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Abstract

Background: Parkinson's disease is the second most common neurodegenerative disorder, and affects 1-2 in 1,000 people in the United States. It is characterized by motor deficits, including gait and balance impairments, bradykinesia, and postural instability among other symptoms. The purpose of this case report is to outline a plan of care for a patient with gait and balance impairments secondary to Parkinson's disease in an outpatient orthopedic setting. **Case Description:** The patient is an 82 year-old female with gait and balance impairments caused by Parkinson's disease. The patient also presents with a recent history of lumbar discectomy, and demonstrates general lower extremity weakness. **Intervention:** Interventions consisted of gait training with an emphasis on cadence, stride length, and arm swing. Interventions also consisted of balance training, both static and dynamic, and postural stability. In addition, select Lee Silverman Voice Treatment-Big (LSVT BIG) exercises were incorporated into the treatment. **Outcome Measures:** The patient was initially assessed using the Timed Up and Go, Dual Task Timed Up and Go, and the 10 Meter Walk test. The patient was treated for a total of 8 visits, and although improvements were observed, the patient was not re-assessed with the above outcome measures due to a fall that required her to cancel her final appointment. **Discussion:** Gait and balance training are common interventions for individuals with Parkinson's disease. It was observed that the patient demonstrated improvements in cadence, arm swing, and stride length throughout treatment. Individualized plans of care and consistency with home exercises are important factors that may lead to improved outcomes for individuals with Parkinson's disease. Future studies should address how dose and compliance of interventions affect the patient's outcome.

Introduction

Parkinson's disease is a neurodegenerative disease that causes a progressive loss of mobility, and is the second most common neurodegenerative disorder following Alzheimer's disease. It affects 2% of men and 1.3% of women at age 40, and the prevalence of Parkinson's disease increases with age, peaking at approximately 80 years of age.[1] In the United States, Parkinson's disease affects 1-2 per 1,000 individuals. Parkinson's disease is characterized by motor deficits, including gait and balance impairments, bradykinesia, postural instability, resting tremor, and rigidity.[13] These impairments are due to the absence of dopaminergic neurons of a structure within the basal ganglia known as the substantia nigra pars compacta. These structures of the central nervous system play a vital role in motor control and motor learning, therefore the absence of dopaminergic neurons in this region will have a profound effect on movement. This disease is also characterized by various non-motor symptoms, which can manifest several years before the motor symptoms. They include olfactory dysfunction, cognitive impairments, psychological impairments, sleep disorders, pain, and fatigue. The diagnosis of Parkinson's disease is made depending on the presence of neuronal loss in the substantia nigra and the ruling out of other pathological diseases, the gold standard being the neuropathological assessment. The clinical diagnosis of Parkinson's disease is made based on the observation of motor symptoms, most often including bradykinesia and rigidity, along with the presence of a resting tremor.[9]

The aforementioned symptoms cause a large impact on the individual's quality of life and limit their ability to perform normal daily tasks independently. However, evidence has shown that exercise can help to improve the quality of life and mortality rates of individuals.[16] In addition, exercise along with proper nutrition has been shown to help individuals maintain progress and ability to perform their normal activities of daily living.[8] Furthermore, it has been demonstrated that balance and gait training have been shown to improve gait and therefore reduce the frequency of falls, thus improving the quality of life of individuals with Parkinson's disease.

A study performed by Baker et al. demonstrated that the use of attentional cueing strategies in gait training for patients with Parkinson's disease can help to increase the patient's step amplitude.[4] In addition, the use of attentional strategies combined with rhythmic cueing during single and dual tasks is also an effective treatment strategy and proved to increase walking speed by approximately10%, and step amplitude by approximately 15% compared to controls. Another study by Rochester et al. found that gait training with external rhythmic cues increased both walking speed and step length during single and dual-tasks.[14] The study also demonstrated that the effects were retained at follow-up, which indicates that training with cues enhances motor learning in patients with Parkinson's disease.[14] This can be explained by the idea that loss of dopamine leads to difficulty performing automatic movements, and the addition of external cues can aid in making automatic movements easier as well as increase attentiveness and engagement on that particular movement.[5]

In addition to external cues, another form of exercise has been a popular treatment method in patients with Parkinson's disease, and is called Lee Silverman Voice Treatment- BIG (LSVT-BIG). It is a treatment protocol that focuses on large amplitude oriented exercises, and has been shown to improve motor performance in patients with Parkinson's disease.[7] A randomized control study compared the effects of LSVT-BIG versus a short training protocol, and found that there was not a significant difference in motor assessments following the standard LSVT-BIG protocol compared to the smaller amount of training sessions using amplitude-oriented training exercises.[6]

Although there is a large amount of research that demonstrates the benefits of exercise in patients with Parkinson's disease, there has not been a published protocol regarding the best frequency, mode, and dose of exercise to improve gait and balance impairments in this population. The purpose of this case report is to outline a plan of care for a patient with gait and balance impairments secondary to Parkinson's disease in an outpatient orthopedic setting.

Case Description

The patient is an 82 year-old female who originally presented to the physical therapy clinic status-post percutaneous lumbar discectomy. The patient presented to therapy with a referral from her surgeon for general lower extremity strengthening. The patient's co-morbidities include Parkinson's disease, and is prescribed the medication Levadopa to help manage her symptoms. The patient reported that she experiences movement latency, shuffling gait, and fear of falling, which she attributes to her Parkinson's disease. The patient reports that she has fallen several times, both in her home and in the community. The patient also reports that she is hesitant to participate in activities outside of her home due to fear of falling, and that she does not trust herself to walk in public spaces. The patient is otherwise healthy and lives alone in a one-story home. She ambulates within her home using a U-step walker, however she ambulates within the community using a single point cane due to being unable to lift the walker into a car. At times, the patient is able to ambulate without an assistive device, however does not do this when she is alone for safety reasons. The patient has support from her daughter, who lives in the same community. The patient is unable to drive due to her Parkinson's disease, which was a barrier in terms of the frequency of her physical therapy appointments, as she was only able to get a ride to therapy once per week. The patient works approximately 3 hours per day and 3-4 days per week at her local family business. She tries to remain active by walking one block to and from work.

The patient's initial treatment of lower extremity strengthening progressed fairly well, however the patient continued to complain of fatigue when walking longer distances. After a routine appointment with her neurologist approximately 3 months after her initial physical therapy evaluation, the patient returned to physical therapy and informed the physical therapist that her Parkinson's disease was progressing and had gotten worse since her last check-up. The patient stated that her neurologist had recommended that the patient attend a Parkinson's group fitness class in a nearby town to improve her gait and mobility. The patient stated that she was unable to do this since she cannot drive, and also informed the physical therapist that she does not like exercising in group settings. The patient stated that she would prefer a one-on-one setting to improve her mobility and balance. The patient wished to continue seeing the local physical therapist and requested to begin working exclusively on improving her Parkinson's disease symptoms. The patient's desired outcomes include improving her gait and balance so that she may ambulate in the community more safely and participate in community events.

The patient was chosen for this case study for several reasons, one of which being that the practice setting is a rural outpatient orthopedic clinic, and it is rare for patients to seek physical therapy to manage the symptoms from Parkinson's disease in this particular clinic due to access to more specialized settings in nearby communities. The patient was also chosen to be the subject of this case study due to obstacles that were overcome in order to provide the best patient care, including lack of transportation to attend physical therapy regularly, and the necessity for the modification of interventions in order to adequately and effectively treat the patient's impairments.

Clinical Impression

Upon initial examination, the patient presented with minor deficits in lower extremity strength (4/5 manual muscle test). In addition, two outcome measures were used in order to assess the patient's gait and balance. The first outcome measure used was the Timed up and Go (TUG), which evaluates a patient's ability to perform a sit-to-stand transfer along with his or her ability to walk, turn around an obstacle, and then stand-to sit. The TUG (MDC = 3.5 sec) was chosen because it evaluates both strength and gait speed, and is a reliable tool to evaluate mobility in patients who have Parkinson's disease.[17] In addition, research has shown that longer TUG times in patients with Parkinson's disease may predict increased risk of falls. The TUG also gives the therapist an idea of how the patient will perform on functionally important tasks that are performed daily and give a good indicator of overall mobility.[8] The TUG has also been shown to have high retest reliability (0.99) as well as a high sensitivity for detecting change.[11] The patient was instructed on and performed the TUG, and completed the test in an average of 17.918 seconds, which indicates that the patient is at risk for falls.

Several gait observations were also made during the patient's TUG trials, which include decreased stride length, decreased cadence, and shuffling of gait. The patient also demonstrated markedly decreased arm swing, as demonstrated in Figure 1. The aforementioned observations are all characteristic gait impairments in patients with Parkinson's disease.

The patient also performed a TUG dual task test, which involves the same instructions as the TUG, plus an additional cognitive task of counting backwards by threes. It has been shown that adding a cognitive component to the TUG increases the ability of the test to predict the risk of falls.[18] A study by Vance et al. also concluded that the TUG-cognitive caused a greater regression of the automaticity of gait than the TUG alone, giving the therapist a better indication of the patient's fall risk while performing normal activities of daily living.[18] The patient's average time on the dual task TUG was 26.681 seconds. The patient demonstrated difficulties performing a cognitive task while ambulating, and stopped several times during the test. She also demonstrated decreased stride length and arm swing.

Figure 1. The patient demonstrated decreased stride length and arm swing during TUG special test.

The second test that the patient performed was the 10-meter walk test (MCID = 0.06 m/s). This test was performed in order to determine the patient's gait speed, which can also be an indicator for mobility and fall risk. The patient's self-selected velocity was 0.62 m/s, and the fast velocity was 1.03 m/s. This test was chosen because it is quick and easy to perform, and can be a good indicator of independence in community mobility, which is one of the patient's goals. The patient's comfortable walking speed of 0.62 m/s places her in the category of "limited community ambulator." [11]

Intervention

Treatment Sessions 1 and 2

The treatment therapist's initial goals were to educate the patient on gait observations made during the examination, and to implement exercises that will aim to improve the impairments observed. The interventions focused on improving cadence and stride length of gait, along with static standing balance. At the beginning of each treatment session, the patient performed a ten minute warm-up on a Nu-Step recumbent cross trainer with a goal of maintaining greater than 60 revolutions per minute (RPM) to promote increase step cadence and increase cardiovascular fitness. The aim was to increase the target RPM as the patient progressed.

The first intervention consisted of gait training with a target step number to cover a certain distance. The aim of this exercise was to provide a visual target for the patient to ambulate toward in the least amount of steps possible in order to promote increased stride length. The patient would start at one end of a small track inside the outpatient clinic, and was instructed to walk forward while being provided with external cues such as "take big steps" and "swing your arms." The start and end points were approximately 30 feet apart. The number of steps the patient took was recorded, and the goal was to decrease the number of steps each week.

The aim of the next exercise was to promote increased step length and arm swing during gait. The step and reach exercise was performed in standing and consisted of a step with a forward weight shift and a contralateral arm swing, as shown in Figure 2. Due to the patient's balance impairments, the exercise was performed near the wall that had a bar so that she could hold on with her contralateral arm if necessary. The patient performed twenty repetitions of this exercise bilaterally, and was allowed resting breaks when necessary.

Figure 2. Step and reach exercise, which aims to promote increased step length and arm swing during gait.

Standing marches were also performed to promote increased step cadence and automaticity. The patient performed two sets of ten repetitions, and seated rest breaks were allowed if the patient appeared fatigued between sets. This exercise was also performed at a bar so that the patient could hold on for balance.

The last intervention that the patient performed during sessions 1 and 2 was static standing balance. Balance interventions included static standing balance with feet together and in tandem stance. The patient aimed to maintain balance with eyes open and eyes closed for as long as possible. The above interventions were performed during weekly treatment sessions, and the patient was instructed to perform the exercises at home at least two times daily to promote motor learning and improve gait.

The patient had difficulty performing the exercises initially, and required several verbal cues and visual demonstration in order to perform. In addition to the implementation of the home exercise program, the patient was educated on the symptoms of Parkinson's disease, including difficulty with motor learning and gait impairments over the course of the first two visits.

Treatment Session 3

The patient returned for her third treatment session three weeks following her evaluation. The patient reported that her home exercises were going "alright," however she sometimes had difficulty remembering to perform them. The patient also reported feelings of unsteadiness over the past couple of days, and stated that it was normal for her to have good weeks and bad weeks due to her Parkinson's disease.

The patient's treatment session consisted of the same exercises performed during the first two sessions, however it was observed that the patient demonstrated improved arm swing with gait training and required less verbal cueing in order to perform exercises with proper form. During the third treatment session, two new exercises were introduced to the patient. The first exercise that was introduced to the patient was a variation of a LSVT-BIG exercise called "side to side" that aims to improve postural stability while performing a large amplitude movement. The exercises involved being seated in a chair, however it is important to note that the patient's back should not be resting against the chair. The patient then reaches laterally with arms abducted outside of their base of support, and then reverses the exercise to the opposite side, as shown in Figure 3. The patient

Figure 3. Side to Side exercise, which aims to improve core stabilization and increased amplitude of movement.

initially had difficulty maintaining an upright posture while reaching to the side outside of her base of support, however was able to perform the exercise with verbal cues and visual demonstration.

The next exercise that was added to the patient's treatment session was a standing march with external auditory cues for a cadence of 90 beats per minute. A metronome was used in order to encourage the patient to maintain her cadence as she performed a marching exercise. This activity proved difficult for the patient, and therefore was performed in sitting as a modification.

Treatment Sessions 4 and 5

The patient continued to report slight unsteadiness throughout her day, which was normal for her. She also reported that she went shopping with a friend and used her single point cane rather than her walker and felt fairly comfortable with it.

The patient's 4th and 5th treatment sessions consisted of the same exercises as performed previously, and the patient continued to demonstrate small improvements. The patient's Nu-Step warm-up RPM goal was increased to 80 RPM. Arm swing was one of the most notable improvements while performing gait training with external cues to "take big steps" and "swing your arms." The patient was instructed on and performed a progression of the LSVT-BIG "side to side" postural stability exercise. To perform this exercise, the patient then reaches laterally with arms abducted outside of their base of support, and then reaches across their body with the same arm as they also rotate their body to the same side, extending their contralateral knee, as shown in Figure 4. The patient performed 20 repetitions of each exercise during treatment sessions, and the new exercises were also added to her home exercise program.

Figure 4. Side to Side progression, which involves a cross body reach and trunk rotation with knee extension.

Treatment Session 6

The patient reported to physical therapy on week six stating that she was not feeling well. She stated that her balance was off, but denied any falls since the beginning of her treatment six weeks ago. Due to the patient not feeling well, not all exercises were performed. Instead, the patient performed her usual ten-minute warm-up with a goal to maintain above 80 steps per minute to promote increased step cadence. She was able to perform forward weight shifts with an arm swing to promote increased arm swing during gait, and demonstrated improvements with this exercise. During gait training with cues for big steps, however, the patient demonstrated increased shuffling of gait and required increased rest breaks. The patient also demonstrated increased sway with balance activities with feet together and in tandem stance. Due to the patient not feeling well, the home exercise was reviewed and the patient was sent home to rest.

Treatment Session 7

The patient reported for physical therapy on week seven, and reported that she still was not feeling the best. She stated that her back had been bothering her over the last week and walking aggravated it, causing her to be sedentary for most of the day. The patient performed a Nu-Step warm-up with a goal of maintaining > 80 steps per minute, and reported that this made her back feel better, therefore performed the activity for 12 minutes. Following her warm-up, the patient attempted to perform gait training with external cues for big steps, however she demonstrated an increased forward lean and required rest breaks due to fatigue, however she denied pain. The patient's standing exercises were not performed this session due to her initial reports of back pain. Instead, the patient

performed modified exercises in sitting, which included 20 repetitions of a seated weight shift with forward reach to imitate arm swing during gait. She also performed amplitude-oriented exercises from the LSVT-BIG protocol that are previously mentioned. Towards the end of her session, the patient reported feeling better and requested to perform gait training. In an effort to promote increased arm swing, the patient performed gait training while holding dowels that the therapist was also holding. As the patient ambulated, the therapist walked behind the patient and facilitated arm swing with use of the dowels for approximately 300 feet. The patient responded very well and was able to ambulate with improved posture and arm swing following the dowel intervention.

Treatment Session 8

The patient was unable to attend her week eight appointment due to a fall, and was seen for her 8th visit nine weeks following her initial appointment. The patient reported that she was standing up from her chair and fell down. She went to the doctor the next day and reported having no broken bones. The patient stated that she was unable to complete and exercises or attend work since her previous treatment due to the fall. The patient reports increased difficulties with walking since her fall, therefore no gait training activities were performed this session. Instead, the patient performed a warm-up on the Nu-Step for ~14 minutes to improve reciprocal stepping motion. The patient was unable to maintain the 80 RPM goal. Following the warm-up, the patient performed modified exercises in sitting, which included 20 repetitions of a seated weight shift with forward reach to imitate arm swing during gait, and denied pain during this exercise. The patient also performed balance exercises including feet together with eyes open and closed for 15 seconds each. She also performed modified tandem stance with eyes open for 15 seconds. The patient completed the session early due to fatigue and was instructed to perform the exercises on her home exercise program that did not cause pain and that she felt safe performing.

The patient was unable to attend her 9th treatment session due to a second fall. The initial plan for the appointment was to perform a re-evaluation and repeat the TUG and 10 meter walk test to track the patient's progress. The patient called to discuss her fall, and reported that she would contact the therapist when she was feeling better to begin treatment again, thus ending the current episode of care.

Outcome Measures

The patient was treated for a total of eight visits, and although improvements were observed, the patient was not re-assessed using the TUG or 10 meter walk test due to a fall, which required her to cancel her appointments until she was feeling better, ending her episode of care. The patient was observed to make several improvements throughout her eight sessions, the greatest improvement being improved arm swing during gait. The patient was able to ambulate with increased stride length following external cues for bigger steps, however tended to fall back into the shuffling pattern shortly after. It was also observed that the patient demonstrated improvements with cadence and gait speed, however the patient's fall made her unable to perform re-examination to measure gait speed. In addition to improvements in gait, the patient was also demonstrated increased strength by the ability to perform sit to stands more easily and rise on the first attempt. Overall, the patient was observed to make small improvements in gait, however it is not known whether the patient's improvement is significant due to the inability to perform the outcome assessments for a second time before the end of her episode of care.

Discussion

The purpose of this case report is to outline a plan of care for a patient with gait and balance impairments secondary to Parkinson's disease in an outpatient orthopedic setting. The goals of the patient's preliminary exercise interventions were to address impairments observed during initial testing. These include shuffling of gait, decreased stride length and cadence, and decreased arm swing. In addition, the patient's initial plan of care included balance training with the goal of improving static

balance and postural stability with the goal of progressing to dynamic balance activities as the patient's balance improved. Interventions to improve gait performance included the use of external cues to promote increased step cadence and stride length, which has been shown to improve motor learning and retention.[14] Research has also shown that attentional cues, such as instructing the patient to take big steps, and rhythmic auditory cues, such as a metronome, have both been shown to consistently reduce gait variability in patients with Parkinson's disease.[3] As the patient progressed, the metronome speed would have increased to further challenge the patient and promote increased gait speed.

In addition to the above interventions, the patient was also prescribed exercise interventions from the LSVT-BIG protocol that aimed to improve arm swing and postural stability, as well as promoting increased amplitude of movements. Studies have shown that these amplitude-oriented movements are effective in improving motor performance in patients with Parkinson's disease.[7] Although the majority of the exercises that the patient in this case study performed were in the seated position, it is possible to transition to standing exercises as the patient progresses.

Throughout the course of treatment, the patient experienced two set backs, including an exacerbation of back pain and a fall, which limited her ability to participate in treatment sessions to the fullest extent. Although the patient was not re-assessed using the TUG, TUG-cognitive, and 10-meter walk test, small improvements were observed during treatment sessions, including increased arm swing and increased step length.

There were several factors and variables that may have limited the patient's ability to progress to her peak potential over the course of her care. The first barrier was the patient's inability to drive due her Parkinson's disease. The patient relied on family and friend's schedules to make it to her appointments and was therefore only able to attend physical therapy once per week. Increased frequency of physical therapy visits may have allowed for more repetitions of each exercise, and therefore increased repetition and motor learning. Because the patient was limited to one weekly physical therapy session due to lack of transportation, her primary form of exercise was an unsupervised home exercise program, which was to be performed two times daily. A study performed by King et al. demonstrated that a home exercise program that is unsupervised is the least effective mode of exercise in individuals with Parkinson's disease.[10] The study also found that individuals with Parkinson's disease perform better when directly supervised by a physical therapist.[10] Future studies may evaluate the effectiveness of physical therapy at different frequencies to determine whether more treatment sessions per week will result in improved outcomes in patients with Parkinson's disease.

Another factor that may have influenced the patient's progress was adherence to her home exercise program. The patient stated that she did not perform her home exercises regularly, as she often forgot how to perform the exercises, or forgot to do them altogether. In addition, the patient may not have performed her home exercise program as regularly as was prescribed due to decreased motivating factors. According to a study by Ashfari et al., patients with Parkinson's disease who exercise less have more perceived barriers and require increased motivation in order to perform exercise compared to individuals who exercise more regularly prior to diagnosis.[2] Motivating factors include significant others, personal trainers, and neurologists telling the individuals that is it important to exercise. Motivating factors also include having an exercise partner, short durations of exercise, and group settings.[2] The patient in this case study was encouraged to exercise by her daughter and physician, however was widowed and preferred to exercise individually rather than in groups. The lack of motivating factors for the patient might have played a role in her lack of adherence to her home exercise program. Future studies must take into account not only the patient's medical history, but also their social history, including motivating factors and barriers to exercise. One tool that can be used is the Unified Parkinson Disease Rating Scale (UPDRS), which is a valid and reliable tool used to measure the severity of Parkinson's disease symptoms.[15] This scale was not used in this case study, however it would have been a useful tool to further evaluate the patient presented. Future studies should evaluate individuals using the UPDRS in order to get a more accurate and well-rounded representation of the patient that can be tracked over time, including evaluation of mentation, behavior mood, activities of daily living, and many other factors that may effect the patient's treatment.

Although the patient was not re-assessed due to a fall, small improvements were observed throughout the course of the patient’s treatment. It must be acknowledged, however, that these improvements are not quantifiable and may not be due to the treatment provided. Further research should evaluate the effectiveness of a similar treatment protocol to the one presented in this case study with a larger population of individuals with Parkinson’s disease, and of varying stages and abilities, in order to determine the effectiveness of the interventions.

References

1. Ascherio A, Schwarzschild MA. The epidemiology of Parkinson's disease: risk factors and prevention. *Lancet Neurological.* 2016; 15:1257-1272.
2. Ashfari M, Yang M, Bega D. Motivators and Barriers to Exercise in Parkinson's Disease. *Journal of Parkinson's Disease.* 2017; 7(2010): 703-711.
3. Baker K, Rochester L, Nieuwbower A. The effect of cues on gait variability—reducing the attentional cost of walking in people with Parkinson's disease. *Parkinsonism and related disorders*. 2008; 14(4): 314-320.
4. Baker K, Rochester L, Nieuwboer A. The immediate effect of attentional, auditory, and a combined cue strategy on gait during single and dual tasks in Parkinson's disease. *Archives of physical medicine and rehabilitation*. 2007; 88(12): 1593-600.
5. Capato TT, Tornai J, Avila P, Barbosa ER, Piemonte ME. Randomized controlled trial protocol: balance training with rhythmical cues to improve and maintain balance control in Parkinson's disease. *BMC Neurology.* 2015; 15(162): 1-7.
6. Ebersach G, Grust U, Ebersach A, Wegner B, Gandor F, Kun AA. Amplitude-oriented exercise in Parkinson's diease: a randomized study comparing LSVT-BIG and a short training protocol. *Journal of Neural Transmission.* 2015; 122(2): 253-256.
7. Farley BG, Fox CM, Ramig L, Farland DC. Intensive amplitude-specific therapeutic approaches for Parkinson's disease. *Topics Geriatr Rehabil.* 2008; 24:99–114.
8. Gobbi LTB, Oliveira-Ferreira MDT, Caetano MJD, Lirani-Silva E, Barbieri FA, Stella F, Gobbi S. 2009. Exercise programs improve mobility and balance in people with Parkinson's disease. Parkinsonism and related disorders. 15S3(2009): S49-S52.
9. Kalia LV, Lang AE. 2015. Parkinson's disease. Lancet 386: 896-912.
10. King LA, Chen Y, Blehm R, Nutt J, Chen Z, Serdar A, Horak FB. Does group, individual, or home exercise best improve mobility for people with Parkinson's disease?. *Journal of Neurological Physical Therapy.* 2015; 39(4): 204-212.
11. Middleton A, Fritz SL, Lusardi M. Walking speed: the functional vital sign. *Journal of Aging and Physical Activity*. 2015; 23(2): 314-322.
12. Morris S, Morris ME, Iansek R. Reliability of measurements obtained with the timed "up & go" test in people with Parkinson disease. *Physical Therapy*. 2001; 81(2): 810-818.
13. Rafferty MR, Prodoehl J, Robichaud JA, David FJ, Poon C, Goelz LC, Vaillancourt DE, Kohrt WM, Comella CL, Corcos DM. Effects of 2 years of exercise on gait impairment in people with Parkinson Disease: The PRET-PD Randomized Trial. *Journal of Neurologic Physical Therapy.* 2017; 41(1): 21-30.
14. Rochester L, Baker K, Hetherington V, Jones D, Willems AM, Kwakkel G, Van Wegen E, Lim I, Nieuwboer A. Evidence for motor learning in Parkinson's disease: acquisition, automaticity and retention of cued gait performance after training with external rhythmical cues. *Brain Research.* 2010; 1319(2010): 103-111.
15. Siderowf A, McDermott M, Kieburtz K, Blindauer K, Plumb S, Shoulson I, Parkinson Study Group. Test-retest reliability of the unified Parkinson's disease rating scale in patients with early Parkinson's disease: results from a multicenter clinical trial. *Mov Disord.* 2002; 17(4): 758-763.
16. Speelman AD, van de Warrenburg BP, van Nimwegen M, Petzinger GM, Munneke M, Bloem BR. How might physical activity benefit patients with Parkinson disease?. Nature Reviews. *Neurology*. 2011; 7(9): 528-534.
17. Stegemoller EL, Nocera J, Malaty I, Shelley M, Okun MS, Hass CJ, NPF Quality Improvement Initiative Investigators. Timed up and go, cognitive, and quality-of-life correlates in Parkinson's disease. *Archives of Physical Medicine and Rehabilitation.* 2014; 95(4): 649-655.
18. Vance RC, Healy DG, French HP. Dual tasking with the timed "up & go" test improves detection of risk of falls in people with Parkinson disease*. Physical Therapy*. 2015; 95(1): 95-102.