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Protocol Article Open Access

Progressive Muscular Strength Protocol for the Functionality of Upper Limbs in Individuals with Parkinson's disease: Protocol Study

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Abstract

Background: There is a lack understanding between the possible effects of physical intervention in motor function of the upper limbs and quality of life in patients with PD.

Objective: To present a progressive muscular strengthening protocol of the upper limbs with focus on the functional capacity.

Methods: The sample has been chosen for convenience. The patients have been divided into two groups: Intervention and Control which have not been distributed randomly. The following instruments have been chosen to be evaluating results: Unified Parkinson Disease Rate Scale, Parkinson's Disease Questionnaire, Nine Hole Peg Test, Test d'Evaluation des Membres Superieurs of Personnes Âgées and handgrip dynamometer. All these instruments have to be applied before and after the training phase which is for 2 months, twice a week and follow up period for one month after the last training session. For demographic characteristics of the sample, descriptive statistics have to be used. The Shapiro-Wilk test has to examine the normality of the sample. Parametric or non-parametric tests have to be performed to check if there is a significant statistical difference between pre- and post-training and follow-up, as correlation tests, pre- and post-training. The significance level of 5% for all procedures have to be adopted.

Results: The strength training has to combine isotonic and isometric exercises using elastic tubes for upper limbs. The program has to be carried out for two months, totalizing 16 sessions. Five subjects in each group started the program, but have not yet finished. Results are expected in 2018.

Discussion: Most studies on muscle weakness in PD focus on the evaluation aspect. Cover mainly studies of physical rehabilitation the lower limbs, and focus on gait and balance. Therefore, it is important to carry out studies that investigate the possible effects of a progressive muscular strengthening protocol in upper limbs in PD patients.

Keywords: Parkinson's disease; Physical therapy (modalities); Upper limbs; Strengthening; Rehabilitation; Disability evaluation; Exercise therapy

Introduction

Parkinson's disease (PD) is primarily a neurodegenerative disorder affecting the motor control. More precisely in the substantia nigra pars compacta compromising the nigrostriatal pathway where the motor symptoms are caused by the degeneration of dopaminergic neurons that participate [1-3].

Diagnosis of PD is predominantly based on clinical features and the diagnostic criteria. The most widely accepted in the world are those that comprise the UK Parkinson's Disease Society Brain Bank. These are: rigidity, bradykinesia, resting tremor, postural instability and gait disorders [4,5]. Moreover, the Movement Disorders Society has included non-motor symptoms as clinical manifestations of PD [5]. In the literature, some authors have been discussing the presence of muscle weakness as an intrinsic symptom of PD or a secondary symptom due to disuse [6-8].

PD produces deterioration of the motor function over the course of the disease, which results in an increase in the number, and severity of symptoms. The motor symptoms progressively produce more restrictions and reduction in dependency of activities of daily living (ADLs). Thus causing a worsening in quality of life [9-12].

Some authors have been pointing out the possible origin of the muscle weakness in PD in comparative studies with control group matched with age and gender [13-16].

Studies on physical rehabilitation in PD mostly highlight lower limbs, gait and balance impairments [17-22]. Those that focus on upper limbs are, in its majority, evaluate mostly aspects in either coordination, strength, power, bradykinesia or functionality [6,14,16,23-25]. There are only three studies focused on the effects of some type of muscle strengthening in the upper limbs. None, however, about functionality [26-28]. Therefore, there is a lack of understanding between possible effects of the physical rehabilitation in upper limbs of PD patients.

Considering that studies in PD patients submitted to resistance exercise programs showed positive results for gait, balance and lower limbs [17-22,29], strengthening training program for upper limbs could promote both functional and clinical benefits for these patients.

Objective

The purpose of this study is to present a progressive muscular strengthening protocol developed by us for upper limbs in PD patients. The protocol is supposed to increase muscle strength, improve motor function of upper limbs and affect positively the quality of life of these individuals.

Methods

The study is a non-randomized controlled longitudinal clinical intervention study.

Initially individuals are to be assessed to determine whether they meet all inclusion criteria, as well as to obtain demographic and clinical data (see Multimedia Appendix 1). The following inclusion criteria is to be considered: clinical diagnosis of idiopathic PD confirmed by a neurologist; patients of both genders, aged between 55-75 years; PD stage 2-3 on the modified Hoehn and Yahr (H&Y) scale (see Multimedia Appendix 2); understand and obey verbal commands using Montreal Cognitive Assessment (MoCA) (see Multimedia Appendix 3).

Patients have be excluded using the following criteria: impaired mental and cognitive state identified by MoCA; present neurological and/or trauma-orthopaedic disorders that diminish upper limb and/or cervical vertebral spine function; patients who underwent surgical procedure for PD; systolic pressure higher than 180 mmHg and diastolic higher than 100 mmHg, and unstable heart disease or cardiac failure; have undergone changes in dose and/or medication after the initial evaluation and during training; have done exercise program with professionals from physiotherapy or physical education, and sports, in the last 3 months before or during the study.

Patients are to come from the University Medical Center. Patients who meet the inclusion criteria, the goals and methods of the research are to be presented. After explanation, if the patients agree to participate in the study, they have to fill out and sign the Informed Consent Form. This project has already been submitted and approved by the Ethics Committee on Human Research of the Institute of Neurology Deolindo Couto. This study has been registered with Brazilian Clinical Trials Registry with the identifier RBR-7Z858K.

This study has been based on convenience sampling. PD patients have been divided into two groups, intervention and control. The intervention group has to perform the Protocol of Exercises with Progressive Strength while the control group has to perform mobility and stretching exercises. To determine the clinical outcomes, the instruments have to be applied during the ON-phase in the morning pre-, post-training and follow up (one month after the intervention) periods.

The measurement results have to use the following instruments: Unified Parkinson's Disease Rating Scale (UPDRS), Parkinson's Disease Questionnaire (PDQ-39), handgrip dynamometer from Jamar, Test d'Evaluation des Membres Superieurs of Personnes Âgées (TEMPA) and 9-Hole Peg test (9HPT).

Primary outcomes have to be investigated, in order to confirm if there are significant differences in values of instruments to be used in the Intervention Group. For this purpose, primary outcomes have to be analysed during pre- and post-training periods comparing them with the control group. The correlation of the various assessment tools in the Intervention Group during pre- and post-training periods has to be investigated.

Clinical Evaluation

The UPDRS evaluates signs, symptoms and certain activities of patients through self-report and clinical observation. This scale, developed in 1987 by combining other scales available at the time [30] became, undoubtedly, the clinical rating scale best used for PD [31]. It is a reliable and valid scale, which qualifies as a suitable method for the evaluation in PD [32]. The UPDRS has high internal consistency and excellent test-retest and inter-rater reliability [30]. It consists of 42 items, divided into four parts: three main sections which evaluate "Mental State and Humor" (Section I), "Activities of Daily Living" (Section II) based on previous information, and "Motor Exam" (Section III) based on clinical examination. The fourth section, "Complications of Therapy" is included to monitor the harmful effects associated with prolonged use of dopaminergic medication. The score for each item ranges from 0 to 4, and the maximum value indicates greater involvement by the disease and the minimum value, normality. The total UPDRS score can range from 0-124 [30]. Sections used in our study, "ADLs" and "Motor Exam" can range between 0-52 and 0-56, respectively.

Quality of life

To evaluate the quality of life (QoL) of the participants, PDQ-39 has to be used. Data has to be collected through a structured questionnaire by interview. This questionnaire, developed in 1995, focuses on interviews with individuals with Parkinson's disease where the perspective is the quality of life [33]. The scale consists of 39 items that can be answered with five different response options: "never", "occasionally", "sometimes", "often", and "always". The questions concern the frequency of the difficulties in the month prior to the appointment. The scores in each item range from 0 (never) to 4 (always). These 39 items are distributed in eight dimensions: Mobility (10 items), Activities of Daily Living (6 items), Emotional Wellness (6 items), Stigma (4 items), Social Support (3 items), Cognition (4 items), Communication (3 items) and Body Discomfort (3 items). Total score is calculated according to the following formula: 100x (sum of the patient scores on 39 questions ÷4x39). The lower the value, the better the quality of life [12,34].

Upper limbs function evaluation

TEMPA, originally created for the elderly, has to be used to evaluate the function of upper limbs [35]. TEMPA has been translated to Brazilian-Portuguese by Michaelsen et al. and validated for PD patients by Freitas et al. [28]. The test consists of eight standardized tasks that represent the ADLs which are assessed during their implementation based on the execution speed, the functional level and the analysis of the tasks performed. These tasks are performed on a platform with standardized measures and materials used, located in precise and predetermined places. In the same way, the start and end of the tasks are standardized. The scores are recorded as follows: on the speed of execution, the tasks are timed from the moment the patient removes the hands of the lower deck up to the moment that completes the task

returning the hands to the starting position. Note that the tasks should be carried out as quickly as possible and the time is recorded only if the task is completed. The functional graduation refers to the independence of the individual in each task. Each task is classified in a four-level scale and defines the quality of implementation based on the following aspects: if the task is successfully completed without hesitation or difficulty; if it is completed with some difficulty; if it is performed in part or with extreme difficulty; or if is not completed even with assistance. Finally, the performed task analysis quantifies the difficulty encountered by the subject according to five items related to sensorimotor skills of the analyzed upper limb: "Strength", "Range of Motion", "Accuracy of Large Movements", "Hold", "Accuracy of Fine Movements". The result is the sum of partial scores of the functional graduation corresponding to the right unilateral, bilateral and left tasks and, similarly, the sum of partial scores of five items of the task analysis. Although the original scale comes up with a negative quotation, with zero indicating no disability, for the purpose of statistical analysis in the validation for PD the values are used disregarding the signs. Thus, higher values correspond to greater disability [35-37].

Nine Hole Peg Test

To evaluate the manual dexterity, the 9HPT has to be applied consisting of nine pegs and a plate with nine holes. The individual is encouraged to pick up a peg at a time and insert into the holes and then he/she must remove the pegs and return them to the place of origin. The runtime of the task has to be timed by the researcher. The result is the average of two runs for each side [38,39]. The 9HPT has the potential to serve as an easily administered and useful tool for assessing the function of the upper limb of a variety of populations including individuals with neurological conditions [40,41]. Earhart et al. concluded that 9HPT is a sensitive measure for changes resulting from PD progression, drug intervention, and may also be useful to detect effects of a physical treatment for PD. These authors defined the values of the minimal change detectable to the 9HPT after intervention.

Manual strength evaluation

The handgrip strength has to be measured by Jamar® manual dynamometer with the device handle in the second space. Manufacturer's recommendations described in the instruction manual [42], and applied according to the American Society of Hand Therapy [43-45]. The patient should be comfortably seated, positioned with the shoulder adducted, the elbow flexed to 90°, forearm in neutral position, and the handle extension position ranging from 0° to 30° . The individual has to be requested to reach the highest strength possible in each hand with verbal command during the test. A demonstration for familiarization with the instrument has to be carried out beforehand. The result is the average of three measurements obtained by each hand [42-45]. This test for PD has been validated by Villafane et al.

Intervention

The Intervention group has to participate in a muscular strength-training program while the Control group has to perform stretching and mobility exercises. The protocol used for the intervention group has to consist of a set of exercises (isotonic and isometric) for upper limbs. The implementation period for the program has to be two months, twice a week, totalizing 16 sessions. The load adjustment has to be held every 15 days, totalizing three settings. In order to minimize the effects of interference from motor fluctuations usual in PD, the test for initial load, load adjustments, and implementation of the program occurs at the same time of day. At the beginning and end of each session, blood pressure and heart rate data has to be checked. The composition of the evaluation procedures, training, and follow up for each group:

The second evaluation session after the training has to determine if there are differences between groups as well as, if the instruments show some improvement in the intervention group. Besides, it is important to verify if after the one month follow up period if there is a stabilization of motor outcomes.

The strength training has to be developed using elastic tubes (Elastos®), which have resistance values that progress in seven levels indicated by different colors validated by Martins et al. (2014). An inelastic band that controls the length of elastic tube has to be used, ensuring the load application previously chosen for the exercise. The resistance control has to take place as follows: the inelastic band has to be moved concomitantly with the elastic tube stopping the movement reaching 100% of its length. This is a feature that we consider important in our protocol because the association of the elastic tube with the inelastic band permits us to control the load necessary for muscle training. Studies usually using elastic bands depend exclusively on the elastic extensibility, making it difficult to apply the exact load to determine during the initial loading test during muscle training [48-50].

A familiarization session has to be held in addition to two tests to choose the initial load. During the familiarization session, explanations of the exercises, postural guidance has to be given and patients have to perform a simulation of movements. The two initial loading tests have to be conducted with an interval of 7 days to confirm the results. In cases where results of initial load being conflicting, the largest load has to be used. According to Buckley et al. [8] the daily variations in performance of subjects with PD may interfere in the results. This suggests more than one load test should be carried out. Thus, two loading tests have to be performed, the first 48 h after the familiarization session.

For the isotonic exercise, the test for the initial load and the load adjustment has to be performed using the 10 Repetitions Maximum Test (10RM) for each movement included in the program. Individuals have to warm up for 5 min through the active-free movement of all joints in both upper limbs separately. The selected elastic tube to be chosen has to be the one that after 3-5 attempts failed to produce concentric muscle contraction in the tenth repetition. There have to be progressive increments until the identification of the maximum load. There has to be a rest period of 1 min between each attempt.

Patients with PD have abnormal generation movement patterns and may also have early fatigue [51,52]. Thus, the 10RM test simulates the number of repetitions that the patients have to perform during the strengthening training. American College of Sports Medicine (2011) recommends 10 to 20 repetitions for elderly and fragile non-conditioned individuals. It should be noted that there is not, to date, a consensus on optimal values for the training variables such as frequency, intensity, volume and rest period specifically for individuals with PD.

For the isometric exercise, we have to adopt a set of exercises with the first load immediately below that chosen for the isotonic exercise. The testing aims to confirm whether the load is suitable for isometric

contraction or not. If above the capacity of the individual, we have to test the loads in decreasing order using a defined load. That is, using strength greater than the individual is capable of isometric contraction for 5 s without compensation and with visible effort. The rest period between each attempt has to be 1 min.

Working conditions with elastic tubes have to be as follows: the elastic tube has to be secured by one end in stable artifact and at the other end there has to be a support handle that has to be held by the individual. The inelastic band has to be positioned parallel to the elastic tube. The individual has to tension the elastic tube to the limit of the inelastic band to ensure the tube deformation by 50%, 100%, 150%, or 200%, depending on the load previously set by the 10RM.

Description of the exercise protocol

Both upper limbs have to be exercised in isolation starting from the dominant upper limb. The program has to consist of movements of flexion/extension, abduction/adduction, internal and external gleno-humeral rotations, elbow flexion/extension, wrist flexion/extension and the session structure has to consist of: "Warm up, Strengthening and Active Stretching". The session has to start at "Warm Up" and end at "Active Stretching" of the trained muscles. Isotonic and isometric exercises have to be performed alternately every session, which it lasts approximately 1 h. The individuals have to perform 2 sets of 10 repetitions with 1 min interval of rest between exercises to isotonic exercise and 2 sets of 8 repetitions with 5 s of isometric with interval of 1 min rest between exercises to isometric exercise. In all exercises, the individual has to be sitting upright in a chair with support.

Statistical analysis

For statistical analysis of the data, SPSS Statistic Software Version 18 has to be used. For demographic characteristics of the sample (age, gender, dominant hand, more impaired side, UPDRS II, UPDRS III, disease time, H&Y, Levodopa daily dose) descriptive statistics have to be used. The Shapiro-Wilk test has to be run in order to analyze the normal distribution of variables. From the result obtained by the normality test, parametric or non-parametric tests have to be performed in order to check whether there is any difference between the two groups and if there is correlation between variables. For all procedures, a significance level of 5% has to be adopted.

Results

Five subjects in each group started the program, but have not yet finished. The final results have to be completed in 2018.

Discussion

Impairments in Activities Daily Living can be observed in PD due to the change in the production and/or modulation of muscle strength [6,12,14,16]. Although some degree of motor impairment may be present from the first stage of the disease [39], the disease progression and complications cause progressive decline in quality of life [12]. Therefore, it is relevant to know whether interventions such as muscular strength training, would achieve functional and quality of life improvement, measured in our study, by TEMPA and PDQ-39, respectively.

The International Classification of Functioning (ICF) created by the World Health Organization (WHO), in 2001, established a unified and standardized language to describe the health and provide a broader view on the health status of individuals [53]. It describes functionality and disability in accordance with health conditions, identifying the skills or disabilities that individuals present in their daily living. Therefore, the health model adopted by WHO makes it essential to use instruments that evaluate skills of "activity and participation" that are able to identify the functional motor conditions of individuals allowing more appropriate therapeutic strategies for rehabilitation.

Corcos et al. state that disagreements about the presence of "Muscle Weakness" as a primary symptom in individuals with PD are still conflicting. It is not clear whether the origin of the muscle weakness is central or peripheral, intrinsic to the disease or a secondary phenomenon caused by progressive motor impairment [6-8,16,54,55]. For Corcos et al. [6] who observed decline in maximal isometric muscle strength between on-off states, the influence of Levodopa on muscle strength may indicate the central origin of muscular weakness.

Other researchers have investigated muscular weakness in PD. Gorniak et al. [14] pointed out changes in muscle strength coordination and modulation in thumb/index bimanual tasks. Allen et al. [13] showed evidence of lower strength and power production in leg extensor muscle. Oliveira et al. [16] noticed decrease in the production of maximal isometric muscle strength and modulation of submaximal isometric muscle strength of pinch grip between thumb and indicator fingers. Jordan, Sagar & Cooper proposed PD has an abnormal pattern in strength production, such as latency, generation of speed and relaxation of the isometric force. On the other hand, they found that individuals recently diagnosed with PD were able to achieve maximum muscle strength levels as compared to the control group.

Motor disorders in upper limbs caused by PD may lead to changes in the dexterity pattern, loss in the movement control such as reach and grasp. Consequently, this may result in decreasing execution speed of sequential, two-handed and, primarily, asymmetrical tasks which demand increased motor complexity [13,15,21,30,55-59]. Fellows et al. also found that handgrip strength may be affected in PD, resulting in significant functional decline for upper limbs [57].

Although the origin of muscle weakness in PD remains unknown, various studies highlight the need to evaluate the effects of implementing exercise programs for increasing muscle strength in order to improve functional performance [6,7,10,56,57].

Van Nimwegen et al. found out that individuals with PD are 29% less active compared to healthy individuals when investigating the influence of factors related to PD in ADLs. Due to the deleterious effect of physical inactivity, many adverse consequences are expected, making it necessary to include specific exercise programs for these patients.

As previously described, muscle weakness is the subject matter of many PD studies; however, studies of physical therapy interventions in PD address mainly lower limbs, missing studies emphasizing upper ones.

To our knowledge, only three studies evaluated the effects of exercises for upper limbs. In the study by Lee et al. the objective was to evaluate the effect of Modified Constraint-Induced Movement Therapy on motor function of upper limbs in PD, but the authors chose Fugl-Meyer scale as a measurement tool. This scale was developed specifically for individuals with hemiparesis after brain injury. Items such as spasticity are not observed in PD. Moreover, motor tests chosen in the study are not validated for PD. For this reason, they did not have sensitivity required to detect the effects of the treatment. In

paper published by Mateos-Toset et al., it is important to stress that only one therapeutic session was carried out. The manual function merely showed significant differences for manual dexterity and strength. Finally, David et al. compared the effects of progressive resistance exercise with a non-progressive exercise intervention. They measured the muscle activity and bradykinesia but did not study the effects on functionality of upper limbs [28].

Therefore, there is a lack of understanding related to the effects of a progressive muscular strength training protocol for upper limbs based on a health model adopted by the WHO. In our study, we have to use different measurement tools for "Structure and body function", "Activities", and "Participation" domains by the International Classification of Functioning, Disability, and Health (ICF) in patients with PD.

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