QUANTITATIVE ASSESSMENT OF DANCE THERAPY INFLUENCE ON THE PARKINSON’S DISEASE PATIENTS’ LOWER LIMB BIOMECHANICS

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Abstract. Parkinson’s disease – progressive neurologic disorder that damages a variety of motor function and reduces the quality of life. Patients with PD are subject to various physical therapy exercises, but recently is applied more often the dance – music therapy. This study aims assessing the therapeutic effect of the modified Lindy Hop dance therapy on lower extremity biomechanics. The experimental study was performed using inertial sensors that registered lower extremity biomechanical parameters during gait. Several spatio-temporal parameters of lower limb were calculated and were found statistically significant between groups, which allows quantifying the influence of dance therapy.

Keywords: Parkinson’s disease, gait, dance therapy, inertial senor, the Unified Parkinson’s disease rating scale (UPDRS).

Introduction

Parkinson’s disease (PD) is the second most common neurodegenerative disorder, which affects about 1 % of people over 60 years and 4 % aged more than 80 years in developed countries (Ghaffari, Kluger 2014). PD is characterized by four main motor symptoms: tremor is characterized by involuntary shaking of the body parts, which is characterized by 4–6 Hz vibration frequency (Deuschl et al. 1998), bradykinesia – slowness of movements (Shiner et al. 2012), rigidity – increased agonistic, antagonistic and synergistic muscle tone, rigidity feeling sick (Santens et al. 2003), postural instability – impaired balance and gait changes (Ozinga et al. 2016). The human gait is characterized by spatial and temporal parameters (Hollman et al. 2011). PD affected gait is characterized by shorter step length, longer double support time (Sohmiya et al. 2013) and joint amplitude decrease compared to healthy subjects amplitudes and kinematic parameters (Roiz et al. 2010).

Various disease assessment scales such as the Unified Parkinson’s Disease rating scale (UPDRS), modified Hoehn and Yahr scale, that determines the severity of the disease (Roiz et al. 2010), Berg balance scale and time get up and go test are used in PD diagnostic, but they are specific and can’t quantify the patient’s condition and quality of movements performed. These scales are used to assess the severity of an individual patient’s disease and allow evaluating both motor and psycho criteria.

PD rehabilitation is a subject to several basic methods, such as motor learning and motor training (Roiz et al. 2010). Lately, the combined dance and music therapy is more often applied for patients with PD. Dance therapy shows noticeable improvement in motor functions, for example gait and balance improvement (Hackney, Earhart 2010). The literature most often mentions application of Argentine tango or classical dance movements and usually this kind of therapy is evaluated using objective assessment scales.

Until now, little research is carried out in attempting to quantify the impact of dance on PD patients. Researchers use various tools for performing an instrumented gait analysis. (Sohmiya et al. 2013) study used a video capture software to quantify PD gait and balance changes after certain physical exercises. Some studies are using combined assessment in the combined dance – music therapy effect on patients with PD motor ratings, both for motion capture software and disease assessment scale. Motion capture systems require special facilities, are expensive both in purchasing and time spent on training qualified personnel and integration in regular clinical practice is rather slow. Body-worn wireless inertial sensors available today are relatively cheaper alternative and easier to apply in clinical setting for capturing the motion data (Ozinga et al. 2016).

The objective of the study is to quantitatively assess an influence of modified Lindy Hop dance therapy on lower
limb biomechanics of PD patients via capturing subjects’
kinematic gait data using wireless inertial sensors.

Materials and methods

Experimental data from 25 PD subjects was collected in
cooperation with Vilnius University Hospital Santariskiu
Klinikos neurology and rehabilitation, physical and sport
center. Subjects were divided into two groups: the first
group (PD group) was assigned for the modified Lindy Hop
dance therapy sessions, while the second group (control
subjects or CO) did not undergo the therapy. Table 1 shows
the demographic and clinical data. In total, PD group have
had 22 dance lessons. Before each lesson, 15 minutes of
moderate exercise was performed, followed by the 45
minutes of dancing. PD group dance lessons continued for
2 months, while group CO had no lessons. Comparing to
other dance types, modified Lindy Hop dance was chosen,
because this dance training is the simplest one.

Table 1. Demographic and clinical characteristics of subject

| Group | n   | Age (mean±SD) | Hoeh and Yahr scale score (mean±SD) |
|-------|-----|---------------|-----------------------------------|
| PD    | 14  | 65.43±9.41    | 2.00±0.62                         |
| CO    | 10  | 57.90±9.27    | 2.15±0.71                         |

Six wireless inertial sensors each having nine degrees
of freedom were used to capture the kinematic parameters
of limbs. These sensors record the linear acceleration, an-
gular velocity and magnetic heading in three dimensions.
The sensors were mounted on subjects lower limb seg-
ments (right and left thigh, shank, foot) using mounting
straps. Sensors recorded data at 51.2 Hz sampling rate using
Bluetooth connection to a personal computer. Measurement
data were processed and analyzed using Matlab and IBM
SPSS v23 software packages.

Before further processing, the raw gyroscope signal
was low pass filtered using fifth order Butterworth filter with
cut-off frequency 5 Hz. In order to reduce the integ-
ration drift, partially due to a continuous component, high
pass Butterworth filtering (order 1, \(F_{\text{cutoff}} = 0.5 \text{ Hz} \)) was
performed.

5 meter waking test was chosen for the lower limb
motor assessment. To quantify the dance influence on the
lower limbs the following parameters were calculated: right
and left legs stride, stance and swing time’s, knee maxi-

ximum extension around heel strike, knee angle at double
knee action, knee maximum flexion around mid-stance,

x maximum flexion at swing phase, hip joint maximum
flexion and extension.

These parameters were calculated using a filtered gy-
roscope signal from the subject’s thigh and shank. Temporal
parameters were calculated using shank angular veloc-
ity signal. The calculation parameters of one subject are
shown in Figure 1. The characteristic shank angular veloc-
ity signal is shown in Figure 1, which allows the gait parameters to calculate.

Gait joint angles are obtained by integrating the an-
gular velocity signal. A knee joint angle is calculated as
integral of difference between angular velocities measured
from two gyroscopes are attached on the adjacent segment
i.e. shank and thigh. For the angles calculation the follo-
wing formulas were used:

\[
\theta_{\text{hip}} = \int \omega_{\text{high}} dt ;
\]

\[
\theta_{\text{knee}} = \int (\omega_{\text{high}} - \omega_{\text{shank}}) dt .
\]

Nonparametric Wilcoxon signed rank test was chosen
for the statistical analysis of the results. Statistical signifi-

xance level \(\alpha = 0.05\). This statistical analysis was chosen
because the data is not distributed according to normal
distribution.

Results

For the quantitative assessment of the lower limbs of 18
kinematic parameters were calculated. For each subject
were calculated these parameter and performed statistical
analysis within and between groups.

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A statistically significant difference was found between these parameters in PD group before and after dance therapy: right knee maximum flexion around mid – stance (p = 0.001), right knee maximum flexion at swing phase (p = 0.001), right hip maximum flexion (p = 0.001), right hip maximum extension (p = 0.008), left hip maximum extension (p = 0.048). A statistically significant difference in the CO group: right hip maximum flexion (p = 0.047), left hip maximum flexion (p = 0.022), left hip maximum extension (p = 0.037).

The following statistically significant differences between the two groups of parameters were found: before right knee maximum flexion around mid – stance (p = 0.005), right knee maximum flexion at swing phase (0.005), left knee maximum extension around mid – stance (p = 0.047), right hip maximum extension (p = 0.028); after: right hip maximum flexion (p = 0.028), right hip maximum extension (p = 0.037), left hip maximum extension (p = 0.013).

The total UPDRS assessment of the two treatment groups was also calculated: PD group UPDRS score decreased from 47.86±17.17 to 40.00±13.81, and for CO group increased from 32.25±12.74 to 45.63±21.24. In order to evaluate the test motor skills UPDRS III score was calculated: PD group decreased from 32.29±11.60 to 27.14±9.85, while in CO group it’s increased: 24.89±13.63 to 37.33±13.63.

Calculated parameters are shown in Table 2.

Table 2. Subjects lower limb biomechanical parameters (*before (mean ± SD), ** after (mean ± SD))

| Parameters                              | PD                  | CO                  |
|-----------------------------------------|---------------------|---------------------|
| Right knee maximum flexion             |                     |                     |
| at mid – stance (°)                     | -5.662±3.412*       | -9.625±8.833*       |
|                                         | -15.172±3.126**     | -15.109±3.750**     |
| Right knee maximum flexion             | 16.872±3.884*       | 21.956±19.734*      |
| at swing phase (°)                      | 29.589±4.726**      | 29.817±4.077**      |
| Right hip maximum flexion              | 18.285±3.368*       | 13.123±4.141*       |
| (°)                                     | 13.514±2.156**      | 16.690±2.268**      |
| Right hip maximum extension            | -13.555±2.521*      | -13.187±9.609*      |
| (°)                                     | -17.554±3.293**     | -13.634±3.019**     |
| Left hip maximum flexion               | 14.598±3.439*       | 13.431±3.529*       |
| (°)                                     | 14.057±3.184**      | 17.958±3.124**      |
| Left hip maximum extension             | -15.253±4.935*      | -16.950±3.660*      |
| (°)                                     | -18.256±3.624**     | -13.290±2.793**     |

Conclusions

After the experimental investigation of the lower limb and processing of biomechanical parameter it was found:

1. The calculations of biomechanical gait parameters and the comparison between proves that dance therapy affects gait parameters. The statistically significant differences in PD group of parameters were found: right knee maximum flexion around mid – stance (mean±SD = -5.662±3.412), right knee maximum flexion at swing phase (mean ±SD = 16.872±3.884), right hip maximum extension (mean±SD = -13.634±3.019), left hip maximum extension (mean±SD = -15.253±4.935). A statistically significant difference in the CO group: right hip maximum flexion (mean ±SD = 13.123±4.141), left hip maximum extension (mean±SD = -16.950±3.660).

Statistically significant differences between PD and CO groups of parameters were found: before right knee maximum flexion around mid – stance (PD: mean±SD = -5.662±3.412, CO: mean±SD = -9.625±8.833), right knee maximum flexion at swing phase (PD: mean±SD = 16.872±3.884, CO: mean±SD = 21.956±19.734), left knee maximum extension around mid – stance (PD: mean±SD = 18.285±3.368, CO: mean±SD = 13.123±4.141); after: right hip maximum extension (PD: mean±SD = -17.554±3.293, CO: mean±SD = -13.634±3.019), left hip maximum extension (PD: mean±SD = -18.256±3.624, CO: mean±SD = -13.290±2.793).

2. Calculation of the total UPDRS score and UPDRS part III proves, that dance therapy affects patients with PD motoric and other diseases motility evaluation criteria. PD group UPDRS score changed from 47.86±17.17 to 40.00±13.81, CO – 32.25±12.74 to 45.63±21.24. In order to evaluate the test motor skills UPDRS III score was calculated: PD – 32.29±11.60 to 27.14±9.85, CO – 24.89±13.63 to 37.33±13.63.

3. The assessment of biomechanical gait parameters, UPDRS and UPDRS part III proves that modified Lindy Hop dance therapy has a positive impact on PD motoric.

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References

Deuschl, G.; Bain, P.; Brin, M. 1998. Consensus statement of the Movement Disorder Society on Tremor. Ad Hoc Scientific Committee, Movement Disorders 13: 2–23. https://doi.org/10.1002/mds.870131303

Ghaffari, B. D.; Kluger, B. 2014. Mechanisms for alternative treatments in Parkinson’s disease: acupuncture, tai chi, and other treatments, Current Neurology and Neuroscience Reports 14(6): 451. https://doi.org/10.1007/s11910–014–0451-y

Hackney, M. E.; Earhart, G. M. 2010. Effects of dance on balance and gait in severe Parkinson disease: a case study, Disability and Rehabilitation 32(8): 679–684. https://doi.org/10.3109/09638280903247905

Hollman, J. H.; McDade, E. M.; Petersen, R. C. 2011. Normative spatiotemporal gait parameters in older adults, Gait Posture 34(1): 111–118. https://doi.org/10.1016/j.gaitpost.2011.03.024

Ozinga, S. J.; Linder, S. M.; Alberts, J. L. 2016. Use of mobile device accelerometry to enhance evaluation of postural instability in Parkinson’s disease, Archives of Physical Medicine and Rehabilitation S0003–9993(16): 30985–6. https://doi.org/10.1016/j.apmr.2016.08.479

Roiz, R. de M.; Cacho, E. W.; Pazinatto, M. M.; Reis, J. G.; Cliquet, A. J.; Barasnevičius-Quagliato, E. M. 2010. Gait analysis comparing Parkinson’s disease with healthy elderly subjects, Arquivos de Neuro-Psiquiatria 68(1): 81–6. https://doi.org/10.1590/S0004–282X2010000100018

Santens, P.; Boon, P.; Van Roost, D.; Caemaert, J. 2003. The pathophysiology of motor symptoms in Parkinson’s disease, Acta Neurologica Belgica 103(3): 129–134.

Shiner, T.; Seymour, B.; Symmonds, M.; Dayan, P.; Bhatia, K. P.; Dolan, R. J. 2012. The effect of motivation on movement: a study of bradykinesia in Parkinson’s disease, PLoS One 7: e47138. https://doi.org/10.1371/journal.pone.0047138

Sohmiya, M.; Wada, N.; Tazawa, M.; Okamoto, K.; Shirakura, K. 2013. Immediate effects of physical therapy on gait disturbance and frontal assessment battery in Parkinson’s disease, Geriatrics Gerontology International 13(3): 630–637. https://doi.org/10.1111/j.1447–0594.2012.00953.x

ŠOKIŲ ĮTAKA APATINIŲ GALŪNIŲ BIOMECHANIKAI SERGANT PARKINSONO LIGA

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Santrauka

Parkinsono liga (PL) – progresuojantis neurologinis sutrikimas, kuris pažeidžia įvairias motorines funkcijas ir sumažina gyvenimo kokybę. Sergant PL, taikomos įvairios fizinių pratimų terapijos, bet paskutiniu metu dažniau taikoma šokių – muzikos – terapija. Eksperimentinio tyrimo metu buvo naudojami inerciniai jutikliai, siekdami registruoti apatinių galūnių biomechaninius parametrus eisenos metu. Šio straipsnio tikslas – įvertinti modifikuotus lindihopo šokių terapijos įtaką apatinių galūnių biomehanikai. Buvo apskaičiuoti apatinių galūnių kinematiniai parametrai ir surasti statistiškai reikšmingi skirtumai tarp grupių ir grupių viduje, kurie leidžia kiekybiniu įvertinti šokių įtaką.

Reikšminiai žodžiai: Parkinsono liga, eisena, šokių terapija, inerciniai jutikliai, signalas, unifikuota Parkinsono ligos vertinimo skalė (UPDRS).