DOI: 10.590/1809-2950/60221032014

CASE STUDY

Influence of treadmill training in dual-task gait in people with Parkinson's Disease: a case report

Influência do treino em esteira na marcha em dupla tarefa em indivíduos com Doença de Parkinson: estudo de caso

Influencia del entrenamiento en cinta rodante em la marcha de doble tarea en indivíduos con la enfermedad de Parkinson: um estúdio de caso

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ABSTRACT | The loss in the automaticity of gait hinders the performance of concurrent activities – Dual Task (DT) – in individuals with Parkinson's disease (PD). One hypothesis for the negative interference of DT on gait is related to the limitation of attention resources in the brain for different activities. When the automation of a task occurs, the negative interference of DT on the gait can be minimized. Because the treadmill promotes automaticity of a better locomotion pattern, due to the repetition that promotes motor learning, the study sought to investigate whether treadmill training can improve the performance of gait on DT in people with PD. Three individuals were evaluated in the on-phase of the antiparkinsonian medication regarding the kinematics (Qualisys Motion Capture System) while in gait, simultaneously performing cognitive activities. Subsequently, the subjects performed a 20-minute workout on the treadmill and were reassessed during gait in cognitive activities. There were increases in the length of the cycle (p=0.01), the length of the step (p=0.01) and in total swing time (p=0.03), and a decrease in the total length of support (p=0.03). These results indicate that treadmill training can promote improvement in the performance of DT on gait in individuals with PD. Longitudinal studies with this focus of research are needed.

Keywords | Parkinson's Disease/rehabilitation; Biomechanical Phenomena.

RESUMO | A perda na automaticidade da marcha dificulta a realização de atividades concorrentes – Dupla Tarefa (DT) – em indivíduos com Doença de Parkinson (DP). Uma hipótese para a interferência negativa da DT sobre a marcha está relacionada à limitação de recursos cerebrais atentivos para as diferentes atividades. Caso ocorra a automatização de uma das tarefas, a interferência negativa da DT sobre a marcha poderá ser minimizada. Como a esteira promove automaticidade de um melhor padrão locomotor, devido à repetição que favorece a aprendizagem motora, o estudo buscou investigar se o treino em esteira pode melhorar o desempenho de marcha em DT em pessoas com DP. Três indivíduos foram avaliados na fase *on* do medicamento antiparkinsoniano quanto à cinemetria (*Qualisys Motion Capture System*), enquanto realizavam a marcha simultaneamente a atividades cognitivas. Posteriormente, os indivíduos realizaram um treino de 20 minutos na esteira e foram reavaliados durante a marcha em atividades cognitivas. Houve aumentos no comprimento da passada (p=0,01), no comprimento do passo (p=0,01) e no tempo total de apoio (p=0,03). Esses resultados indicam que o treino em esteira pode promover melhora no desempenho de marcha em DT em indivíduos com DP, sendo necessários estudos longitudinais com esse foco de investigação.

Descritores | Doença de Parkinson/reabilitação; Fenômenos Biomecânicos.

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Presentation: Sept. 2013 – Accepted for publication: July 2014 – Financing source: National Council for Scientific and Technological Development (CNPq) – Conflict of Interests: nothing to declare – Approval at the Ethics Committee 143.802, CAAE 03063812.0.0000.5537.

RESUMEN | La pérdida en el automatismo de la marcha dificulta la realización de actividades simultáneas – Doble Tarea (DT) – en personas con enfermedad de Parkinson (EP). Una hipótesis para la interferencia negativa de la DT en la marcha está relacionada con la limitación de recursos cerebrales de atención para diferentes actividades. Cuando se produce la automatización de una de las tareas, la interferencia negativa de la DT sobre la marcha podrá ser minimizada. Como la cinta de correr promueve la automaticidad de un mejor patrón locomotor, debido a la repetición que favorece el aprendizaje motor, el estudio trató de investigar si el entrenamiento en cinta de correr puede mejorar el desempeño de marcha en DT en personas con EP. Tres individuos fueron evaluados en la fase *on* del medicamento antiparkinsoniano en cuanto a la cinemática (*Qualisys Motion Capture System*), mientras se realizaba la marcha simultáneamente a actividades cognitivas. Posteriormente, los individuos realizaron un entrenamiento de 20 minutos en la cinta y fueron evaluados de nuevo durante la marcha en actividades cognitivas. Hubo aumentos en longitud de la pasada (p=0,01), la longitud del paso (p=0,01) y en el tiempo total del abalanzar (p=0,03) y una disminución de en tiempo total de apoyo (p=0,03). Estos resultados indican que el entrenamiento en cinta puede promover la mejora en el rendimiento de marcha en DT en personas con EP, y que se necesitan estudios longitudinales con este enfoque de investigación.

Palabras clave | Enfermedad de Parkinson/rehabilitación; Fenómenos Biomecánicos.

INTRODUCTION

Due to the current world population ageing, there has been an increase in incidence of progressive neurological disorders, including Parkinson's disease (PD). It is estimated that around 40 million people worldwide will be diagnosed with this disease by 2020[1].

One of the reasons of this disease's signs and symptoms is the imbalance of the basal nuclei. Considering these nuclei play a key role in control of repetitive and learned movements, PD patients cannot adequately perform automatic sequential movements such as gait[2], one of the biggest and most incapacitating problems of this population[3].

In PD, gait is characterized by some changes in temporal-spatial and angle variables, including decrease in velocity, stride length and upper limbs balance, compensatory increase in pace and in variability of steps, reduction of hip width and extension at medium support phase, knee flexion in balance, and plantar flexion at propulsion[4,5].

Daily life often requires the execution of more than one task at once, which is called dual-task (DT)[6]. The ability to perform a secondary task is advantageous during gait, once it allows one to communicate with other people, to transport objects and to monitor the environment in order to avoid situations that may harm balance[7]. In healthy individuals, motor cortex regions initiate movements while basal nuclei perform, regulate and refine them, leaving the former free for other important tasks required[8]. As the automaticity promoted by basal nuclei is impaired in PD, a constant and conscious control is needed in gait[9]. Therefore, when a task is performed concomitantly to this function, the frontal lobes dedicate to the secondary task whilst gait is predominantly controlled by impaired basal nuclei, which makes DT interferes negatively in gait[10].

One of the models to explain this interference is "capability or resource sharing model", which is based on the argument of limited attention function of the brain. It means that when a person performs two tasks simultaneously, the neural network divides them to take care of. Dual-task interference happens if attention resources available are exceeded, thus decreasing performance of one or both tasks[11].

Another plausible explanation for negative interference of simultaneous tasks on gait in PD patients is the presence of cognitive disabilities related to execution functions, especially attention and working memory. According to this theory, there would be no limits to attention resources in the brain, impairing dual-task gait, but the problem would be execution and cognitive disabilities in PD patients while managing simultaneous tasks[12].

As a consequence, changes in PD patients' gait are more evident in dual-task situations. A study comparing dual-task gait features in PD and healthy patients showed reduction in stride speed and length, as well as increased stride variation and gait asymmetry in PD patients, all factors predisposing them to falls[13].

Tasks influencing gait may be cognitive or motor. Cognitive tasks involve attention, arithmetic calculations, verbal or conversational fluency, and memory. Motor tasks, on the other hand, involve handling and carrying objects[14]. O'Shea *et al.*[7] reported that PD patients' gait is equally impaired by cognitive and motor secondary tasks; however, studies have shown that cognitive tasks interfere more on gait compared to motor ones[2,6].

Facing worsening of quality of gait in dual-task situations, PD patients have always been oriented to avoid such situations[8]. In contrast, studies have recently shown that gait training associated with secondary tasks can improve the variables related to dual-task gait performance in PD patients[15-17].

Canning *et al.*[15] conducted a study on gait in multitask situations with PD patients and reported increase in gait speed. Yogev-Seligmann *et al.*[16] performed a pilot-study on dual-task situations with PD patients and found increase in gait speed and decrease of stride variability in such situations. Brauer and Morris[17] made an intervention of dual-task gait and reported immediate effects of the training on gait in these conditions after a 20-minute session. Results were increase in stride length and speed.

However, the causes of improvement are not well established yet. It is not known whether changes happen because of specific dual-task training, which allow better management of tasks, or simply because gait training improved the locomotor patterns and, therefore, secondary tasks' performance. Based on resource sharing model, one of these tasks should be automatic in order to minimize the demand of attention to secondary tasks and not to exceed resources naturally available in the brain[11]. With loss of automaticity in PD, trainings focused on gait only can make locomotor patterns automatic and reduce the demand of attention to such tasks afterwards, allowing the performance of more challenging secondary tasks[14].

Grounded on this assumption, could gait training improve dual-task gait in PD patients, even in situations other than multitask? The literature lacks studies on the influence of isolate gait training over variables related to dual-task gait in PD patients.

Studies have proven treadmills as excellent source of gait training in PD. It may function as external track mediated by proprioceptive receptors, establishing gait rhythm to compensate the basal nuclei internal regulation disabilities; it can, therefore, activate neuronal circuits named central pattern generators[18]. Twenty-minute training on treadmills has been proven as minimal time capable of causing significant changes on gait patterns in Parkinson's disease[19].

This study, therefore, aimed to investigate the effects of treadmill gait training over the performance of ground gait in PD patients. There is a need to evaluate whether locomotor training, with emphasis to sharing resource model, could improve gait in PD patients. The secondary tasks were cognitive, for these are known to interfere negatively on gait.

METHODOLOGY

This case study was conducted at *Laboratório de Intervenção e Análise do Movimento* (LIAM), in the Department of Physical Therapy of *Universidade Federal do Rio Grande do Norte*, in June 2012. Three PD patients (two males and one female) participated in this pilot study sample.

Patients were recruited by telephone call based on a list of patients assisted in the Physical Therapy sector of *Hospital Universitário Onofre Lopes* (Natal, RN, Brazil). Participants aged 54, 68 and 70 years, were diagnosed with 3-mid stage progression idiopathic PD (modified Hoehn & Yahr scale), made use of Antiparkinsonian medications, and were able to walk without the aid of external devices.

Kinematic gait analysis in dual-task was performed using Qualisys Motion Capture Systems (Qualisys Medical AB, 411 13 Gothenburg, Switzerland), which enables the record of temporal-spatial variables related to gait and angle variables related to hips, knee and ankle joints (Figure 1).

For gait training, the electric treadmill *Gait Trainer 2* (*Biodex Medical System*, NY, USA) was used, with a coupled weight suspension system. However, as patients did not use the weight suspension in our study, the vest was used for safety only (Figure 2).

Study procedures were performed in two days. On the first day, kinematic dual-task gait analysis on the ground was performed. On the second day, patients were submitted to treadmill training and a second kinematic dual-task gait analysis on the ground. There was a one-day interval between the analysis, performed by examiner 1, and the training, followed up by examiner 2.

This study was approved by the Research Ethics Committee of *Universidade Federal do Rio Grande do Norte*, protocol 146.802/2012. Volunteers were first of all notified about the study purposes and then signed the informed consent form, complying with Resolution 196/96 by the National Health Council. Then, kinematic dual-task gait analysis on the ground was performed. Anatomical landmarks were marked using double-side adhesive tape and bandage, and tracking markers were attached to body segments by Velcro elastic bands (Figure 3).

After positioning of markers and calibration of the equipment, a static collection was performed so the system could recognize the anatomical landmarks and reconstruct the biomechanical model. Patients remained in orthostatic position, with arms crossed on the chest, feet apart in line with their hips and in front of one of the cameras, while a 3-second record was made.

Then, anatomical landmarks were removed for dynamic collections. Only tracking markers related to thighs and legs, fifth metatarsus head, lateral and calcaneal malleolus, corresponding to the feet.

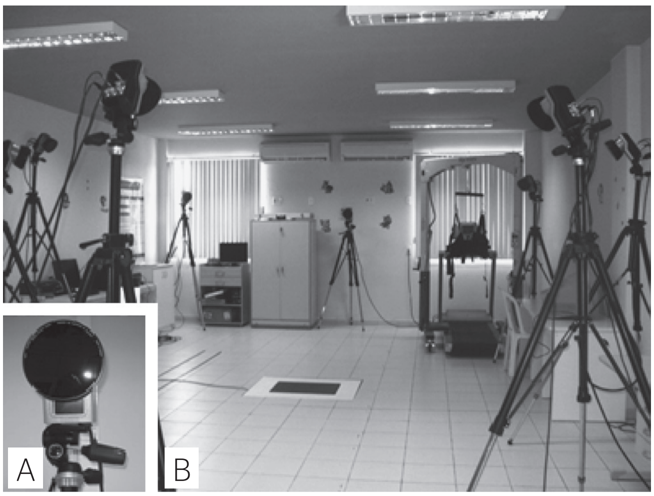

Figure 1. Qualisys Motion Capture System (A) and cameras positioning (B)

Figure 2. Treadmill

Patients were oriented to walk an 8-meter distance at maximum comfortable speed while performing a cognitive task. As they were walking the distance, a letter of the alphabet would be chosen and they were supposed to speak as many words beginning with that letter as possible. Ten dynamic collections were conducted.

On the second Day, patients performed gait training on a treadmill for 20 minutes. The speed was set by patients at a comfortable limit, that is, they should walk fast without feeling pain or losing balance. Vital signs (heart rate and blood pressure) were monitored before, during and after training.

Immediately after treadmill training, gait on the ground was reassessed at dual-task conditions by ten dynamic captures, like procedures performed in the first day.

Statistical analysis was made with *Statistical Package for Social Sciences* (SPSS) 19.0. Paired t-test was used to compare data before and after intervention, with significance level at 5%.

RESULTS

After training, results showed increase in stride length, step width and total balance time (%), as well as decrease in total support time (%) during dual-task gait. Values of temporal-spatial variables referring to evaluations pre and post-training on the treadmill are shown in Table 1.

Joint angle variables did not present changes.

DISCUSSION

This study investigated immediate effects of treadmill gait training on PD patients' gait on the ground in dual-task

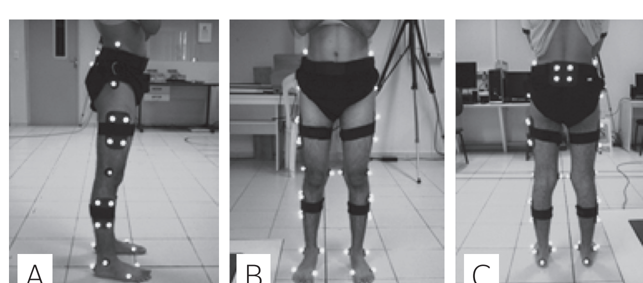

Figure 3. Lateral (A), anterior (B) and posterior (C) view of landmarks

situations. Results showed improvement in temporal-spatial variables of subjects after intervention.

Analysis of temporal-spatial variables showed increase in stride and step lengths. Gait hypokinesia verified in PD reflects the difficulty to internally regulate stride length and activate motor control system. Nevertheless, studies have reported that PD patients' can generate a normal stride pattern upon adequate sensory stimulation, because despite disabled pale-cortical projections, the intact circuits of pre-motor cortex are activated and control guided-movements externally. Therefore, the constant rhythm provided by the treadmill could function as an external track. Also, visual inputs received and the distance of feet on the treadmill have been suggested as a possible mechanism providing changes in PD patients' gait[20].

Another feasible explanation for the benefits of treadmill training is related to central pattern generators (CPGs). The treadmill forces stride by facilitating the stretching of hip and plantar flexors in the end of the support phase. As both upper limbs are automatically pulled back, afferent nerves carry stimuli to CPGs, causing the stride pattern to be regular[19].

As to improvements even in dual-task situations, repeated practice of treadmill movements may have led to automaticity of locomotor patterns, once repetition is a basic prerequisite for motor learning[21]. As cognitive training was nor performed, different tasks' management capability could not be assessed. However, if only motor training could improve temporal-spatial variables related to dual-task gait, we cannot discard the hypothesis of task automaticity as an alternative to minimize negative interference of secondary tasks on gait, sticking to the resource sharing model.

Increase in balance time and decrease in support time show better performance at changing steps and better balance, minimizing risk of falls[4]. Considering

Table 1. Mean values and standar deviation of spatial and temporal variables before and after treatment

Variables	Pre-training	Post-training
Velocity (m/s)	0.69±0.11	0.86±0.11
Stride lenght (m)	0.91±0.01	1.08±0.02*
Stride width (m)	0.11±0.03	0.10±0.02
Total support time (%)	0.64±0.005	0.61±0.01*
Total balance time (%)	0.35±0.01	0.38±0.01*
Double-support time (%)	0.14±0.005	0.08±0.05
Step lenght (MA)	0.48±0.01	0.55±0.02*
Support time – MA (%)	0.32±0.005	0.31±0.01
Balance time – MA (%)	0.17±0.005	0.18±0.01

AL: most affected limb; *p<0.05

that only one 20-minute session could cause significant changes in dual-task gait, this tool in association with practice sessions may be effective to decrease negative influences of secondary tasks on PD patients' gait. Even dissociated of cognitive task training, treadmill can improve secondary tasks influence on ground gait.

Once this study verified only immediate effects of treadmill training on gait with secondary tasks, the sample size was small, and we did not assess patients' capability of managing different tasks, we suggest that further studies investigate the longitudinal effects of treadmill training in a bigger sample and compare results with a control group in order to analyze cognitive aspects.

CONCLUSION

One session of gait training on the treadmill improved temporal-spatial variables at dual-task gait in PD patients, a finding not yet described in previous studies. Results suggest that treadmill training is an alternative to improve PD patients' performance at dual-task gait, thus reducing negative interferences of the secondary task.

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