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QUANTITATIVE ASSESSMENT OF DANCE THERAPY INFULENCE 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 Santariškių 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, angular velocity and magnetic heading in three dimensions. The sensors were mounted on subjects lower limb segments (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 integration drift, partially due to a continuous component, high pass Butterworth filtering (order 1, F_{cutoff} = 0.5 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 maximum extension around heel strike, knee angle at double knee action, knee maximum flexion around mid-stance, knee maximum flexion at swing phase, hip joint maximum flexion and extension.

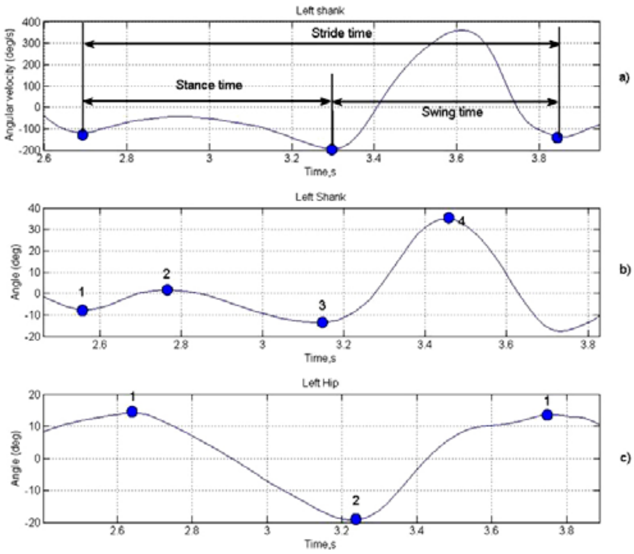

Fig. 1. a) Left shank angular velocity, b) Left knee angles: 1 – maximum knee extension around heel strike; 2 – knee joint angle at double knee action; 3 – maximum knee extension around mid-stance; 4 – maximum knee flexion at swing phase, c) Left hip joint angle: 1 – maximum hip flexion; 2 – maximum hip extension

These parameters were calculated using a filtered gyroscope signal from the subject's thigh and shank. Temporal parameters were calculated using shank angular velocity signal. The calculation parameters of one subject are shown in Figure 1. The characteristic gait point is show in Figure 1, which allows the gait parameters to calculate.

Gait joint angles are obtained by integrating the angular 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 following formulas were used:

$$\theta_{hip} = \int \omega_{thigh} dt ; \quad (1)$$

$$\theta_{knee} = \int (\omega_{thigh} - \omega_{shank})dt . \quad (2)$$

Nonparametric Wilcoxon signed rank test was chosen for the statistical analysis of the results. Statistical significance level ά = 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.

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 around mid – stance, (°)	–5.662±3.412* –15.172±3.126**	–9.625±8.833* –15.109±3.750**
Right knee maximum flexion at swing phase (°)	16.872±3.884* 29.589±4.726**	21.956±19.734* 29.817±4.077**
Right hip maximum flexion (°)	18.285±3.368* 13.514±2.156**	13.123±4.141* 16.690±2.268**
Right hip maximum extension, (°)	–13.555±2.521* –17.554±3.293**	–13.187±9.609* –13.634±3.019**
Left hip maximum flexion, (°)	14.598±3,439* 14.057±3.184**	13.431±3.529* 17.958±3.124**
Left hip maximum extension,(°)	–15.253±4.935* –18.256±3.624**	–16.950±3.660* –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 = –13.555±2.521), 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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ŠOKIŲ ĮTAKA APATINIŲ GALŪNIŲ BIOMECHANIKAI SERGANT PARKINSONO LIGA

D. Lukšys, J. Griškevičius

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, siekiant registruoti apatinių galūnių biomechaninius parametrus eisenos metu. Šio straipsnio tikslas – įvertinti modifikuotos lindihopo šokių terapijos įtaką apatinių galūnių biomechanikai. Buvo apskaičiuoti apatinių galūnių kinematiniai parametrai ir surasti statistiškai reikšmingi skirtumai tarp grupių ir grupių viduje, kurie leidžia kiekybiškai įvertinti šokių įtaką.

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