-of-water condition). As result, the subject was immersed in water, but without direct contact with it, what appears as "dry" immersion. A single one DI session lasted for 45 min, under monitoring of ECG and blood pressure. The program of DI session was comprised of 7 sessions of DI, with the periodicity of 3 days. Altogether, the DI load was 3 hours and 15 min within 25-30 days. Neurological examination before and after the DI procedure was conducted by an experienced neurologist.

TABLE I. CLINICAL AND ANTHROPOLOGIC CHARACTERISTICS OF THE STUDIED GROUPS

Group	Age, (years)	Height (cm)	Weight (kg)	UPDRS-III (score)	Duration (years)	Stage by H&Y	LEDD (mg)
DI, n=11	61 53-67	171 167-179	78 64-83	25 15-29	4,5 3-6,25	2 1-3	312 300-450
noDI, n=3	50 46-55	178 171-186	94 86-114	21 15-28	4 3-6	2 1,5-2	470 450-550

In the DI group, data is presented as median (M, 25-75%), in the noDI group only M and min-max range is shown due to insufficient number of subjects, LEDD - levodopa equivalent daily dose. H&Y - Hoehn and Yahr scale.

Induction of perturbation. Perturbation was induced with the horizontal slip (heel strike). To conduct it, we used a commercially available treadmill Kettler Marathon (Kettler, Germany), housed in the laboratory, with running area 152 x 60 cm. To perceive the perturbation, subjects were positioned on the surface of the black-colored, two-ply running belt, facing towards the belt motion, 1,1 m ahead of the back edge of the device (for safety, to prevent falling backwards), with eyes open, hands freely hanging down, and barefoot (Fig. 1). After the motion videocapture system was on, the assistant pushes the start button on the operation panel of the treadmill, and the running belt started its progression. The speed of running belt motion was set at 1 km/h (some 0,28 m/s). Such low speed was chosen for two reasons: 1) subjects with PD were presumed to have slower postural reactivity to horizontal displacement of the standing surface, so they could fall at faster speed, 2) the length of the running belt is rather short, what potentially would have provoked excessively fast reaching the back edge of the device. For safety, subjects were protected with harness. Additionally, another one assistant has constantly kept watch on the subject at the rear edge of the treadmill.

Before the study, we tested the characteristics of the treadmill as a perturbation-inducing device. To do this, we calibrated the characteristic of acceleration of the running belt, since it is assumed that a stable speed is not achieved immediately. To proceed, we quantified the travel of light-returning marker settled on the heel which is supposed to stay motionless during perturbation. The velocity profile of the running belt is presented on Fig. 3. It turned out, that the running belt accelerated from 0 to 1 km/hour (0,28 m/s) in cal. 0,5 s (Fig. 3). After that, the subject continued to passively move staying on the running belt. When he was approaching the "0,5 m" mark from the rear edge of the treadmill, the assistant presses the Off button on the treadmill operation panel. Altogether, the test lasted for some 2-2,5 s. For metrics of postural reactivity we have chosen the height of the head light-returning sphere, which informed on the moment when compensatory backwards movement of the body started (Fig. 1). With this, we measured the latent time (onset) of the postural reaction (relief), or reaction time (RT, in seconds). Also, we evaluated the body (head) tilt during perturbation (in mm). Schematization of the whole test is presented on Fig. 1. Scenery of the test is presented on Fig. 2.

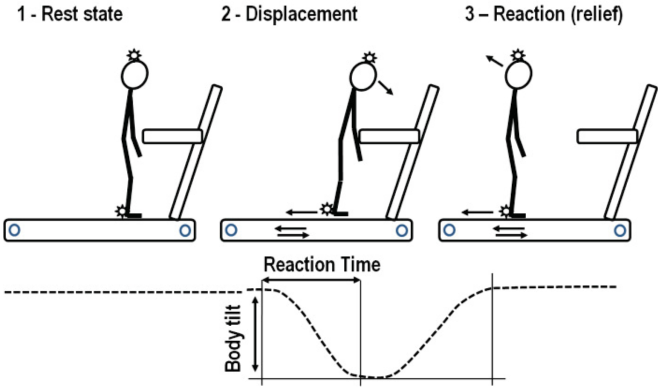

Fig. 1. Schematization of the experimental protocol for postural reactivity with treadmill-induced perturbation. Upper panel: 1 - subjects stands at ease on the running belt in vertical position (rest state); 2 - the running belt starts to horizontally move, what provokes *physical* displacement of the subject's feet and tilting forward so that CoP founds itself in front of the subject's area of support (displacement); 3 - physiological reaction on the floor displacement (compensatory backward movement of the body). ☼ marks position of the light-returning spheres. On the bottom panel the dashed line represent the trajectory of the head light-returning sphere. The double-sided arrows show the reaction time on displacement of the running belt and the body tilt before the reaction (in Z axis).

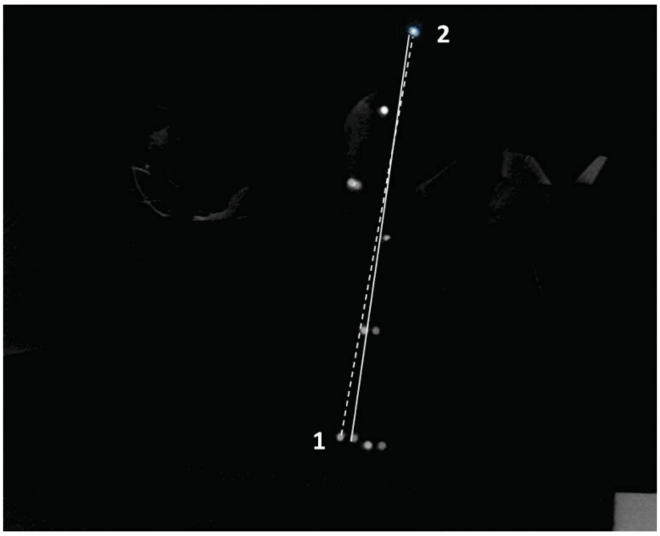

Fig. 2. Two video shots (at resting state and maximal displacement), manually overlapped. It is seen that feet (1) have displaced backwards by some 10 cm, while the head (2) - only by some 2 cm forward and downwards. Solid line show represents the axis between right heel and the head at rest state, the dashed - at maximal backward body displacement.

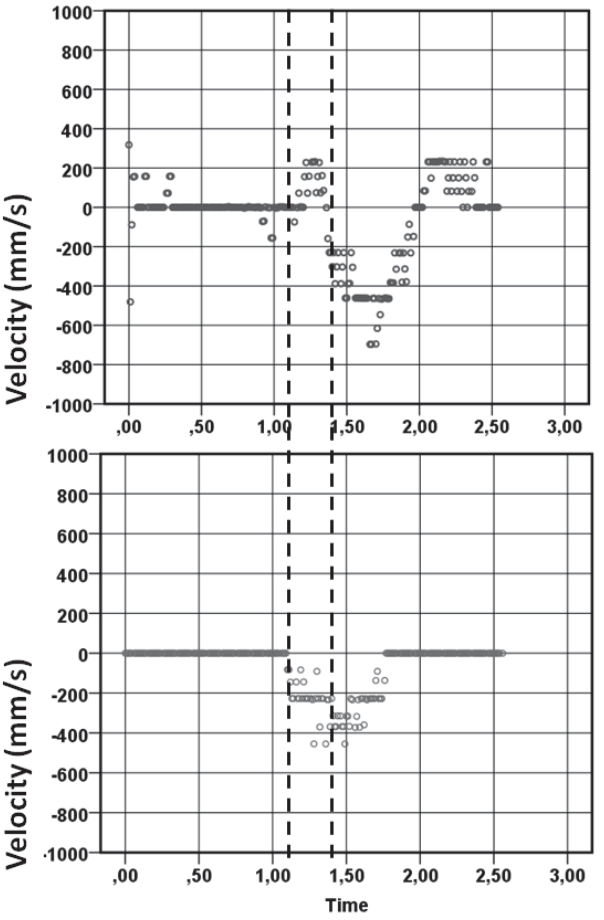

Fig. 3. Time profile of velocity of the light-returning sphere settled on the head (upper panel) and heel (lower panel), in Y-axis. Values on the horizontal axis represent seconds, the vertical axis -mm/s. Dashed vertical lines represent the reaction time (time from the start of displacement and the beginning of reaction).

The TUG test. The sit-to-stand motion (standing up) was tested with a widely used 3 m TUG (Timed Up and Go) test, which consists of several consequent phases/tasks (sit-to-stand transition, walking forward 3 m, turning by 180°, walking back, and stand-to-sit transition).Only the first task (sit-to-stand transition) was analyzed, as the number of steps (usually 3-4) was not enough for accurate computations, and each of steps (the first, the middle, the last) was functionally specific. The TUG test was in-detail described in our earlier paper [22]. The scenery of the sit-to-stand transition is shown on Fig. 5. For metrics, we used the time between the beginning of standing up and the upright position (s), and speed of standing up (mm/s).

Motion videocapture. Before the test, light-returning spheres were attached atop the head of subjects with help of a sport cap made of knitted wool, and on the major joints (Fig. 2). For motion capture we used a video analyzing system (Videoanaliz 3D, Biosoft Ltd, Moscow, Russia). This method was in-detail described in our earlier paper [22]. Example of head trajectory during the TUG test traced with reflective markers is presented on Fig. 6.

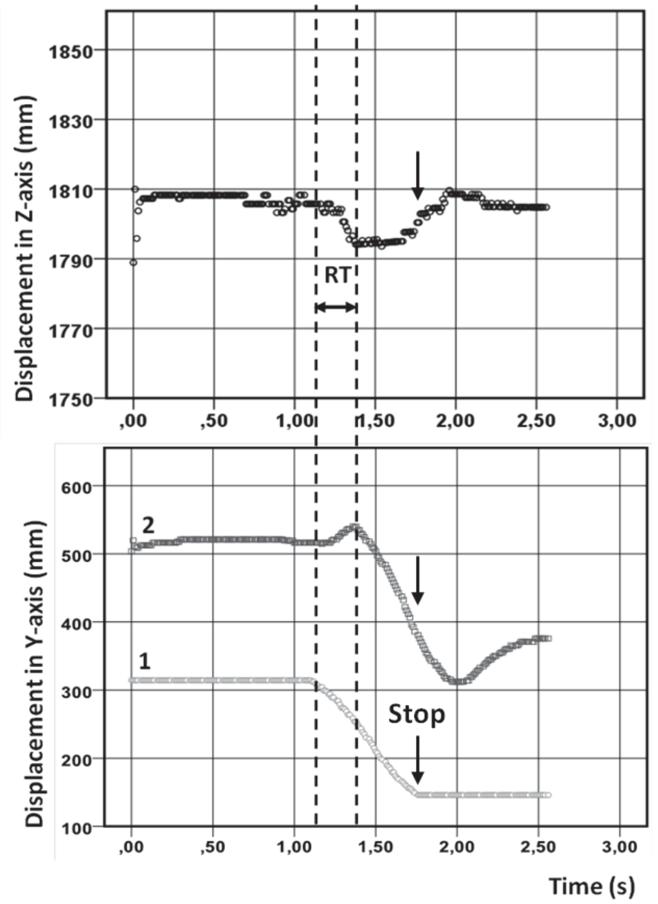

Fig. 4. Time profile of displacement of the head light marker in Z axis (upper panel) and Y axis (trace 2, bottom panel). Displacement of the heel marker (belt displacement in time) is represented by the trace 1 (bottom panel). The same subject as on Fig. 3. Dashed vertical lines represent the reaction time (time from the start of displacement and the beginning of reaction). The difference between traces 1 and 2 is clearly seen, as trace 2 (head) represent postural reaction during the start and stop (black arrow).

Fig. 5. Scenery of the TUG test. Light-returning spheres are attached to all joints and head. Left panel - the subject seats, right panel - the subject stands up and walks forth with eyes open.

Statistical analysis. For statistics, we used the IBM SPSS 21.0 Statistics (IBM, USA). To evaluate influence of DI on the studied parameters we applied the Friedman non-parametric test for multiply comparisons among 3 study points - before (preDI), 1 day after (postDI), and 2 weeks after the program of DI sessions (DI2w). Graphs were built with SPSS 21.0 software on the basis of numerical values extracted from real videocapture records.

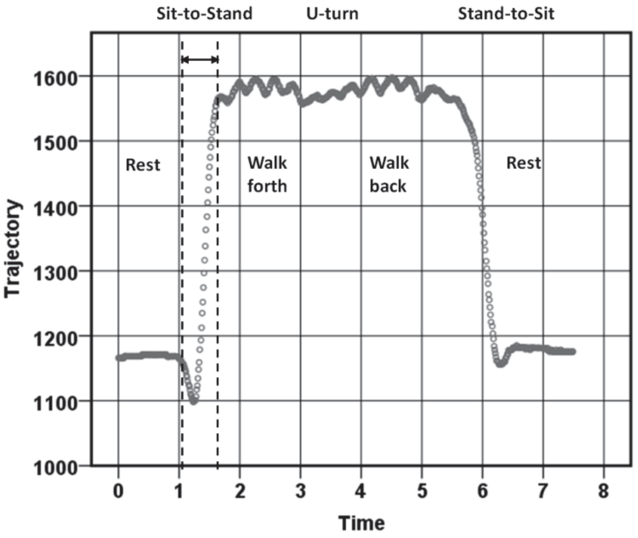

Fig. 6. Head trajectory in the Z axis (sagittal, up-down direction) during the TUG test. Two vertical dotted lines and the double-headed arrow between them present the sit-to-stand transition (standing up). To stand up, subjects had to adjust their CoP forward what is seen as tilting downward (and forth, not shown). Correspondingly, head position became lower (7 cm deep downwards travel of the trajectory on this graph). Walking forth and back is clearly seen as wavy (sine like) trajectory from 1,6 to 5,5 s, the U-turn is seen right in the middle of the picture, stand-to-sit - on the right end of the trajectory. Values on the horizontal axis represent seconds, the vertical axis - mm (height of the head above the floor).

IV. RESULTS

1. Technical aspects (treadmill as a displacement inductor).

At the assigned velocity (1 km/hour, 0,28 m/s), the treadmill allowed inducing the horizontal displacement with following characteristics: 1) peak velocity was achieved within cal. 0,5 s; 2) during this time, the belt has displaced by some 200 mm, and 3) in Z-axis the head has tilted down as much as 20 mm. Such modest displacement was not reliably well captured by the applied video system from the distance of 6 m used by us [22]. For example, the traces of the head light markers were not enough smooth on video, especially for velocity (Fig. 3). As for the TUG test, the traces were of reasonably good quality, as displacement was much bigger (some 500 mm).

The treadmill was not instrumented in the present study. Therefore, we asked assistants to push On and Off button on the operation panel of treadmill. That should be taken into consideration in further studies.

2. Characteristics of the postural reactivity with treadmill-induced perturbation. Mean values of reaction time and body tilt in both DI and noDI groups are presented on the Table II and III, correspondingly.

TABLE II. THE REACTION TIME ON TREADMILL-INDUCED HORIZONTAL SLIP PERTURBATION ALONG THE COURSE OF DI SESSIONS

Group / Condition	PreDI	PostDI	DI2w	Friedman test
DI	0,98±0,4	1,05±0,4	1,29±0,5	0,485
noDI	0,82 ±0,25	0,77 ±0,33	0,8 ±0,17	0,761

The values are presented in seconds

TABLE III. BODY TILT (Z AXIS) INDUCED BY THE HORIZONTAL SLIP PERTURBATION ALONG THE COURSE OF DI SESSIONS

Group / Condition	PreDI	PostDI	DI2w	Friedman test
DI	19,2±13,6	13,4±6,4	20,8±14,7	0,519
noDI	15,7 ±4,6	14,3 ±9,0	10,7 ±4,7	0,717

The values are presented in millimeters

In general, we found no statistically significant effect of the program of DI sessions on the postural reactivity of subjects with PD. Only a slight tendency to decrease was found for the body tilt right after the program of DI sessions (table III). Neither effect was seen in the control noDI group.

2. *Characteristics of the postural transition in the TUG test.* Mean values of reaction time and body tilt in both DI and noDI groups are presented on the Table IV and V, correspondingly.

TABLE IV. TIME OF THE SIT-TO-STAND PHASE OF THE TUG TEST ALONG THE COURSE OF DI SESSIONS

Group / Condition	PreDI	PostDI	DI2w	Friedman test
DI	0,74±0,23	0,73±0,18	0,75±0,3	0,498
noDI	0,69 ±0,15	0,66 ± 0,19	0,69 ±0,25	>0,5

The values are presented in seconds

TABLE V. SPEED OF STANDING UP DURING THE SIT-TO-STAND PHASE OF THE TUG TEST ALONG THE COURSE OF DI SESSIONS

Group / Condition	PreDI	PostDI	DI2w	Friedman test
DI	0,67±0,28	0,65±0,22	0,66±0,26	0,423
noDI	0,65 ±0,16	0,71 ±0,21	0,72 ±0,26	>0,5

The values are presented in millimeters

Alike the postural reactivity, we found no significant effect of the program of DI sessions on the characteristic of postural transition of subjects with PD.

V. DISCUSSION

The purpose of this study was clearly dual - 1) technological, and 2) physiological. First, we aimed at testing feasibility of a technique inducing standardized slip displacement of human feet with the running belt of a custom treadmill, i.e. to use it as a perturbation-inducing tool. Second, based on that methodological approach we aimed at evaluation of postural reactions in subjects with PD under the conditions of DI. In addition, we studied postural transition in the same study group with motion videocapture during the sit-to-stand phase of the TUG test.

1. Technological aspects. From a technological point of view, the suggested method of inducing the postural reaction with slip perturbation from the running belt of the treadmill proved feasible and promising as it is standard/repeatable, in line with pre-existing literature [18,19]. Also, treadmills are available on the market. However, we found that the slip stimulus (displacement of the running belt) develops rather slowly. The acceleration phase lasted for some 0,5 s at a speed 1 km/hour. To compare, in the study of de Kam et al. [23] the acceleration phase lasted for 300 ms, which allowed acceleration at the level of 1,5-1,75 m/s^2. Usually, the support-surface perturbations in activity of daily life (slips, falls) appear as more brisk. Similarly, in laboratory and hospital, faster perturbations are used to test postural reactivity (brisk pulling, release of pushing, etc.). Perhaps, only slowly accelerating escalators in big shopping centers or slowly taking-off transport vehicles would represent such perturbation in real life. From the other side, older adults and subjects with PD in real life would rather avoid faster, hence more hazardous, accelerations. Presumably, due to such slow slip acceleration the body tilt, seen as the head tilt, was rather small (around 20 mm), which could explain slower reaction on it (around 1 s).

Such low-amplitude perturbation and, correspondingly, modest trunk postural reaction on it was not reliably captured by the motion videocapture system from the distance of 6 m. The recorded trajectories were rather rough (discrete) by view what complicated further trajectory analysis. As for the postural transition during the TUG test, the quality of trajectories of reflector markers captured with video was notably better (more smooth), presumably due to 10-fold bigger displacement of the head.

2. Physiological aspects. From physiological point of view, we found that such characteristics of human's motor activity, as postural reactivity and postural transition stood largely unmodified by means of the program of DI sessions. Such result could be discussed and explained in two aspects.

First, some limitations and inconsistencies in the study protocol could have contributed to the result. Namely, insufficiently strong/fast (inadequate) stimulus, as it is discussed above and in the "Limitations" section further in the text. Usually, during slip perturbations subjects with PD produce compensatory steps [24], what was not the case in the current study. Second, in healthy subjects, trunk postural reaction takes some 90-300 ms for slip perturbation of different intensity [18, 19, 25]. In PD subjects, reaction time depends on the severity of the disease, and in least severe cases, reaction time does not differ from that of healthy controls [24, 26]. In the present study, subjects had relatively mild-stage PD (1-3 by H&Y).

Second, subjects in our study were non-fallers, and they had relatively low UPDRS-III score. There is a subtype of PD, characterized by the postural instability and gait difficulty (PIGD), evaluated with items 27 to 30 of UPDRS-III. In the PIGD subtype subjects, most of the TUG phases are slowed in comparison with the non-PIGD (tremulous type) PD subjects [27]. In our study, subjects did not belong to the PIGD subtype, as they had only 2 to 4 score in PIGD subtotal of maximally possible 16. Third, all subjects, but one, took their anti-PD therapies 1 hour before measurements, what means that they were On-medication during measurements. The Off-medication state is regarded as more discriminative for PD-specific symptoms [1].

3. Limitations to the study. There were several limitations to current study. First, the onset of the slip stimulus should have appeared as unpredictable (unannounced). The subjects in our study stood with eyes open, therefore they were able to control operations with the buttons on the treadmill panel, performed by the assistant. As such, though the exact moment of the pushing-on was not known to subjects (was unannounced), they still were prepared to the onset of slip by predicting it from the assistants motor behavior. Usually, such kind of studies are performed without announcement of the stimulus onset [28, 29]. In further studies, the operational panel must be screened from the subject. Second, only one direction of the perturbation was applied (anterior-posterior, forwards). However, this direction seems to be the least affected in PD in comparison to backwards slip [30], or the mediolateral direction [14]. Third, arm protective movements were not studied, though they are considered important in balance control in PD [31]. Also, these movements are susceptible to the dopaminergic therapy [30], what looks promising also for a the DI conditions. Forth, the mediolateral strategy during anterior-posterior slip perturbation was not evaluated in the current study, though reportedly it is activated during forwards and backwards slips [24].

4. Perspective and further studies

Sung and Danial [19], along with videocapture used IMU to evaluate trunk reactive movements. We also have promising experience with IMU application during the TUG test [22]. Using IMU allows reasonably accurate tracing of a body segment trajectory in 3D and even discriminate between healthy controls and PD patients by gait characteristics [22]. Therefore, it looks valuable to use IMU-based methods in the present study. Also, we regard that surface EMG (sEMG), along with kinematic measures, could be also a useful method to evaluate the trunk postural reactivity. Unlike to the IMU and motion videocapture, sEMG would have allowed direct estimation of the reaction in leg and trunk muscles, which actually execute such reaction [25].

Additionally, there are some "provocation" motor tests, which help converging/translating the laboratory-suited studies to a much more realistic activity of daily life, for example, hand-held tasks (holding a tray with a cup of water) [25], or tasks with increased posture threat ("posture anxiety") [31]. As activity of daily life is easily evaluated with rating scales, the effect of DI on postural reactivity could be better traced with these provocation tasks. In this case, the motor task (the body balance) appears as the primary, and the additional task (hand held, conversation, subtracting, etc) - as the secondary one [32].

VI. CONCLUSION

In sum, we regard this paper as promising exploratory study to further investigate postural activity in PD subjects, and, in broader aspect, in older people, under different gravity conditions. Microgravity is modeled not only with DI or parabolic flights, as it is done in space physiology, but also with the "bed rest" technique. Bed rest is often the case for older people, as many of them conduct sedentary life style in attempt to avoid falls. This, in turn, leads to a conditions of "functional immobilization" [32], what is similar with the bed rest conditions. In addition, in the future, it is assumed that the elderly and even people with neurological diseases will make space and suborbital flights, which will support interest in the study of posture in different gravitational conditions during aging and varied age-related pathologies, including parkinsonism.

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