Projeto de Pesquisa:
Efeito da estimulação transcraniana por corrente contínua (ETCC) na assimetria da marcha em pessoas com doença de Parkinson

Informações Preliminares

Responsável Principal

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Instituição Proponente

CNPJ: 48.031.918/0028-44	Nome da Instituição: UNIVERSIDADE ESTADUAL PAULISTA JULIO DE MESQUITA FILHO

É um estudo internacional? Não

Assistentes

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223.676.818-48	Fabio Augusto Barbieri

Área de Estudo

Grandes Áreas do Conhecimento

- Grande Área 4. Ciências da Saúde

Propósito Principal do Estudo

- Clínico

Título Público da Pesquisa: Efeito da estimulação transcraniana por corrente contínua (ETCC) na assimetria da marcha em pessoas com doença de Parkinson

Contato Público

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Contato Científico: Vinicius Cavassano Zampier

Desenho de Estudo / Apoio Financeiro

Desenho do Estudo: Intervenção/Experimental

Condições de saúde ou problemas

Condição de saúde ou Problema
Doença de Parkinson

Descritores Gerais para as Condições de Saúde

CID1-10:Classificação Internacional de Doenças

Código CID	Descrição CID
G20	Doenca de Parkinson

DeCS:Descritores em Ciência da Saúde

Código DECS	Descrição DECS
D010300	Doença de parkinson

Descritores Específicos para as Condições de

CID1-10:Classificação Internacional de Doenças

Código CID	Descrição CID
G20	Doenca de Parkinson

DeCS:Descritores em Ciência da Saúde

Código DECS	Descrição DECS
D010300	Doença de parkinson

Tipo de Intervenção: Experimental

Natureza da Intervenção

- Dispositivo

Descritores da Intervenção

Descritores da Intervenção

Intervenções
Estimulação transcraniana por corrente contínua

Lista de CID

Código CID	Descrição CID
G20	Doenca de Parkinson

Lista de DECS

Código DECS	Descrição DECS
D010300	Doença de parkinson

Fase

- Fase 1

Haverá uso de placebo ou a existência de grupos que não serão submetidos em nenhuma intervenção:

Será necessário a implementação de um grupo placebo para testar a eficácia da estimulação transcraniana por corrente contínua na assimetria da marcha de pessoas com doença de Parkinson

Haverá aplicação de washout:

Será necessário a aplicação de um período washout de uma semana para verificar qual protocolo de estimulação transcraniana por corrente contínua apresenta melhores resultados

Desenho:

Ensaio clínico randomizado duplo cego sham-controlado.

Apoio Financeiro

CNPJ	Nome	E-mail	Telefone	Tipo
				Financiamento Próprio

Palavra Chave

Palavra-chave
Controle motor
Marcha
Assimetria

Estimulação transcraniana por corrente contínua
Doença de Parkinson

Detalhamento do Estudo

Resumo:

Gait disorders, such as asymmetries in spatiotemporal parameters, are considered one of the leading causes of disability in individuals with Parkinson¿s disease (PD). Initially, gait asymmetry can be attributed to unilateral motor degeneration, and its progression is associated with changes in motor cortex activity. Individuals with PD exhibit increased motor cortex activity as a compensatory strategy to cope with motor deficits and maintain gait control. In this context, therapies that directly modulate cortical activity, such as transcranial direct current stimulation (tDCS), may contribute to reducing gait asymmetry. This study aims to investigate, through two randomized clinical trials, the effects of single and multiple tDCS sessions on gait asymmetry in individuals with PD. In the first study, the effects of three tDCS protocols, applied for 20 minutes at an intensity of 2 mA, will be compared: (1) unilaterally over the motor cortex contralateral to the most affected side, (2) unilaterally over the motor cortex ipsilateral to the most affected side, and (3) bilaterally over the motor cortex. The protocol order will be randomized for each participant, with a one-week interval between sessions. In the second study, the effects of multiple tDCS sessions on gait asymmetry will be evaluated, using the most promising protocol identified in Study 1. The intervention will last four weeks, with 20-minute sessions at 2 mA conducted on non-consecutive days (48-hour intervals). The findings from these studies will provide a solid theoretical foundation for understanding the effects of a non-pharmacological therapy on gait asymmetry in individuals with PD, contributing to the development of more effective clinical strategies.

Introdução:

Parkinson's disease (PD) is typically characterized as a brain disorder that causes involuntary or uncontrollable movements, such as difficulty with balance and coordination. The literature consistently shows that individuals with PD exhibit reduced gait velocity and step length, as well as increased gait variability. In addition, gait asymmetry (GA) defined as differences in the bilateral behavior of the steps or legs during walking is believed to result from the disease and the imbalanced strength of muscles, a typical symptom of PD. Indeed, GA exacerbates gait impairments, leading to an increased risk of falls; approximately 70% of individuals with PD fall annually, and 13% fall more than once a week. GA is a relevant clinical concern that should be addressed during the rehabilitation of movement disorders. Understanding the effects of PD on GA could improve mobility and reduce the incidence of falls, highlighting the importance of therapeutic interventions aimed at minimizing GA in individuals with PD. Under normal conditions, the ability to perform steady and symmetric gait does not rely heavily on cognitive resources. However, when gait is impaired (e.g., as in PD), GA appears to depend more on attentional and cognitive input. This is particularly evident in individuals with PD during dual-task conditions, in which increased GA and greater impairment in gait parameters are commonly observed. GA is typically assessed through spatiotemporal gait parameters (e.g., step length, swing time, or stance time), while muscle-based evaluations of GA remain relatively underexplored. Many individuals with PD demonstrate greater spatiotemporal GA (e.g., step length, step time, and swing time) than age-matched healthy controls. Moreover, environmental factors also influence GA in PD; for instance, individuals with PD display greater asymmetry in step length and duration when encountering obstacles, compared to neurologically healthy controls. Clinical evidence supports the pathogenic role of asymmetry in disrupting the rhythmic right/left antiphase activation of the lower limbs during gait in PD. The asymmetric degeneration of dopaminergic neurons in the substantia nigra, particularly within the basal ganglia, is the most apparent explanation for motor asymmetry in PD. This imbalance in dopaminergic signaling alters the cortico, basal ganglia, thalamus, cortical circuits, contributing to deficits in motor coordination and gait. Consequently, therapeutic interventions that modulate neural activation appear to be a promising approach to reduce GA in PD, as they may enhance neural functioning, trigger plasticity processes, and improve spatiotemporal gait parameters. Nevertheless, the effects of neural modulation on brain areas involved in gait control such as the motor and prefrontal cortices on GA, whether in spatiotemporal parameters or muscle activity during walking, have not yet been thoroughly investigated, particularly with regard to the prescription of effective therapeutic interventions to mitigate GA in PD. In recent years, non-invasive brain stimulation (NIBS) techniques have been increasingly employed to address a range of pathological conditions. Among these, transcranial direct current stimulation (tDCS) stands out as a safe and user-friendly technique and has become one of the most frequently used in research settings. Activity in the ventro-posterolateral thalamic nucleus increases in response to tDCS, suggesting potential modulation of basal ganglia function and improvements in motor control. Prior studies have reported positive effects of tDCS on motor performance in both individuals with PD and neurologically healthy older adults. For example, a single 20-minute tDCS session over the motor cortex increased gait speed in healthy older adults. In individuals with PD, eight 20-minute tDCS sessions targeting the motor cortex improved balance control by reducing the time needed to recover balance following a perturbation. However, the effects of tDCS applied unilaterally targeting either the more or less affected hemisphere or bilaterally on GA in individuals with PD remain poorly understood. Neurophysiological studies have revealed asymmetries in M1 excitability [33, 34] and reduced transcallosal inhibition in the more affected hemisphere compared to the less affected one [35, 36]. These findings may reflect the asymmetric dysfunction of the striato frontal motor circuit and are believed to contribute to the characteristic motor asymmetry in PD. Since a reduction in GA (e.g., step length asymmetry) indicates improved motor control, it is essential to clarify the efficacy of therapeutic interventions, such as tDCS, which can modulate neural excitability in brain regions involved in the basal ganglia thalamus cortical circuits. Investigating both acute and long-term effects of tDCS on GA in PD is crucial to optimizing therapeutic strategies, particularly during the early stages of the disease. Consequently, evaluating changes in GA may serve as a valuable metric for assessing intervention outcomes and refining gait rehabilitation approaches in PD. To further our understanding of tDCS effects on GA in individuals with PD and to establish an optimal stimulation protocol, it is essential to explore both the immediate and long-term impacts of this technique. Furthermore, identifying a protocol capable of inducing early neuroplastic changes and maintaining these effects over time is critical for maximizing therapeutic outcomes. Therefore, this study aims to address the current knowledge gaps by experimentally investigating: (i) the immediate effects of tDCS on GA and the influence of different tDCS target areas on GA, and (ii) the long-term effects of repeated tDCS sessions on GA in individuals with PD.

Hipótese:

i) An acute term of tDCS applied over the M1 and DLPFC of the most affected brain hemisphere would reduce the asymmetry in spatial-temporal gait parameters such as step length, velocity, time width and double support phase in people with PD; Considering that anodal tDCS over the most affected brain hemisphere significantly improved the motor performance of both hands when compared to the application in the least affected brain hemisphere in people with PD, we expect that one session of acute tDCS over the M1 and DLPFC of the most affected brain hemisphere will lead to an accentuated reduction on GA in PD compared to applied tDCS on the least affected brain hemisphere or bilateral stimulation over the M1 and DLPFC; ii) long-term anodal tDCS would reduce the asymmetry in spatial-temporal gait parameters such as step length, velocity, time width and double support phase in people with PD and its effect will persist at least 1-month follow-up the last session.

Objetivo Primário:

The main aim of this project is to investigate the effects of a single tDCS session on different stimulation targets, as well as the

effects of multiple tDCS sessions on GA in individuals with PD, through two separate studies

Objetivo Secundário:

i) determine whether the acute term of tDCS applied over the M1 and dorsolateral prefrontal cortex (DLPFC) of most affected brain hemisphere can improve GA in people with PD, and compare the effect of tDCS on the least affected brain hemisphere vs. the most affected brain hemisphere vs. bilateral stimulation over the M1 and DLPFC on GA in people with PD; ii) to examine the effects of long-term anodal tDCS on GA in people with PD.

Metodologia Proposta:

ParticipantsIndividuals with idiopathic PD will be recruited from specialized centers in the Bauru region and diagnosed according to the UK Parkinson's Disease Brain Bank criteria. All procedures will comply with the Declaration of Helsinki, and all participants will provide written informed consent before enrollment.Study DesignTwo randomized, double-blind, sham-controlled clinical trials will be conducted to investigate the acute and long-term effects of transcranial direct current stimulation (tDCS) on gait asymmetry in people with PD. Study 1 will use a crossover design in which each participant receives both active and sham tDCS combined with three stimulation setups, whereas Study 2 will use a parallel-group design with repeated sessions of active or sham tDCS.Study 1 ¿ Acute tDCS EffectsIn Study 1, participants will complete six tDCS sessions (three active and three sham) in randomized and counterbalanced order. In each condition (active or sham), stimulation will be applied in three weekly sessions targeting: (1) the primary motor cortex/dorsolateral prefrontal cortex (M1/DLPFC) of the most affected hemisphere (C3 or C4), (2) the M1/DLPFC of the less affected hemisphere, and (3) bilateral M1/DLPFC, with at least one week between sessions to avoid carry-over effects. Active tDCS will be delivered at 2 mA for 20 minutes using saline-soaked sponge electrodes (25 cm²), with the anode over C3/C4 (unilateral or bilateral) and the cathode(s) over the contralateral (or bilateral) supraorbital area; sham stimulation will mimic ramp-up and ramp-down but will be switched off after approximately 10 seconds.Study 2 ¿ Long-term tDCS EffectsStudy 2 will investigate the long-term effects of the most effective montage identified in Study 1 using a randomized, double-blind, parallel-group design. Participants will be allocated to active or sham tDCS and will receive 12 sessions over four weeks (three sessions per week with 48-hour intervals), at 2 mA for 20 minutes in the active group and for 10 seconds in the sham group, with identical electrode placement and ramp procedures.Gait and EMG AssessmentIn both studies, clinical characterization will include the Hoehn and Yahr scale, the motor section of the Unified Parkinson's Disease Rating Scale, and the Montreal Cognitive Assessment. Gait will be assessed before and 15¿20 minutes after each tDCS session in Study 1, and at pre-intervention, post-intervention, and one-month follow-up in Study 2. Participants will perform multiple trials of barefoot overground walking on an 8 × 3 m walkway at preferred speed, while three-dimensional kinematics are recorded with a 10-camera motion capture system and reflective markers on the feet and C7. Surface electromyography (EMG) of tibialis anterior, gastrocnemius medialis, vastus lateralis, and biceps femoris of both legs will be recorded using a wireless system synchronized with foot switches to define gait phases. Spatiotemporal parameters (step length, velocity, width, duration, and double support) and EMG root mean square values will be calculated for each limb, and gait asymmetry indices will be derived using a symmetry index comparing most and less affected sides.Data Analysis and SafetyNormality of the variables will be checked, and appropriate parametric or non-parametric tests will be applied. In Study 1, acute effects will be analyzed using repeated-measures models including stimulation condition (active vs sham), time (pre vs post), and setup (most affected, less affected, bilateral). In Study 2, mixed models with repeated measures will compare groups (active vs sham) across time (pre, post, follow-up) for gait and EMG asymmetry outcomes, with significance set at ¿ = 0.05 and effect sizes reported. Adverse events (e.g., tingling, itching, headache) will be systematically monitored at each session, and any serious event will lead to interruption of stimulation and referral to medical evaluation.

Critério de Inclusão:

Age above 50 years, Hoehn and Yahr stage up to 3, ability to walk independently, stable antiparkinsonian medication.

Critério de Exclusão:

Exclusion criteria include history of brain surgery or other neurological or musculoskeletal disorders affecting gait and any metallic implant over the head.

Riscos:

Participation in this study involves minimal risks that are mainly associated with transcranial direct current stimulation (tDCS) and repeated gait assessments. tDCS is a non¿invasive brain stimulation technique that uses low-intensity direct current (2 mA) applied through saline¿soaked sponge electrodes positioned on the scalp. Previous studies have shown that tDCS is generally safe when applied within these parameters; however, participants may experience mild, transient adverse effects such as tingling, itching, burning sensation or redness under the electrodes, as well as occasional headache or fatigue during or shortly after stimulation. These symptoms usually resolve spontaneously within minutes and will be systematically monitored at each session; if discomfort becomes intolerable, stimulation will be immediately interrupted and the participant will be evaluated by the research team.The gait assessment procedures require participants to walk repeatedly along an 8 × 3 m walkway at their preferred speed while barefoot, with reflective markers and surface electromyography electrodes attached to the skin. These procedures may cause mild musculoskeletal fatigue or discomfort due to repeated trials and may induce transient imbalance, particularly in individuals with Parkinson¿s disease, who already present gait and postural control impairments. To minimize these risks, assessments will be conducted in a controlled laboratory environment, participants will be continuously supervised by trained researchers, and a member of the team will walk alongside the participant to provide physical assistance if needed. Trials will be stopped immediately if the participant reports excessive fatigue, dizziness, pain, or any other symptom of discomfort.There are no known serious or long¿term adverse effects associated with the tDCS parameters used in this protocol in individuals with Parkinson¿s disease; nonetheless, any unexpected or serious adverse event will lead to immediate discontinuation of the intervention, notification of the responsible neurologist, and referral for appropriate clinical care. Confidentiality risks will be minimized by coding all data and storing personal information separately from research records in password¿protected files accessible only to the research team. Participants will be informed that they can withdraw from the study at any time, without any penalty or impact on their usual clinical care.

Benefícios:

Participation in this study may provide both direct and indirect benefits to individuals with Parkinson¿s disease and to the broader scientific and clinical community. At the individual level, the tDCS intervention may lead to improvements in spatiotemporal gait symmetry (e.g., step length, step timing, double support), which are closely related to functional mobility and risk of falls in people with PD. By targeting motor and prefrontal cortical regions involved in gait control, tDCS may enhance neural excitability and promote neuroplastic adaptations that translate into more stable and efficient walking patterns. These changes could contribute to increased safety during daily activities, greater independence, and better perceived quality of life, although such benefits cannot be guaranteed for any given participant.At the scientific and societal levels, this project is expected to generate novel evidence regarding the acute and long¿term effects of different tDCS montages on gait asymmetry in PD, a symptom that is highly prevalent and functionally disabling yet poorly explored in the context of non¿invasive brain stimulation. The results will help identify the most effective stimulation targets (most affected hemisphere, least affected hemisphere, or bilateral stimulation) and optimize stimulation parameters for future clinical use. In addition, this study will contribute to the development of non¿pharmacological, low¿cost therapeutic strategies that can complement conventional pharmacological and surgical treatments, potentially expanding

rehabilitation options for individuals with PD. The findings may also support the inclusion of tDCS¿based approaches within multidisciplinary assistive technology programs at the host institution and collaborating centers.

Metodologia de Análise de Dados:

EMG Gait variables data will be recorded from Noraxon electromyograph device and a camera system VICON and will be prosses in MatLab environment. All analyses will be performed using standard statistical software (e.g., SPSS, R), with the significance level set at ¿ = 0.05. Continuous variables will be inspected for data entry errors, outliers, normality (e.g., Shapiro¿Wilk test) and homogeneity of variances; when necessary, data will be transformed or analyzed with non parametric tests. Descriptive statistics (mean, standard deviation, confidence intervals) will be calculated for all gait, electromyography (EMG) and clinical variables.
For each participant, spatiotemporal gait parameters (step length, step time, gait speed, step width, double support phase) and EMG amplitude (root mean square) of the tibialis anterior, gastrocnemius medialis, vastus lateralis and biceps femoris will be calculated separately for the most affected and less affected sides. Gait asymmetry indices will be derived using a symmetry index that compares the values of the most affected and less affected limbs for each parameter.
Study 1 ¿ Acute effects
In Study 1, the acute effects of tDCS will be evaluated using repeated measures analyses that account for stimulation condition (active vs sham), stimulation target (most affected hemisphere, less affected hemisphere, bilateral) and time (pre vs post). For normally distributed variables, repeated measures ANOVA with appropriate within subject factors will be applied to gait and asymmetry outcomes; when assumptions are violated, equivalent non parametric tests (e.g., Friedman test with post hoc Wilcoxon signed rank tests) will be used. Significant interactions (e.g., condition × time, condition × target × time) will be followed by planned pairwise comparisons with adjustment for multiple testing (e.g., Bonferroni correction). Effect sizes (e.g., partial eta squared or rank based measures) will be reported to quantify the magnitude of tDCS effects on gait asymmetry.
Study 2 ¿ Long term effects
In Study 2, group (active vs sham) and time (baseline, post intervention, one month follow up) effects on gait and EMG asymmetry indices will be examined using mixed ANOVA with one between subject factor (group) and one within subject factor (time), when parametric assumptions are met. If assumptions are not satisfied, non parametric alternatives for repeated measures (e.g., Mann¿Whitney tests on change scores, Friedman tests within groups) will be applied. For significant group × time interactions, post hoc tests with multiple comparison correction will identify at which time points active tDCS differs from sham and whether improvements are maintained at follow up.
Exploratory analyses and missing data
Exploratory correlation analyses may be performed between gait asymmetry indices and clinical measures (e.g., Hoehn and Yahr stage, UPDRS motor scores, cognitive performance) to investigate associations between changes in gait and disease severity. Missing data will be documented; if the amount is small and random, analyses will use available cases, whereas systematic missingness will be examined and handled according to best statistical practice (e.g., sensitivity analyses).

Desfecho Primário:

The primary outcomes will be symmetry indices computed for spatiotemporal gait parameters (step length, step time, gait speed, step width and double support phase) comparing the most affected and less affected limbs. For each parameter, a symmetry index will be calculated using established formulas (e.g., Herzog et al.) so that a value of zero indicates perfect symmetry and positive or negative values indicate the magnitude and direction of asymmetry. In addition, symmetry indices for EMG variables (root mean square amplitude and co¿activation ratios of tibialis anterior¿gastrocnemius medialis and vastus lateralis¿biceps femoris) will be computed across gait phases for both legs.
These indices will be used to test the main hypotheses that (i) a single tDCS session (Study 1) and (ii) multiple tDCS sessions (Study 2) reduce gait asymmetry in people with Parkinson¿s disease, and that these effects differ according to stimulation target and are maintained at one¿month follow¿up in the long¿term protocol.

Desfecho Secundário:

Mean values of spatiotemporal parameters (gait speed, step length, step time, step width, double support duration) for the most affected and less affected limbs, independently of asymmetry indices, will be treated as secondary outcomes to characterize overall gait performance and potential tDCS¿induced improvements. In the sample size calculations for both studies, gait speed is used as the reference variable for detecting group and condition differences over time.
Electromyographic activity and co¿activation:
Secondary outcomes will include phase¿specific EMG root mean square activity of tibialis anterior, gastrocnemius medialis, vastus lateralis and biceps femoris, as well as co¿activation ratios of antagonistic muscle pairs at the ankle and knee across gait phases. These measures will quantify changes in neuromuscular control patterns associated with tDCS and their contribution to changes in gait asymmetry.
Clinical and functional measures:
Disease severity (Hoehn and Yahr stage, UPDRS motor part III) and cognitive status (Montreal Cognitive Assessment) will be analyzed as secondary outcomes and potential correlates of changes in gait asymmetry. Exploratory analyses may examine associations between changes in gait/EMG asymmetry and clinical variables to better understand which patients benefit most from the intervention.

Tamanho da Amostra no 28

Data do Primeiro Recrutamento: 03/08/2026

Países de Recrutamento

País de Origem do Estudo	País	Nº de participantes da pesquisa
Sim	BRASIL	28

Outras Informações

Haverá uso de fontes secundárias de dados (prontuários, dados demográficos, etc)?

Sim

Detalhamento:

O grau de acometimento e o estágio evolutivo da doença de Parkinson serão verificados a partir da "unified Parkinson's disease rating scale" (UPDRS) e pela escala de Hoen Yarh respectivamente. A condição cognitiva global de cada participante será verificada de acordo com o "Montreal cognitive assessment" (MoCA) corrigido de acordo com os níveis de escolaridade. Por fim, um esquinários sobre possível efeitos adversos da aplicação da estimulação transcraniana por corrente contínua será aplicado em cada participante ao termino de cada sessão de estimulação.

Informe o número de indivíduos abordados pessoalmente, recrutados, ou que sofrerão algum tipo de intervenção neste centro de pesquisa:

28

Grupos em que serão divididos os participantes da pesquisa neste centro

ID Grupo	Nº de Indivíduos	Intervenções a serem realizadas
Grupo ETCC sham	14	os participantes irão receber a estimulação por 10 segundos
Grupo ETCC ativo	14	os participantes irão receber a estimulação por 20 minutos

O Estudo é Multicêntrico no Brasil?

Não

Propõe dispensa do TCLE?

Não

Haverá retenção de amostras para armazenamento em banco?

Não

Cronograma de Execução

Identificação da Etapa	Início (DD/MM/AAAA)	Término (DD/MM/AAAA)
Estudo 2	05/10/2026	21/12/2026
Recrutamento inicial e aplicação das escalas de caracterização da amostra	01/07/2026	31/07/2026
elaboração de relatórios e escrita de artigos	11/01/2027	31/03/2027
Estudo 1	03/08/2026	30/09/2026

Orçamento Financeiro

Identificação de Orçamento	Tipo	Valor em Reais (R$)
nada a declarar até o presente momento	Outros	R$ 0,00
Total em R$		R$ 0,00

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Arquivo Anexos:

Tipo	Arquivo

TCLE / Termos de Assentimento / Justificativa de Ausência	TCLE_posdoc_zampier.docx
Projeto Detalhado / Brochura Investigador	projeto_posdoc_R1_V2.docx
Folha de Rosto	folha_de_rosto_ass_zampier.pdf
Cronograma	cronograma_zampier.docx

Finalizar

Manter sigilo da integra do projeto de pesquisa: Sim

Prazo: Até a publicação dos resultados