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Escola de Educação Física, Fisioterapia e Terapia Ocupacional
Programa de Pós-graduação em Ciências da Reabilitação

Sherindan Ayessa Ferreira de Souza

TREINAMENTO MUSCULAR RESPIRATÓRIO EM INDIVÍDUOS COM DOENÇA DE PARKINSON

Belo Horizonte
2024

Sherindan Ayessa Ferreira de Souza

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Orientadora: Prof. Dra. Christina Danielli Coelho de Morais Faria

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RESUMO

As disfunções respiratórias estão entre as principais causas de internações hospitalares e morte em indivíduos com doença de Parkinson (DP). Indivíduos com DP comumente apresentam redução da força muscular respiratória e da *endurance* muscular inspiratória, o que parece estar relacionado as incapacidades e à redução da qualidade de vida. O treinamento muscular respiratório (TMR) é amplamente utilizado em diversas populações para melhorar a força muscular respiratória e outros desfechos relacionados. Entretanto, ainda há questões a serem esclarecidas sobre a eficácia do TMR para melhora de desfechos de saúde e funcionalidade de indivíduos com DP. Neste contexto, esta tese apresenta os resultados de cinco estudos relacionados ao TMR nessa população. **Os dois primeiros estudos** referem-se, respectivamente, ao protocolo e à revisão sistemática sobre as propriedades de medida e a utilidade clínica de instrumentos de medida utilizados na telerreabilitação em indivíduos com condições neurológicas, dentre elas a DP. Foram incluídos 47 estudos e identificados 43 instrumentos. Somente três desses estudos foram realizados com indivíduos com DP. Oito instrumentos foram recomendados por suas adequadas propriedades de medida e utilidade clínica, nenhum deles para indivíduos com DP. **O terceiro e o quarto estudos** referem-se, respectivamente, ao protocolo e ao ensaio clínico aleatorizado (ECA) desenvolvido com o objetivo de investigar a eficácia de um programa domiciliar de TMR (inspiratório e expiratório realizados simultaneamente) de alta intensidade na força dos músculos inspiratórios e expiratórios (desfechos primários), *endurance* muscular inspiratória, pico de fluxo de tosse, dispneia, fadiga, capacidade de exercício e qualidade de vida (desfechos secundários) de indivíduos com DP. Os indivíduos foram alocados aleatoriamente no grupo experimental (GE) ou controle (GC). O GE realizou o TMR de alta intensidade (60% da pressão inspiratória máxima (PImáx) e 60% da pressão expiratória máxima (PEmáx)) por 40 minutos por dia (2 sessões de 20 minutos), 7 vezes/semana, durante 8 semanas. O GC seguiu o mesmo protocolo, mas sem carga. Foram incluídos 34 indivíduos (69,53±8,35 anos). Comparado ao GC, o GE apresentou, significativamente, aumento da PImáx (19,56cmH_2O; IC95%:9,67-29,45), PEmáx (24,29cmH_2O; IC95%:9,87-38,71), *endurance* muscular inspiratória (1,21minutos; IC95%:0,39-2,03), capacidade de exercício (39,35metros; IC95%:0,58-78,12) e redução na dispneia (-0,71pontos; IC95%:1,30- -0,12). Os efeitos na PImáx, *endurance* muscular inspiratória e na dispneia foram mantidos no *follow-up*. Ambos os grupos apresentaram melhora no pico de fluxo de tosse e na qualidade de vida, efeitos que também foram mantidos no *follow-up*. **O quinto estudo** investigou, nos participantes do ECA, as perspectivas, autoeficácia barreiras e facilitadores à intervenção. Não foram observadas diferenças significativas entre os grupos para nenhum dos desfechos. Em uma escala de 0 a 100, a importância do TMR foi 91,39 (IIQ 20). Cinquenta e cinco por cento (n=17) dos indivíduos concordaram que praticar exercícios em domicílio é preferível. Em uma escala de 1 a 5, a autoeficácia foi de 3,90±0,14. As principais barreiras foram a falta de equipamento (n=29;93,5%), informação (n=28;90,3%), suporte (n=28;90,3%) e conhecimento por parte dos profissionais (n=28;90,3%). Os principais facilitadores foram a realização dos exercícios em domicílio (n=4) e os efeitos percebidos do treinamento (n=4). Aponta-se, portanto, a necessidade de estudos metodológicos que investiguem as propriedades de medida e aplicabilidade clínica de instrumentos de medida para avaliação de desfechos de saúde e funcionalidade em indivíduos com DP por telerreabilitação. O TMR realizado em domicílio e envolvendo exercícios inspiratório e expiratório de alta intensidade é eficaz para melhorar importantes desfechos nessa população. Por fim, as perspectivas dos participantes, a

autoeficácia, bem como as barreiras e facilitadores identificados, devem ser utilizados para desenvolver estratégias eficazes para implementar o TMR domiciliar.

Palavras-chave: doença de Parkinson; ensaio clínico aleatorizado; fraqueza muscular respiratória; treino muscular respiratório; visita domiciliar.

ABSTRACT

Respiratory dysfunction is one of the leading causes of hospitalization and death in individuals with Parkinson's disease (PD). Individuals with PD commonly exhibit reduced respiratory muscle strength and inspiratory muscle endurance, which seem to be associated with increased disability and a lower quality of life. Respiratory muscle training (RMT) is widely used in various populations to improve respiratory muscle strength and other related outcomes. However, research on this intervention in individuals with PD remains limited. To reduce this gap, five studies were conducted to investigate the application of RMT in this population. **The first two studies** consist of the protocol and the systematic review investigating the measurement properties and clinical utility of measurement tools used in telerehabilitation in individuals with neurological conditions, among them the PD. A total of 47 studies were included, identifying 43 measurement tools. Only three of these studies were conducted with individuals with PD. Eight instruments were recommended for their adequate measurement properties and clinical utility, none of them for individuals with PD. **The third and fourth studies** consist of the protocol and the randomized clinical trial (RCT) that evaluated the efficacy of high-intensity home-based inspiratory and expiratory muscle training on inspiratory and expiratory muscle strength (primary outcomes), inspiratory muscle endurance, peak cough flow, dyspnea, fatigue, exercise capacity, and quality of life (secondary outcomes) of individuals with PD. Individuals were randomly assigned to either the experimental group (EG) or the control group (CG). The EG performed high-intensity RMT (60% of maximum inspiratory pressure (MIP) and 60% of maximum expiratory pressure (MEP)) for 40 minutes per day (2 sessions of 20 minutes per day), 7 days a week, for 8 weeks. The CG followed the same protocol but without any load. Thirty-four individuals (69.53±8.35 years) were included. Compared to the CG, the EG showed significant increases in MIP (19.56 cmH_2O; 95% CI: 9.67-29.45), MEP (24.29 cmH_2O; 95% CI: 9.87-38.71), inspiratory muscle endurance (1.21 minutes; 95% CI: 0.39-2.03), exercise capacity (39.35 meters; 95% CI: 0.58-78.12) and reduction in dyspnea (-0.71 points; 95% CI: 1.30- -0.12). The improvements in MIP, inspiratory muscle endurance and dyspnea were maintained at follow-up. Both groups showed improvements in peak cough flow and quality of life, which were also maintained at follow-up. **The fifth study** investigated the perspectives, self-efficacy, barriers and facilitators of the intervention among RCT participants**.** Thirty-one individuals (69.68±8.31 years) were included. No significant differences between the groups were observed for any outcomes. On a scale of 0 to 100, the perceived importance of RMT was rated at 91.39 (IQR 20). Fifty-five percent (n=17) of participants preferred exercising at home. On a scale of 1 to 5, self-efficacy was 3.90±0.14. The main barriers identified were lack of equipment (n=29;93.5%), information (n=28;90.3%), support (n=28;90.3%) and knowledge on the part of health professionals (n=28;90.3%). The main facilitators were performing the exercises at home (n=4) and the perceived effects of the training (n=4). Therefore, there is a need for methodological studies that investigate the measurement properties and clinical applicability of instruments used to assess health and functional outcomes in individuals with PD. Additionally, it was highlighted that home-based high-intensity combined inspiratory and expiratory muscle training is effective in improving key outcomes in this population. Finally, participants' perspectives, self-efficacy, as well as identified barriers and facilitators, can inform the development of effective strategies for implementing home-based RMT.

Keywords: home environment; Parkinson disease; randomized controlled trials; respiratory muscles; respiratory muscle training.

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LISTA DE ABREVIATURAS E SIGLAS

CAPES	Coordenação de Aperfeiçoamento de Pessoal de Nível Superior
CIF	Classificação Internacional de Funcionalidade, Incapacidade e Saúde
CNPQ	Conselho Nacional de Desenvolvimento Científico e Tecnológico
COEP	Comitê de Ética em Pesquisa
CONSORT	*Consolidated Standards of Reporting Trials*
DALYs	Anos de Vida Ajustados por Incapacidade
DBS	Deep Brain Stimulation
DP	Doença de Parkinson
ECA	Ensaio Clínico Aleatorizado
EEFFTO	Escola de Educação Física, Fisioterapia e Terapia Ocupacional
FAPEMIG	Fundação de Amparo à Pesquisa do Estado de Minas Gerais
FC	Frequência Cardíaca
FR	Frequência Respiratória
FSS	*Fatigue Severity Scale*
LabCare	Laboratório de Avaliação e Pesquisa em Desempenho Cardiorrespiratório
MCID	Minimal Clinically Important Difference
MDC	Minimal Detectable Change
MIP	Maximum Inspiratory Pressure
MEP	*Maximum Expiratory Pressure*
MRC	*Medical Research Council*
NEUROLAB	Laboratório de Estudos em Reabilitação Neurológica do Adulto
PA	Pressão Arterial
PD	Parkinson's Disease
PDQ-39	*Parkinson's Disease Questionnaire-39*
PEmáx	Pressão Expiratória Máxima
PImáx	Pressão Inspiratória Máxima
PRPq/UFMG	Pró-reitoria de Pesquisa da Universidade Federal de Minas Gerais
RCT	Randomized Clinical Trial
RMT	Respiratory Muscle Training
SD	Standard Deviation
SEM	Standard Error of Measurement
SpO_2	Saturação Periférica de Oxigênio
TC6	Testes de Caminhada de Seis Minutos
TCLE	Termo de Consentimento Livre e Esclarecido
TMR	Treinamento Muscular Respiratório
UFMG	Universidade Federal de Minas Gerais
UPDRS	*Unified Parkinson's Disease Rating Scale*
6MWT	Six-Minute Walk Test

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PREFÁCIO

A presente tese foi elaborada conforme as normas do Colegiado do Programa de Pós-Graduação em Ciências da Reabilitação da Universidade Federal de Minas Gerais (UFMG) sob a orientação da professora doutora Christina Danielli Coelho de Morais Faria do Departamento de Fisioterapia da UFMG e coorientação da professora doutora Aline Alvim Scianni e da doutora Bruna Mara Franco Silveira.

Este trabalho foi desenvolvido como requisito parcial à obtenção do título de Doutor em Ciências da Reabilitação. O doutorado do Programa de Pós-Graduação em Ciências da Reabilitação da UFMG requer como obrigações o cumprimento de, no mínimo, 36 créditos acadêmicos, além da elaboração e desenvolvimento de uma tese, a produção de artigos científicos e a defesa oral da tese. Dessa forma, a fim de atender os critérios exigidos pelo programa, o desenvolvimento da presente tese envolveu duas fases distintas. A primeira, realizada durante os anos de 2020 a 2022, compreendeu o cumprimento dos créditos exigidos pelo programa (as disciplinas realizadas estão descritas no ANEXO A), além da elaboração do projeto de pesquisa e sua submissão ao Comitê de Ética e Pesquisa (ANEXOS B), aquisição de materiais, atualização bibliográfica e produção e publicação de artigos científicos. Já a segunda fase, realizada durante os anos de 2022 a 2024, compreendeu a produção e publicação de artigos científicos, coleta e processamento dos dados e elaboração da tese.

Para facilitar a compreensão dos achados da presente tese, esta foi estruturada em seis capítulos, conforme a descrição abaixo:

- **Capítulo 1:** Introdução, contemplando a contextualização da doença de Parkinson (DP), as disfunções respiratórias nessa população e seus impactos na saúde e qualidade de vida desses indivíduos, além de possíveis intervenções eficazes para esta condição, com ênfase no treinamento muscular respiratório (TMR). Este capítulo também compreende a justificativa e o objetivo do estudo.
- **Capítulo 2:** Refere-se ao primeiro e segundo artigos da tese, o protocolo da revisão sistemática conduzida com o objetivo de investigar as propriedades de medida (confiabilidade, validade e responsividade) e a utilidade clínica dos instrumentos de medida utilizadas na telerreabilitação em indivíduos com

condições neurológicas, incluindo indivíduos com DP, bem como a respectiva revisão sistemática. Nesta revisão, não foram encontrados instrumentos de medida com adequadas propriedades de medida para avaliar desfechos relacionados às funções respiratórias de indivíduos com DP por telerreabilitação. Esses achados foram fundamentais para determinar alguns procedimentos metodológicos do estudo principal, especialmente os métodos de mensuração dos desfechos. A ficha de avaliação utilizada para o desenvolvimento deste trabalho está em apêndice (APÊNDICE A). O protocolo foi publicado no periódico *Plos One* e a revisão sistemática no periódico *Clinical Rehabilitation*.

- Artigo 1 - BRITO SAF, SCIANNI AA, PENICHE PDC, FARIA CDCM. *Measurement properties of outcome measures used in neurological telerehabilitation: A systematic review protocol. PLoS One,* 17(3):e0265841, 2022.
- Artigo 2 - BRITO SAF, SCIANNI AA, PENICHE PDC, FARIA CDCM. *Measurement properties of outcome measures used in neurological telerehabilitation: A systematic review using COSMIN checklist. Clinical Rehabilitation*, 37(3):415-435, 2023.

- **Capítulo 3:** Contém a descrição detalhada dos materiais e métodos do estudo principal desta tese, um ensaio clínico aleatorizado, que investigou os efeitos de um programa domiciliar de TMR (inspiratório e expiratório realizados simultaneamente) de alta intensidade em indivíduos com DP. Além disso, compreende o terceiro artigo desta tese, o protocolo do ensaio clínico publicado no periódico *Plos One*.
  - Artigo 3 - BRITO SAF, SCIANNI AA, SILVEIRA BMF, OLIVEIRA ERM, MATEUS ME, FARIA CDCM. *Effects of high-intensity respiratory muscle training on respiratory muscle strength in individuals with Parkinson's disease: Protocol of a randomized clinical trial. PLoS One,* 18(9):e0291051, 2023.
- **Capítulo 4:** Compreende o quarto artigo desta tese, o ensaio clínico aleatorizado, a ser submetido ao periódico *Physioterapy*.
  - Artigo 4 - *High-intensity combined inspiratory and expiratory training increases respiratory muscle strength in Parkinson's disease: a randomized clinical trial.*

- **Capítulo 5:** Compreende o quinto artigo desta tese que investigou as perspectivas, autoeficácia, facilitadores e barreiras ao TMR domiciliar, a ser submetido ao *Journal of Neurologic Physical Therapy*.
    - Artigo 5 - *Perspectives, self-efficacy, barriers and facilitators to home-based respiratory training in Parkinson Disease*
- **Capitulo 6:** Contém as considerações finais da tese, especificamente as implicações clínicas e limitações do estudo.

Além disso, foi desenvolvido um artigo (ANEXO C) com resultados secundários obtidos com os participantes do estudo principal desta tese, cujo objetivo foi investigar a validade da aplicação por telefone Escala de Severidade da Fadiga (FSS) e da escala de dispneia do *Medical Research Council* (MRC) em indivíduos com DP:

- BRITO SAF, SCIANNI AA, MENEZES KKP, SCALDAFERRI MEF, MAGALHÃES JP, FARIA CDCM. *Telephone-based assessment of fatigue and dyspnea in individuals with Parkinson's disease.* Artigo submetido à *Disability and Rehabilitation*.

Outro estudo foi desenvolvido como trabalho de conclusão de curso de graduação de uma estudante bolsista de iniciação científica que auxiliou nas coletas de dados do projeto de pesquisa relacionado a esta tese. Este trabalho foi coorientado pela doutoranda e já foi finalizado.

Trabalho de Conclusão de curso da estudante de graduação Élem Rodrigues Martins de Oliveira. *"Validade da Aplicação por Telefone da Versão Brasileira do Parkinson's Disease Questionnaire-39 (PDQ-39) para Avaliar a Qualidade de Vida de Indivíduos com Doença de Parkinson"*. Este trabalho será organizado como artigo científico e submetido para a publicação em 2025.

As referências bibliográficas utilizadas, as quais estão de acordo com as normas da Associação Brasileira de Normas Técnicas (ABNT NBR 14724:2005), estão incluídas ao final da tese, juntamente com os apêndices e anexos desenvolvidos/utilizados.

Ao final da tese, há o mini-currículo da doutoranda, com a descrição das atividades acadêmicas e produção científica durante o período de doutoramento. Além dos artigos científicos, os resultados parciais do estudo foram apresentados em vários eventos científicos e publicados nos anais dos respectivos eventos.

CAPÍTULO 1

INTRODUÇÃO

1 INTRODUÇÃO

1.1 Doença de Parkinson

As doenças neurológicas estão entre as principais causas de incapacidades no mundo (Ferrari *et al.*, 2024). A doença de Parkinson (DP) é a segunda doença neurodegenerativa mais prevalente e com maiores anos de vida ajustados por incapacidade (DALYs), ficando atrás apenas da doença de Alzheimer (Steinmetz *et al.*, 2024). Entre as doenças analisadas pelo *Global Burden of Diseases, Injuries and Risk Factors Study*, a DP apresentou o maior crescimento em prevalência, incapacidade e mortalidade (Feigin *et al.*, 2017). No período de 1990 a 2019, houve um aumento de mais de 150% na prevalência e incidência da DP (Ou *et al.*, 2021), estimado-se que aproximadamente 8 milhões de pessoas no mundo tenham DP (Ou *et al.*, 2021). Entretanto, esses números podem estar subestimados devido à escassez de dados oficiais sobre a incidência e prevalência da DP em muitos países, especialmente nos países subdesenvolvidos e em desenvolvimento (Ou *et al.*, 2021), como o Brasil.

Um estudo realizado em populações rurais e urbanas de países da América Latina apontou uma prevalência de 2% de DP entre indivíduos idosos (Llibre-Guerra *et al.*, 2022). Segundo o Instituto Brasileiro de Geografia e Estatística (IBGE), há aproximadamente 32 milhões de idosos no Brasil (Instituto Brasileiro de Geografia e Estatística, 2022). Se a prevalência encontrada nesse estudo for extrapolada para a população de idosos do Brasil, projeta-se que aproximadamente um 640 mil de brasileiros tenham DP. Além disso, projeções indicam que a incidência global da DP ainda irá aumentar (Dorsey *et al.*, 2018; Ou *et al.*, 2021). Conforme evidenciado por esses números expressivos, a DP impõe uma carga substancial, contribuindo para 3,2 milhões de DALYs, um número que aumentou 2,5 vezes entre 1990 e 2016 (Feigin *et al.*, 2020).

O aumento na prevalência de DP, bem como nos DALYs, foi mais acentuado em países com Índice Sociodemográfico médio (Feigin *et al.*, 2020; Ou *et al.*, 2021), como o Brasil. No que se refere à carga humanística, um estudo multinacional que analisou os dados de 2017 a 2022 encontrou que aproximadamente 40% dos cuidadores de indivíduos com DP em estágio inicial a intermediário relatam uma carga moderada a grave (Chaudhuri *et al.*, 2024). Por fim, no que concerne à carga econômica, os custos médios anuais aumentaram aproximadamente de duas a três vezes em indivíduos com doença avançada nos Estados Unidos e na Europa em comparação com aqueles com doença intermediária (Chaudhuri *et al.*, 2024). Além disso, o custo do uso de recursos em indivíduos com doença avançada foi

consistentemente alto em todos os países analisados (Chaudhuri *et al.*, 2024). No Brasil, estima-se que o custo médio anual da DP no estágio inicial é de US$2.538,05, sendo que esse valor é praticamente duplicado nos estágios mais avançados (Bovolenta *et al.*, 2023).

A neuropatologia da DP é multifatorial e heterogênea, mas há alguns marcos patológicos da doença (Mcgregor; Nelson, 2019). Um marco neuropatológico da DP é a presença de inclusões intracelulares conhecidas como corpos de Lewy, decorrentes da agregação da proteína α-sinucleína (Morris; Spillantini; Sue; Williams-Gray, 2024). O local mais conhecido de deposição dos corpos de Lewy e de neurodegeneração é o mesencéfalo, especificamente nos neurônios dopaminérgicos da substância negra, parte compacta, e, em menor intensidade, na área tegmentar ventral (Morris; Spillantini; Sue; Williams-Gray, 2024). Com a perda de neurônios dopaminérgicos na parte compacta da substância negra, ocorre a diminuição da dopamina em todo o sistema nigroestriatal que possui importantes funções, como controlar os movimentos voluntários, preparação de programas motores e na execução automática de programas motores já aprendidos (Kalia; Lang, 2015; Machado; Haertel, 2022).

Além disso, estudos indicam a ocorrência de degeneração em outras áreas do tronco encefálico (Morris; Spillantini; Sue; Williams-Gray, 2024; Sun *et al.*, 2023; Zhou *et al.*, 2021). Por exemplo, de acordo com o modelo proposto por Braak *et al.* (2003), nos estágios iniciais da DP observa-se o comprometimento do núcleo motor dorsal do vago, formação reticular, núcleo caudal da rafe e o *locus coeruleus/ subcoeruleus* (Morris; Spillantini; Sue; Williams-Gray, 2024; Sun *et al.*, 2023; Zhou *et al.*, 2021). Ademais, estudos têm demonstrado que indivíduos com DP apresentam alterações em outros sistemas à medida que a doença progride, como as projeções colinérgicas, serotoninérgicas e noradrenérgicas (Mcgregor; Nelson, 2019; Schapira; Chaudhuri; Jenner, 2017). Por fim, também ocorre ocomprometimento do sistema nervoso autônomo (Conti *et al.*, 2024), sendo estudada a hipótese de que a agregação de α-sinucleína tem início no intestino e é transportada através do nervo vago para o núcleo motor dorsal do vago no tronco cerebral (Chandra *et al.* 2017).

A DP apresenta três sinais motores clássicos, também conhecidos como sinais cardinais: bradicinesia, tremor de repouso e rigidez (Postuma *et al.*, 2015; Morris; Spillantini; Sue; Williams-Gray, 2024). Essas características motoras têm apresentação heterogênea entre os indivíduos com DP. Em geral, são observados dois subtipos principais: tremor dominante e rígido-acinético (Kalia; Lang, 2015). Além disso, conforme previamente discutido, a DP também afeta outros sistemas e, consequentemente, ocasiona várias incapacidades não motoras, como alterações ventilatórias e respiratórias, déficits cognitivos, fadiga, disfunção autonômica, distúrbios do sono, alterações gastrointestinais, dentre outras (Kalia; Lang,

2015). Esses sintomas não motores podem se manifestar vários anos antes dos sintomas motores, na fase conhecida como pré-motora ou prodrômica, e estão associados à redução da qualidade de vida relacionada à saúde (Kalia; Lang, 2015). Além disso, é comum que indivíduos com DP experimentem flutuações no controle dos sintomas devido ao uso de medicação, um fenômeno conhecido como efeito "ON-OFF". O período "ON" corresponde à fase em que os sintomas da doença estão controlados pelo uso da medicação, enquanto o "OFF" refere-se à piora dos sintomas, resultante da redução ou ausência do efeito da medicação (Chou *et al.*, 2018).

A Classificação Internacional de Funcionalidade, Incapacidade e Saúde (CIF) (Organização Mundial de Saúde; Organização Pan-Americana de Saúde, 2003) apresenta uma estrutura utilizada tanto para descrever a funcionalidade quanto para orientar o estabelecimento de metas terapêuticas e planos de intervenção, sendo mundialmente utilizada em indivíduos com DP. Em um estudo conduzido por Raggi *et al.* (2011), indivíduos com DP reportaram deficiências em estruturas e funções corporais, como nas funções de força e do tônus muscular, além de limitações de atividade e restrições na participação social, como dificuldades durante a caminhada e restrição para utilizar meios de transporte (Raggi *et al.*, 2011). Além disso, esses indivíduos identificaram a presença de fatores ambientais que foram qualificados como barreiras ou facilitadores, como as atitudes individuais de membros da família e os sistemas e políticas dos serviços de seguridade social (Raggi *et al.*, 2011).

1.2 Disfunções Respiratórias na Doença de Parkinson

Disfunções respiratórias são alterações não motoras importantes e comumente observadas em indivíduos com DP. Essas disfunções estão entre as principais causas de internações hospitalares e morte nessa população, e estão associadas ao aumento do tempo de internação e dos custos de saúde, bem como com resultados hospitalares desfavoráveis (Bäckström *et al.*, 2018; Shaibdat; Ahmad; Azmin; Ibrahim, 2023). Além disso, em estudos prévios, foi constatado que as infecções respiratórias foram a principal causa de hospitalização no período analisado, enquanto a pneumonia por aspiração foi a principal causa de morte nessa população (Bäckström *et al.*, 2018; Shaibdat; Ahmad; Azmin; Ibrahim, 2023).

Acredita-se que a prevalência das disfunções respiratórias na DP ainda seja subestimada, além de ser bastante variável. Uma revisão de literatura apontou que a prevalência dos distúrbios restritivos em indivíduos com DP variou de 28% a 94%, e a dos distúrbios obstrutivos variou de 6,7% a 67% (D'Arrigo *et al.*, 2020). A fisiopatologia das disfunções respiratórias na DP ainda é incerta. Mecanismos biomecânicos, neurológicos e sensoriais parecem estar associados às alterações respiratórias encontradas nesses indivíduos. Algumas características biomecânicas inerentes à DP, como alterações posturais e rigidez na musculatura torácica, redução da mobilidade torácica (Docu Axelerad *et al.*, 2021), e alterações na ativação e coordenação da musculatura das vias aéreas superiores (Monteiro *et al.*, 2014; Docu Axelerad *et al.*, 2021), podem estar relacionadas às disfunções respiratórias encontradas nesses indivíduos. Além disso, o tremor, a bradicinesia e a discinesia induzida por levodopa podem comprometer a função respiratória nessa população (Docu Axelerad *et al.*, 2021).

Alterações neuropatológicas também foram associadas às disfunções respiratórias observadas em indivíduos com DP. Conforme descrito anteriormente, uma das características neuropatológicas da DP é a depleção de neurônios dopaminérgicos localizados na substância negra do mesencéfalo (Morris; Spillantini; Sue; Williams-Gray, 2024). Essa destruição neuronal ocorre também em outras áreas do encéfalo, como nos núcleos do tronco cerebral que controlam o sono e a respiração. Durante a evolução da doença, ocorre a agregação da proteína α-sinucleína no bulbo e nos centros respiratórios que participam da coordenação respiratória e da identificação de hipoxemia periférica ou hipercapnia (Docu Axelerad *et al.*, 2021). Por fim, Lee *et al.* (2018) investigaram a relação entre o volume de massa cinzenta e disfunção respiratória em indivíduos com DP, e relataram que aqueles com função pulmonar anormal apresentavam menor volume de massa cinzenta em várias regiões do cérebro, incluindo a formação para-hipocampal esquerda, o giro fusiforme direito, o cisto cerebelar direito e os giros pós-central esquerdo (Lee *et al.*, 2018).

Estudos já demonstraram que indivíduos com DP apresentam redução da função pulmonar (capacidade vital, capacidade vital forçada, volume total da parede torácica e volume expiratório forçado em 1 s durante as fases ON da medicação), aumento da frequência respiratória durante as fases OFF, bem como alteração da cinemática da caixa torácica, sensibilidade laríngea reduzida e reflexo de tosse comprometido (Ebihara *et al.*, 2003; Mcmahon; Blake; Lennon, 2023; Pitts *et al.*, 2008). Além disso, uma revisão sistemática com metanálise recente constatou que indivíduos com DP apresentam fraqueza dos músculos respiratórios e tosse ineficaz (Mcmahon; Blake; Lennon, 2023).

Embora a disfunção respiratória seja frequente e potencialmente grave, ela pode não ser observada precocemente devido ao reduzido nível de atividade física dos indivíduos com DP (Haas; Trew; Castle, 2004; Van Nimwegen *et al.*, 2011). Com o declínio do nível de atividade física, esses indivíduos podem não realizar atividades que demandem um gasto energético suficiente para provocar adaptações respiratórias que revelem a disfunção respiratória (Van Nimwegen *et al.*, 2011). Por isso, as abordagens voltadas para a melhora desses desfechos frequentemente são iniciadas em fases mais avançadas da doença.

A fraqueza dos músculos respiratórios é uma disfunção respiratória que pode estar presente já nos estágios iniciais da DP (Baille *et al.*, 2016; Baille *et al.*, 2019; Santos *et al.,* 2019), e que se intensifica com a progressão da doença (Santos *et al.,* 2019). Guedes *et al.* (2012) investigaram a pressão inspiratória máxima (PImáx) e a pressão expiratória máxima (PEmáx) em indivíduos com DP durante os períodos de uso e não uso de levodopa e compararam com indivíduos controles saudáveis pareados quanto ao sexo e idade (Guedes *et al.*, 2012). Foram encontrados valores das pressões respiratórias máximas significativamente menores em indivíduos com DP (PImáx homens = 65,0 ± 17,9 cmH_2O; PImáx mulheres = 55,6 ± 18,8 cmH_2O; PEmáx homens = 81,9 ± 14,7 cmH_2O; PEmáx mulheres = 64,4 ± 21,9 cmH_2O) quando comparados a indivíduos saudáveis (PImáx homens = 86,9 ± 6,2 cmH_2O; PImáx mulheres = 70,0 ± 14,1 cmH_2O; PEmáx homens = 120,0 ± 29,4 cmH_2O; PEmáx mulheres = 105,6 ± 19,4 cmH_2O) (Guedes *et al.*, 2012). Santos *et al.* (2019) avaliaram a função pulmonar e força muscular respiratória em diferentes estágios da DP e compararam a de indivíduos saudáveis pareados (Santos *et al.,* 2019). Foi encontrada uma redução significativa desses desfechos em todas as fases da DP, e a força muscular respiratória diminuiu com a progressão da doença (Santos *et al.,* 2019). Além disso, foi observada uma correlação significativa entre algumas variáveis da função pulmonar e os sinais cardinais da DP (tremor de repouso, rigidez e bradicinesia). Por fim, foi reportada, também, uma correlação positiva entre a força muscular respiratória e a qualidade de vida nesses indivíduos (Santos *et al.,* 2019).

Como descrito anteriormente, indivíduos com DP podem apresentar redução da força muscular tanto da musculatura inspiratória quanto expiratória (Baille *et al.*, 2016; Mcmahon; Blake; Lennon, 2023; Santos *et al.,* 2019). Ambos os grupos musculares desempenham um importante papel para a manutenção de uma função respiratória adequada, sendo que a fraqueza desses músculos tem muitos impactos na saúde, funcionalidade e qualidade de vida desses indivíduos (Gea *et al.*, 2012; Laghi; Tobin, 2003; Rodríguez; Crespo; Del Valle; Olmedillas, 2020; Santos *et al.*, 2019). A fraqueza muscular inspiratória predispõe à

ocorrência de dispneia, redução da capacidade funcional, baixa tolerância ao exercício (Gea *et al.*, 2012; Laghi; Tobin, 2003), surgimento de atelectasias e retenção de secreções, o que é um importante fator de risco para infecções (Sapienza; Troche; Pitts; Davenport, 2011). Por sua vez, na presença de fraqueza muscular expiratória, há um aumento do risco de acúmulo de secreções e desenvolvimento de complicações respiratórias (Francesco *et al.*, 2019; Bolser; Davenport, 2002; Fontana; Lavorini, 2006), como pneumonia. Isso é especialmente importante em indivíduos com DP, uma vez que a pneumonia é a principal causa de morte nesses indivíduos (Bäckström *et al.*, 2018). Por fim, a fraqueza muscular inspiratória e expiratória estão associadas à ocorrência de fadiga e à redução da qualidade de vida nessa população (Santos *et al.*, 2019; Van de Wetering-Van Dongen *et al.*, 2022). Nesse cenário, observa-se que tanto a força muscular inspiratória quanto expiratória deve ser avaliada em indivíduos com DP e, quando detectada fraqueza muscular, intervenções voltadas para o aumento da força de ambos os grupos musculares devem ser realizadas.

1.3 Treinamento Muscular Respiratório

Devido ao impacto negativo da fraqueza muscular respiratória na saúde (Bäckström *et al.*, 2018; Shaibdat; Ahmad; Azmin; Ibrahim, 2023), na funcionalidade (Gea *et al.*, 2012; Haas; Trew; Castle, 2004; Laghi; Tobin, 2003) e na qualidade de vida (Santos *et al.*, 2019) de indivíduos com DP, diversas abordagens terapêuticas têm sido utilizadas com o objetivo de aumentar a força muscular respiratória nesses indivíduos (Mcmahon; Blake; Lennon, 2020). Uma revisão sistemática com metanálise, conduzida por Mcmahon, Blake e Lennon (2020), teve como objetivo avaliar os efeitos de intervenções não farmacológicas na função respiratória de indivíduos com DP (Mcmahon; Blake; Lennon, 2020). Nesta revisão, foram incluídos estudos que avaliaram os efeitos de intervenções globais, como exercício aeróbico, yoga, ciclismo, fortalecimento muscular periférico e treinamento específico da musculatura respiratória (fortalecimento muscular inspiratório ou expiratório realizados isoladamente) (Mcmahon; Blake; Lennon, 2020). Os resultados da metanálise apontaram que as intervenções não farmacológicas promoveram um aumento estatisticamente significativo na força muscular respiratória e no pico de fluxo expiratório (Mcmahon; Blake; Lennon, 2020). Além disso, foram incluídos estudos que demonstraram que o treinamento muscular respiratório (TMR) aumentou significativamente o pico de fluxo da tosse e reduziu a dispneia,

mas, devido à heterogeneidade dos dados, não foi possível realizar a metanálise envolvendo esses desfechos (Mcmahon; Blake; Lennon, 2020).

O TMR é uma intervenção não farmacológica amplamente utilizada em outras populações com o objetivo de melhorar a força muscular respiratória e outros desfechos associados, como pico de fluxo da tosse e dispneia. Revisões sistemáticas já demonstraram que o treinamento específico da musculatura respiratória é eficaz para o aumento da força e *endurance* muscular inspiratória, da função respiratória e da capacidade de exercício em indivíduos com diversas condições de saúde, como doença pulmonar obstrutiva crônica (Huang *et al.*, 2024) e insuficiência cardíaca (Azambuja; de Oliveira; Sbruzzi, 2020), além de indivíduos com outras condições neurológicas, como pós-acidente vascular encefálico (Liu *et al.*, 2024), lesão medular (Lemos *et al.*, 2020) e esclerose múltipla (Templeman; Roberts, 2020).

Uma revisão sistemática de ensaios clínicos aleatorizados (ECA) foi desenvolvida com o objetivo de investigar os efeitos do TMR na função respiratória de indivíduos com DP (Rodríguez; Crespo; Del Valle; Olmedillas, 2020). Foram incluídos apenas cinco estudos provenientes de três ECA distintos. Desses cinco estudos, um investigou o efeito do treinamento muscular inspiratório na força muscular inspiratória, *endurance* muscular respiratória, dispneia e qualidade de vida (Inzelberg *et al.*, 2005). Dois estudos, provenientes de um único ECA, avaliaram o efeito do treinamento muscular expiratório na deglutição (Troche *et al.*, 2010), força muscular expiratória e função pulmonar (Sapienza; Troche; Pitts; Davenport, 2011). Finalmente, outros dois estudos, provenientes de um único ECA, compararam os efeitos de um programa de treinamento muscular inspiratório versus expiratório na força muscular inspiratória, expiratória, no pico de fluxo de tosse voluntário e em parâmetros fonatórios (Reyes; Castillo; Castillo; Cornejo, 2018; Reyes *et al.*, 2019). Os resultados dessa revisão sistemática demonstraram que o TMR pode ser uma abordagem eficaz para melhorar a força e a *endurance* muscular inspiratória, a função pulmonar e de deglutição, a dispneia e os parâmetros fonatórios em indivíduos com DP, considerando os diferentes protocolos utilizados pelos estudos (Rodríguez; Crespo; Del Valle; Olmedillas, 2020). No entanto, foi constatado que existe um número pequeno de estudos que investigaram os efeitos do TMR na função respiratória de indivíduos com DP (apenas três ECA), e que os estudos existentes apresentam qualidade metodológica moderada e heterogeneidade em suas medidas de resultados, o que impossibilitou a condução de uma metanálise (Rodríguez; Crespo; Del Valle; Olmedillas, 2020). Portanto, os autores concluíram que as evidências são

limitadas para qualquer recomendação para a prática clínica, sugerindo a realização de novos ECA (Rodríguez; Crespo; Del Valle; Olmedillas, 2020).

Não foram encontrados estudos que investigassem o efeito do TMR na fadiga e na capacidade de exercício de indivíduos com DP. A fraqueza dos músculos respiratórios está associada à fadiga e predispõe à baixa capacidade de exercício, sintomas altamente prevalentes e frequentemente incapacitantes nesta população (Garber; Friedman, 2003; Pechstein; Gollie; Guccionem, 2020; Siciliano *et al.*, 2018). Em indivíduos pós-acidente vascular encefálico, já foi demonstrado que o TMR melhora significativamente esses desfechos (Sutbeyaz; Koseoglu; Inan; Coskun, 2010). Portanto, é possível que o TMR também apresente resultados similares em indivíduos com DP.

Os músculos respiratórios são músculos esqueléticos e, portanto, o treinamento dessa musculatura deve seguir os mesmos princípios do treinamento de músculos esqueléticos periféricos. De acordo com o princípio da especificidade do exercício, o treinamento focado no grupo muscular alvo é o ideal para promover adaptações nesse músculo (Kasper; Korey, 2019). Considerando que indivíduos com DP podem apresentar fraqueza tanto da musculatura inspiratória quanto expiratória (Mcmahon; Blake; Lennon, 2023), e que ambos os grupos musculares são essenciais para a manutenção de uma função respiratória adequada (Gea *et al.*, 2012; Laghi *et al.*, 2003; van de Wetering-van Dongen *et al.*, 2022), é importante que o treinamento de ambos os grupos seja realizado nessa população.

O treinamento combinado da musculatura inspiratória e expiratória oferece diversas vantagens, como a redução do tempo necessário para o treino, quando comparado ao treinamento isolado (primeiro inspiratório, depois expiratório ou vice-versa); maior acessibilidade, já que pode ser realizado com um único dispositivo; e maior facilidade de execução. Além disso, o treinamento simultâneo da musculatura inspiratória e expiratória pode potencializar os efeitos do treinamento (Xu *et al.*, 2018). Por exemplo, em um ECA foram comparados diferentes protocolos de TMR em indivíduos com doença pulmonar obstrutiva crônica. Foi observado que os programas que combinaram o treinamento das musculaturas inspiratória e expiratória resultaram em maiores benefícios em comparação ao treinamento isolado da musculatura inspiratória (Xu *et al.*, 2018).

Ademais, uma possível razão para a falta de efeitos significativos observados em alguns desfechos investigados nos ECA sobre o TMR na DP pode ser a progressão inadequada da carga, duração insuficiente do treinamento e/ou baixa frequência de treinamento (Dankel *et al.*, 2017; Kasper; Korey, 2019). Seguindo o princípio da sobrecarga,

os resultados do TMR podem ser potencializados com o aumento do volume de treinamento, o que inclui maior carga, duração e frequência (Dankel *et al.*, 2017; Kasper; Korey, 2019).

Por fim, o TMR é geralmente realizado várias vezes por semana (5 a 6 vezes), sendo frequentemente conduzido em domicílio (Rodríguez; Crespo; Del Valle; Olmedillas, 2020). Essa é uma vantagem significativa desse tipo de treinamento, pois reduz as dificuldades relacionadas ao transporte e à necessidade de um acompanhante com disponibilidade de tempo, aumenta a flexibilidade de horários para a realização dos exercícios, elimina o tempo gasto em deslocamentos, diminui o desconforto que alguns participantes sentem ao praticar exercícios em grupo e pode oferecer um melhor custo-benefício (Schootemeijer *et al.*, 2020). Isso é especialmente relevante para indivíduos com DP, que frequentemente apresentam diversas incapacidades que impactam significativamente sua capacidade de locomoção (Machado; Haertel, 2022; Morris; Spillantini; Sue; Williams-Gray, 2024). No entanto, as demandas do treinamento combinado de alta intensidade dos músculos inspiratórios e expiratórios podem tornar a execução em domicílio mais desafiadora. Portanto, é essencial explorar os efeitos do treinamento combinado de alta intensidade dos músculos inspiratórios e expiratórios em domicílio nessa população e identificar as barreiras e facilitadores associados a esta proposta de intervenção.

Conforme apresentado, há uma escassez na literatura científica de estudos com adequada qualidade metodológica sobre a eficácia de um programa domiciliar de TMR (inspiratório e expiratório realizados simultaneamente) de alta intensidade em indivíduos com DP, e, portanto, dados insuficientes para a elaboração de recomendações robustas para a prática clínica. Além disso, não foram encontrados estudos que investigassem a eficácia de um programa domiciliar realizando simultaneamente o treinamento inspiratório e expiratório nessa população. Da mesma forma, não foram encontrados estudos que avaliassem o impacto dessa intervenção em desfechos importantes, como fadiga e capacidade de exercício, que têm potencial para serem melhorados pelo TMR nesses indivíduos. Por fim, para a adequada implementação do TMR, diversos fatores devem ser considerados, como as percepções dos indivíduos, a autoeficácia em relação ao exercício, bem como as barreiras e facilitadores ao treinamento. No entanto, não foram identificados estudos que tenham explorado esses aspectos especificamente no contexto do TMR em indivíduos com DP.

2 JUSTIFICATIVA

Indivíduos com DP apresentam redução da força muscular inspiratória e expiratória, da resistência muscular respiratória e do pico de fluxo da tosse (Ebihara *et al.*, 2003; Mcmahon; Blake; Lennon, 2023; Pitts *et al.*, 2008), além de dispneia (Baille *et al.*, 2019) e fadiga (Santos *et al.*, 2019; Van de Wetering-Van Dongen *et al.*, 2022). Essas incapacidades já foram demonstradas em diversos estudos ao longo das últimas décadas (Baille *et al.*, 2019; Ebihara *et al.*, 2003; Mcmahon; Blake; Lennon, 2023; Pitts *et al.*, 2008; Santos *et al.*, 2019; Van de Wetering-Van Dongen *et al.*, 2022). Existem evidências consistentes sobre a eficácia do TMR para melhorar esses desfechos em várias populações, como indivíduos com condições respiratórias e cardíacas (Azambuja; de Oliveira; Sbruzzi, 2020; Huang *et al.*, 2024). No entanto, ainda são poucos os estudos de boa qualidade metodológica voltados para essa temática em indivíduos com DP, sendo insuficientes para elaborar recomendações robustas para prática clínica (Mcmahon; Blake; Lennon, 2020; Rodríguez; Crespo; Del Valle; Olmedillas, 2020). Esse cenário é ainda mais inquietante quando se considera que as disfunções respiratórias estão entre as principais causas de internação hospitalar e morte em indivíduos com DP, além de serem associados ao aumento do tempo de internação, resultados hospitalares desfavoráveis e elevados custos de saúde (Bäckström *et al.*, 2018; Shaibdat; Ahmad; Azmin; Ibrahim, 2023). A pneumonia, em particular, é a principal causa de morte nessa população (Bäckström *et al.*, 2018; Shaibdat; Ahmad; Azmin; Ibrahim, 2023).

Estudos têm demonstrado que a realização de um programa domiciliar de TMR (inspiratório e expiratório realizados simultaneamente) de alta intensidade pode ser uma estratégia ainda mais eficaz para indivíduos que apresentam redução de força muscular em ambos os grupos musculares (Menezes *et al.*, 2019; Xu *et al.*, 2018). Esse tipo de treinamento também oferece diversas vantagens, como a redução do tempo necessário para o treino, quando comparado ao treinamento isolado (primeiro inspiratório, depois expiratório ou vice-versa); maior acessibilidade, já que pode ser realizado com um único dispositivo; e maior facilidade de execução. No entanto, em condições neurológicas há uma escassez de pesquisas sobre esta temática e não foram encontrados estudos que tenham investigado os efeitos desse tipo de treinamento em indivíduos com DP (Mcmahon; Blake; Lennon, 2020; Rodríguez; Crespo; Del Valle; Olmedillas, 2020).

Além disso, uma possível razão para a falta de efeitos significativos observados em alguns desfechos já investigados nos ECA sobre o TMR na DP pode ser a progressão

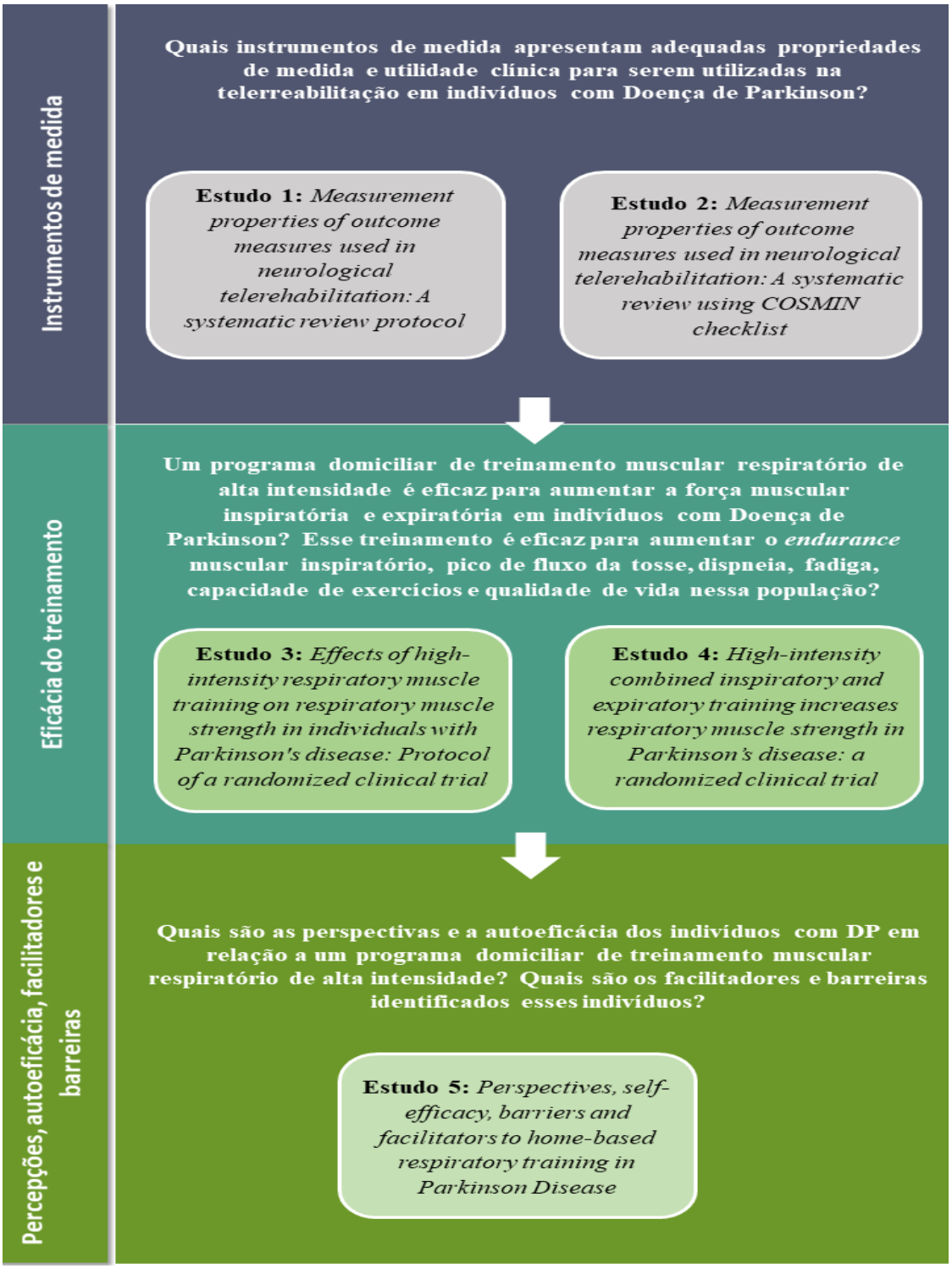
inadequada da carga, duração insuficiente do treinamento e/ou baixa frequência de treinamento (Dankel *et al.*, 2017; Kasper; Korey, 2019). Portanto, faz-se necessária a condução de ECA utilizando maiores volumes de treinamento (carga, duração e frequência) (Dankel *et al.*, 2017; Kasper; Korey, 2019).

Como previamente mencionado, o TMR é realizado várias vezes por semana (5 a 6 vezes) e, por isso, é comumente conduzido no ambiente domiciliar (Rodríguez; Crespo; Del Valle; Olmedillas, 2020). Isso é particularmente relevante para indivíduos com DP, que frequentemente apresentam várias incapacidades que afetam sua capacidade de locomoção. Contudo, a avaliação do TMR geralmente requer a presença física dos indivíduos, o que implica em deslocamentos (Machado; Haertel, 2022; Morris; Spillantini; Sue; Williams-Gray, 2024). A realização dessas avaliações de forma remota, utilizando a telerreabilitação, pode ser uma estratégia importante para aumentar a viabilidade do treinamento. No entanto, é essencial utilizar ferramentas de medida que apresentem adequadas propriedades de medida (confiabilidade, validade e responsividade) para uso por telerreabilitação nessa população, bem como que possuam utilidade clínica (Brito *et al.*, 2023).

Por fim, diversos fatores podem influenciar a implementação de um programa de treinamento, como as percepções dos indivíduos, sua autoeficácia, além dos facilitadores e barreiras ao exercício (Schootemeijer *et al.*, 2020). A adesão a longo prazo ao exercício só pode ser alcançada quando os indivíduos possuem uma visão positiva sobre o treinamento, elevada autoeficácia, e quando os facilitadores e barreiras são cuidadosamente considerados (Schootemeijer *et al.*, 2020). Contudo, não foram encontrados estudos que tenham investigado as percepções e a autoeficácia, ou que tenham identificado os facilitadores e barreiras relacionados a um programa domiciliar de TMR em indivíduos com DP.

Esses argumentos reforçam a importância dos estudos apresentados nesta tese. A seguir, será apresentado um fluxograma que ilustra o raciocínio utilizado no desenvolvimento de cada um desses estudos, com o objetivo de facilitar a compreensão da sequência dos artigos abordados (Figura 1).

Figura 1. Representação esquemática do racional utilizado no desenvolvimento de cada um dos estudos desta tese



Fonte: elaborada pelo próprio autor

3 OBJETIVOS

Objetivo geral: Investigar os efeitos de um programa domiciliar de TMR (inspiratório e expiratório realizados simultaneamente) de alta intensidade na força muscular inspiratória e expiratória em indivíduos com DP.

Objetivos específicos:

- Investigar as propriedades de medida (confiabilidade, validade e responsividade) e a utilidade clínica das ferramentas de medida utilizadas na telerreabilitação em indivíduos com condições neurológicas, incluindo a DP (**Artigos 1 e 2**);
- Avaliar se um programa domiciliar de TMR (inspiratório e expiratório realizados simultaneamente) de alta intensidade é eficaz para melhorar a força muscular inspiratória e expiratória, resistência muscular inspiratória, pico de fluxo da tosse, dispneia, fadiga, capacidade de exercícios e qualidade de vida de indivíduos com DP (**Artigos 3 e 4**).
- Investigar as perspectivas, autoeficácia, facilitadores e barreiras a um programa domiciliar de TMR em indivíduos com DP (**Artigo 5**).

CAPÍTULO 2

ARTIGOS 1 E 2

PLOS ONE

STUDY PROTOCOL

Measurement properties of outcome measures used in neurological telerehabilitation: A systematic review protocol

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Abstract

Several measurement tools commonly used in face-to-face neurological rehabilitation have been used in telerehabilitation. However, it is not known whether these tools have adequate measurement properties and clinical utility. This systematic review aims to investigate the measurement properties and the clinical utility of measurement tools used in telerehabilitation in individuals with neurological diseases. A systematic review to investigate the measurement properties and clinical utility of measurement tools used in telerehabilitation in individuals with neurological conditions will be conducted. This systematic review will follow the Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) statement. this systematic review protocol was registered in the International Prospective Register of Systematic Reviews (PROSPERO) on 28 May 2021 (registration number: CRD42021257662). Electronic searches will be performed in following databases: Medical Literature Analysis and Retrieval System Online (MEDLINE Ovid), Excerpta Medica Database (Embase Classic + Embase Ovid), Physiotherapy Evidence Database (PEDro), Scientific Electronic Library Online (Scielo), and Literatura Latino-Americana e do Caribe em Ciências da Saúde (LILACS). Two trained independent reviewers will select the studies according to the inclusion criteria, and will also extract the data, evaluate the clinical utility and methodological quality. The relevant data such as design, participants, settings, and mode of administration, measurement properties, and clinical utility will be summarized. Disagreements between reviewers will be resolved by consensus or by the decision of a third independent reviewer. Hand searches of other relevant studies will be employed. The COnsensus-based Standards for the selection of health Measurement Instruments (COSMIN) checklist and the clinical utility scale will be used to assess the methodological quality and clinical utility of these tools, respectively. This systematic review will provide information regarding the measurement properties and the clinical utility of the measurement tools used in neurological telerehabilitation. This information will be useful to assist health professionals in choosing adequate measurement tools and planning new research studies.

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Introduction

Neurological conditions have a high prevalence and incidence [1]. These disorders are the leading cause of disabilities and the second biggest cause of death worldwide [1]. From 1990 to 2016, the disabilities and deaths caused by neurological conditions increased approximately 39% and 15%, respectively [1]. It leads to impairments, activity limitations, and participation restrictions [2], as well as negative impacts on the quality of life [3–6]. This makes these individuals commonly in need of rehabilitation services. According to Cieza et al. 2021, neurological conditions were one of the largest determinants of the need for rehabilitation [7]. However, they usually face barriers to access the rehabilitation centers, such as transport problems, lack of a caregiver, high costs, among others [8–10]. In contexts as the COVID-19 pandemic, these barriers may be even greater, as social distancing is recommended to avoid the spread of the virus [11]. Therefore, telerehabilitation has been an innovative alternative to delivery rehabilitation services.

Telerehabilitation can be defined as the remote delivery of rehabilitation services using information and communication technologies, such as telephone, videoconferencing, and sensors [12]. Telerehabilitation sessions can be used to assess, goal-setting, intervention, education, and monitoring [2]. The use of telerehabilitation has increased over time as technologies become increasingly prevalent and easily accessible [12].

Telerehabilitation has several benefits, such as easier access, can be carried out at the individual's home, does not require transportation [13], and has a lower cost when compared to face-to-face rehabilitation [14–16]. In recent years, the use of telerehabilitation has increased, mainly due to the development of new computer technologies and more advanced devices that allow long-distance communication [12, 16]. Moreover, during the COVID-19 pandemic, this strategy was even more widespread.

Recent systematic reviews assessed the effectiveness of telerehabilitation in individuals with neurological conditions [17–19]. In these reviews, various outcomes were investigated, and many measurement tools commonly applied in the face-to-face evaluation were used, such as Barthel Index, Berg Balance Scale, Fugl-Meyer Upper Extremity, Action Research Arm Test, and Stroke Impact Scale [17–19]. However, assessing remotely an individual can be challenging [20].

It is important to consider that the results of these measurement tools may be different when comparing telerehabilitation and face-to-face rehabilitation. The measurement tools commonly used in face-to-face rehabilitation may require adaptations for use in telerehabilitation [20]. For example, the Fulg-Meyer Scale [21] commonly used in the face-to-face evaluation of individuals after stroke can be a challenge to remote use [20]. In addition, communication, comprehension, and interaction are different remotely when compared to face-to-face [22]. All these factors can interfere with the measurements provided by the tools. Hence, it is important to establish the measurement properties of the measurement tools, when used in telerehabilitation. The choice of tools with adequate and accurate measurement properties is important to guarantee the quality and reliability of the results, both in research and in clinical practice [23].

As previously discussed, in recent years a wide range of studies have investigated the use of telerehabilitation, consequently, the number of studies investigating the measurement properties of these measurement tools has also increased [17–19, 22]. Systematic reviews are considered the best way to synthesize existing information and provide a comprehensive analysis of the full range of literature on a particular topic [23]. To our knowledge, no systematic review gathered information on the measurement properties and clinical utility of the measurement tools used in telerehabilitation in individuals with neurological conditions. Given the growth

of telerehabilitation in research and clinical practice [12, 16] and the challenges of using measurement tools in remote evaluation [20], a systematic review is necessary. Furthermore, this is an important source of information for researchers and professionals to choose measurement tools with adequate measurement properties and clinical utility. Therefore, this systematic review aims to investigate the measurement properties and the clinical utility of measurement tools used in telerehabilitation in individuals with neurological diseases.

Methods

This systematic review protocol was conducted following Preferred Reporting Items for Systematic Review and Meta-Analysis Protocols (PRISMA-P) [24, 25] and the systematic review results will be reported according to Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA 2020 statement) [26].

Study registration

According to PRISMA-P guidelines [24, 25], this systematic review protocol was registered in the International Prospective Register of Systematic Reviews (PROSPERO) on 28 May 2021 (registration number: CRD42021257662).

Eligibility criteria

All full-text papers that aimed to investigate the measurement properties of measurement tools used in telerehabilitation in adults (age $\geq$18 years old), who had a neurological condition, for example, stroke, Parkinson's disease, spinal cord injuries, multiple sclerosis, cerebellar ataxia, traumatic brain injuries, and peripheral nervous system diseases, will be included. The searches will not be limited by study design, language, or date of publication.

Research reports, working papers, conference proceedings, conference abstracts, commentaries, letters, dissertations, theses, and editorial papers will be excluded. Systematic reviews and qualitative studies will also be excluded, but their reference lists will be screened for relevant studies.

Search strategy for identification of relevant studies

Electronic search will be carried out for articles indexed on following databases: Medical Literature Analysis and Retrieval System Online (MEDLINE Ovid), Excerpta Medica Database (Embase Classic + Embase Ovid), Physiotherapy Evidence Database (PEDro), Scientific Electronic Library Online (Scielo), and Literatura Latino-Americana e do Caribe em Ciências da Saúde (LILACS). The search strategy was designed according to previous studies and with the assistance of an experienced researcher. The established search strategy for the MEDLINE database will be adapted to suit the other databases. The search strategy (S1 File) is composed of blocks of key terms related to the target population, telerehabilitation, as measurement properties, as follows:

Target population: Individuals with neurological conditions. The search was developed based on a systematic review by Marinho-Buzelli et al. 2015 [27].

Telerehabilitation: The search was developed based on a Cochrane systematic review by Laver et al. 2020 [28].

Measurement properties: The search was developed based on a systematic review by Silva et al. 2014 [29].

Selection of the studies

The selection of the studies will be carried out in three stages. In the first stage, searches will be carried out in the databases. Then, it will be saved and maintained in the Rayyan Systems Inc software [30]. In the second stage, the reviewers will screen the titles and abstracts of the records for eligibility, and the duplicates will be removed. In the third stage, selected full-text articles will be screened for eligibility. The excluded studies and the reason for the exclusion will be recorded. The selection will be performed by two reviewers (SAFB and PCP) independently. Disagreements between reviewers will be resolved by consensus or by the decision of a third independent reviewer (CDCMF). During the selection and screening of the studies, reviewers will be blinded to authors, journals, and outcomes. If additional information would be necessary, the authors of the paper will be contacted. According to the PRISMA 2020 statement [26], a study flow diagram will be created to depict the flow of information through the different stages of this systematic review.

Data extraction

Two reviewers (SAFB and PCP) will independently extract data from the articles using a predesigned data extraction form. The relevant data extracted from all the included studies will be summarized in tables. Disagreements between reviewers will be resolved by consensus or by the decision of a third independent reviewer (CDCMF).

The tables will contain the following data: study authors; year and country of publication; participants and settings (including data on age, gender, type of neurological condition, and severity of the condition); name, outcomes, and characteristics of the measurement tools; settings and mode of administration (such as telephone, videoconferencing, and sensors); measurement properties (internal consistency, reliability, measurement error, content validity, face validity, construct validity, structural validity, cross-cultural validity, criterion validity, responsiveness); clinical utility; and methodological quality of the study.

Assessment of the methodological quality of the included studies

The methodological quality of the included studies will be assessed using the Consensus-based Standards for the selection of health Measurement Instruments (COSMIN) Risk of Bias checklist [31, 32]. In the COSMIN checklist three domains are distinguished (reliability, validity, and responsiveness), and each domain contains one or more measuring properties. The COSMIN checklist is composed of ten boxes (one box for instrument development and nine boxes for the measurement properties). The boxes contain various items, and each item can be scored on a 4-point rating scale (i.e. very good, adequate, doubtful, inadequate). Standards that are considered not applicable can be skipped. An overall quality score can be obtained by taking the lowest rating for each item in one box ("worst score counts" method) for each measurement property [31–33]. Following the recommendation by Prinsen et al. 2018 [34], the criteria for good measurement properties will also be used [34, 35]. The criteria for good measurement properties present pooled or summarized results per measurement property per measurement tool. Each item can be scored as sufficient (+), insufficient (–), or indeterminate (?) [34, 35]. The assessment will also be carried out by two reviewers independently (SAFB and PCP). Disagreements will be discussed between the two reviewers and, if necessary, a third reviewer (CDCMF) will be consulted.

Assessment of the clinical utility of the identified tools

The clinical utility can be characterized by the ease with which an instrument is incorporated into clinical practice [36, 37]. This can be evaluated by the instrument's ability to be brief and

simple to apply, understand and score [23]. Parameters used to investigate clinical utility include the acceptability (individual friendliness of the instrument, often characterized by the total time to complete the tool and is influenced by the total number of items and the interpretability of the items) and the feasibility (ease of use, such as required specific training, costs, the need of supervision during the completion of the instrument, and time needed to score) [37]. In addition, the clinical utility can be assessed by criteria that may influence the clinicians in using a measurement tool in their practice, such as time to administer, analyze and interpret the measure, cost, need of specialized equipment/training, portability, and accessibility [36]. Studies that have investigated clinical utility using any of these definitions will be included.

Moreover, the clinical utility of all measurement tools will be collected and reported using the scale proposed by Tyson & Connell [36]. This is a 10-point scale that assessed the following criteria:

- Time to administer, analyze and interpret the measure (<10 minutes = 3 points, 10–30 minutes = 2 points, 30–60 minutes = 1 point, >1 hour = 0 points)
- Cost (<£100 = 3 points, £100–£500 = 2 points, £500–£1,000 = 1 point, >£1000 or unknown = 0 point)
- Need of specialized equipment/training ('No' = 2 points, 'Yes, but only simple, easy to use equipment which does not need specialist training' = 1 point, 'Yes' or 'Unknown' = 0 points)
- Portability, and accessibility ('Yes, easily (can go in pocket)' = 2 points, 'Yes, in a briefcase or trolley' = 1 point, 'No or very difficult' = 0 points) [36].

The assessment will also be carried out by two reviewers independently (SAFB and PCP).

Data synthesis

A narrative synthesis will be carried out, which will provide texts and tables to synthesize and discuss the data of the studies and methodological characteristics, as previously described in the data extraction section. In addition, texts and tables will be used to summarize the findings regarding the methodological quality [31, 32], quality of measurement properties [33–35], and clinical utility [36, 37].

Discussion

According to our knowledge, this systematic review will be the first one to assess the measurement properties and clinical utility of measurement tools used in telerehabilitation in individuals with neurological conditions. The purpose is to provide a discussion of the strengths and limitations of the different tools used in the evaluation performed during telerehabilitation of individuals with neurological conditions.

Remote delivery health services have been used for a few years. Recently, its use has increased in rehabilitation services, mainly in some specialties such as neurological and cardiac rehabilitation [16]. In the global crisis caused by the COVID-19 pandemic, the rehabilitation services had to adapt quickly to continue offering treatment to the patients [22]. One solution found was telerehabilitation since it allows the rehabilitation of individuals by substituting the traditional face-to-face approach, thus respecting safety rules preconized by health organizations, such as social distancing [38]. Therefore, telerehabilitation has increased exponentially in the last year, both in research and in clinical practice [22].

Investigating the measurement properties of the measurement tools is important to ensure an adequate evaluation of the outcomes [23]. The therapist-patient interaction, characteristics, and settings are different in telerehabilitation when compared to face-to-face rehabilitation

[16]. This may reflect different measurement properties compared to those previously investigated in the face-to-face evaluation. Furthermore, functional evaluation has been identified as a challenge to telerehabilitation practice [20, 39]. The identification and use of measurement tools that have appropriate measurement properties and clinical utility may enhance the feasibility and credibility of the evaluation performed remotely, and the comparability of interventions carried out by telerehabilitation. The results of this systematic review will be useful to assist physiotherapists in choosing the measurement tools they will use in telerehabilitation practice. Moreover, it can direct the definition of future research goals and the planning of new research studies.

This review employs a systematic, clear, and replicable inclusion and exclusion criteria and search strategy, as well as the approach regarding the searching, screening, and extracting data. The methods and instruments used in this study are recommended and validated. The involvement of two reviewers in all stages from the selection to the data extraction phase, as well as the assessment of the methodological quality of the included studies, will enhance the methodological rigor and credibility of the results found. The results from this systematic review will be spread by scientific peer-review publications and presentations at conferences and scientific events.

Supporting information

S1 Checklist. PRISMA-P (Preferred Reporting Items for Systematic review and Meta-Analysis Protocols) 2015 checklist: Recommended items to address in a systematic review protocol*.
(DOC)

S1 File. Search strategy.
(DOCX)

Author Contributions

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Measurement properties of outcome measures used in neurological telerehabilitation: A systematic review using COSMIN checklist

Sherindan Ayessa Ferreira de Brito, Aline Alvim Scianni, Paula da Cruz Peniche, and Christina Danielli Coelho de Morais Faria

Abstract

Objective: To summarize the measurement properties (reliability, validity, and responsiveness) and the clinical utility of measurement tools used in telerehabilitation in individuals with neurological conditions.
Design: Systematic review.
Subjects: Individuals with neurological conditions.
Intervention: Not applicable.
Main measures: The methodological quality of the studies using the COSMIN Risk of Bias Checklist, the quality of the measurement properties using the criteria for good measurement properties, and the clinical utility of the measurements using the Tyson & Connell scale.
Results: From the 22,188 identified studies, 47 were included. Forty-three measurement tools were identified. The main modes of administration were telephone and videoconference. Studies involved mostly individuals with stroke, multiple sclerosis, and Alzheimer's disease. Criterion validity and reliability were the most investigated measurement properties. None of the tools had their responsiveness investigated. Twenty-two measurement tools have at least one measurement property evaluated as "sufficient" in a study with appropriate methodological quality ("very good" or "adequate"). Nineteen measurement tools showed adequate clinical utility. Eight measurement tools, investigated in individuals with stroke, spinal cord injury or Alzheimer's disease, all administered by telephone, were recommended.
Conclusion: The present results can be used to assist in choosing appropriate measurement tools, both in research and clinical practice, during telerehabilitation in individuals with neurological conditions. Measurement error, content validity, structural validity, and responsiveness need to be further investigated. In addition, the measurement properties of tools used in telerehabilitation in other neurological conditions, such as Huntington's disease, should also be investigated.
Registration number: CRD42021257662.

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Keywords
Neurological rehabilitation, reliability, systematic review, telerehabilitation, validity

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Introduction

Neurological conditions are the leading cause of disabilities worldwide, and commonly induce long-term impairments.[1] Moreover, this can lead to activity limitations and participation restrictions, in addition to having an impact on the perception of health and quality of life.[2,3,4] Therefore, individuals with neurological conditions often need rehabilitation services.[5] However, these individuals have a wide range of barriers impeding the access to these services, such as personal and environmental barriers.[5,6,7,8] In this context, telerehabilitation is an innovative and promising alternative.

Telerehabilitation is the use of information and communication technologies, such as the internet, videoconferencing, email, and telephone calls to deliver rehabilitation services to the community.[9,10] In recent times, the use of telerehabilitation has increased extensively,[9] especially in the last year due to the COVID-19 pandemic. Telerehabilitation has several advantages as it does not require transporting the patient to the clinic. It can be performed in the community, increasing convenience and saving time.[11] In the global crisis caused by pandemics, telerehabilitation has enabled rehabilitation services to be maintained in compliance with the safety rules to avoid the spread of the virus, such as social distancing.[12] In addition, some studies indicate that telerehabilitation is cost-effective when compared to face-to-face rehabilitation.[9,11]

Telerehabilitation has been widely used to deliver rehabilitation services to individuals with neurological conditions.[13,14,15] Several measurement tools commonly used in face-to-face rehabilitation are also used in telerehabilitation.[13,14,15] However, the settings and characteristics of rehabilitation are different in the long-distance approach compared to face-to-face encounters.[16] Thus, to guarantee the adequate assessment of the outcomes, its measurement properties within the context of telerehabilitation must be investigated.[17]

The measurement properties of a measuring tool must be evaluated to ensure the quality and reliability of clinical results in different contexts. Therefore, it is important that studies on measurement properties are developed. It is also essential that researchers and clinicians choose measurement tools that have adequate measurement properties.[18] In addition, tools with clinical utility should be selected to ensure the ease of incorporation of a measurement tool in clinical practice.[19,20] This is particularly important in the context of telerehabilitation, since the assessments can be carried out in different environments, such as in the community or in the individual's home.[11,21]

To our knowledge, no prior systematic review has summarized the measurement properties and clinical utility of measurement tools used in telerehabilitation in individuals with neurological conditions. This can increase precision and confidence in the measurements, as well as assist the professionals in choosing measurement tools. Moreover, it can identify gaps in the literature, and guide the design of new research questions and the planning of future studies. Therefore, this study aimed to summarize the measurement properties (reliability, validity, and responsiveness) and the clinical utility of measurement tools used in telerehabilitation in individuals with neurological conditions, as well as to evaluate both the methodological quality of the studies on measurement properties and the quality of such properties.

Method

This systematic review was reported using the Preferred Reporting Items for Systematic Reviews and Meta-Analysis statement guidelines (PRISMA).[22] The

protocol of this study has been registered on the International Prospective Register of Systematic Reviews (PROSPERO) (available in: https://www.crd.york.ac.uk/PROSPERO/ registration number: CRD42021257662) and recently published.[23]

A comprehensive search was carried out on the following electronic databases: Medical Literature Analysis and Retrieval System Online (MEDLINE Ovid), Excerpta Medica Database (Embase Classic + Embase Ovid), Physiotherapy Evidence Database (PEDro), Scientific Electronic Library Online (Scielo), and Literatura Latino-Americana e do Caribe em Ciências da Saúde (LILACS). The searches were carried out on databases in June 2021. The search strategy included blocks of terms related to the target population (neurological conditions), telerehabilitation, and measurement properties (Supplemental material 1).

All full-text studies that aimed to investigate the measurement properties of measurement tools used in telerehabilitation in individuals (≥18 years of age) who had any neurological condition, for example Alzheimer' disease, Huntington's disease, multiple sclerosis, Parkinson's disease, stroke, and so on were included. The searches were not limited by study design, language, or date of publication.[23]

Research reports, working papers, conference proceedings, conference abstracts, commentaries, letters, dissertations, theses, and editorial papers were excluded. Systematic reviews and qualitative studies were also excluded.[23] The selection of the studies was carried out in three stages: (1) searches in electronic databases; (2) examination of the title and abstract of the records for eligibility; (3) examination of the full-text of the records selected for eligibility. All phases were carried out by two reviewers independently. Disagreements between reviewers were resolved by consensus and, when necessary, by the decision of a third independent reviewer.[23] Handsearching was performed in the reference list of the full-texts included to identify further studies.[23]

Data collection process and quality assessment

As described in the published protocol,[23] the relevant data extracted from all the included studies was summarized in tables. Articles were grouped by mode of administration (telephone, mail, e-mail, videoconferencing, online assessment, smartphone application, online software, and multimedia system). The excluded studies and reasons for this were recorded and summarized in Figure 1.

The methodological quality of the studies, the quality of the measurement properties, and clinical utility were assessed by the same two independent reviewers and, when necessary, a third reviewer was consulted.[23]

- Assessment of the methodological quality of the included studies: to assess the methodological quality of the included studies, the Consensus-based Standards for the selection of health Measurement Instruments (COSMIN) Risk of Bias checklist was used.[24,25] The COSMIN Risk of Bias checklist is composed of ten boxes: PROM development, content validity, structural validity, internal consistency, cross-cultural validity\Measurement invariance, reliability, measurement error, criterion validity, hypotheses testing for construct validity, responsiveness.[24,25] Each item can be scored in a 4-point rating scale: very good, adequate, doubtful, inadequate.[24,25] An overall quality score can be obtained by taking the lowest rating for each item in one box ("worst score counts" method).[24,25]
- Assessment of the quality of the measurement property: to assess the quality of the measurement property, the criteria for good measurement properties were used. These criteria complement the evaluation of the measurement properties, as the COSMIN does not determine the cut-offs that are considered adequate for the statistical analysis of each measurement property.[25,26] This is composed of eight items (structural validity, internal consistency, reliability, measurement error, hypotheses testing for construct validity, cross-cultural validity \measurement invariance, criterion validity, responsiveness).[25,26] Each item can be rated as either "sufficient," "insufficient," or "indeterminate," following the COSMIN recommendation.[25,26] In the COSMIN user manual,[27]

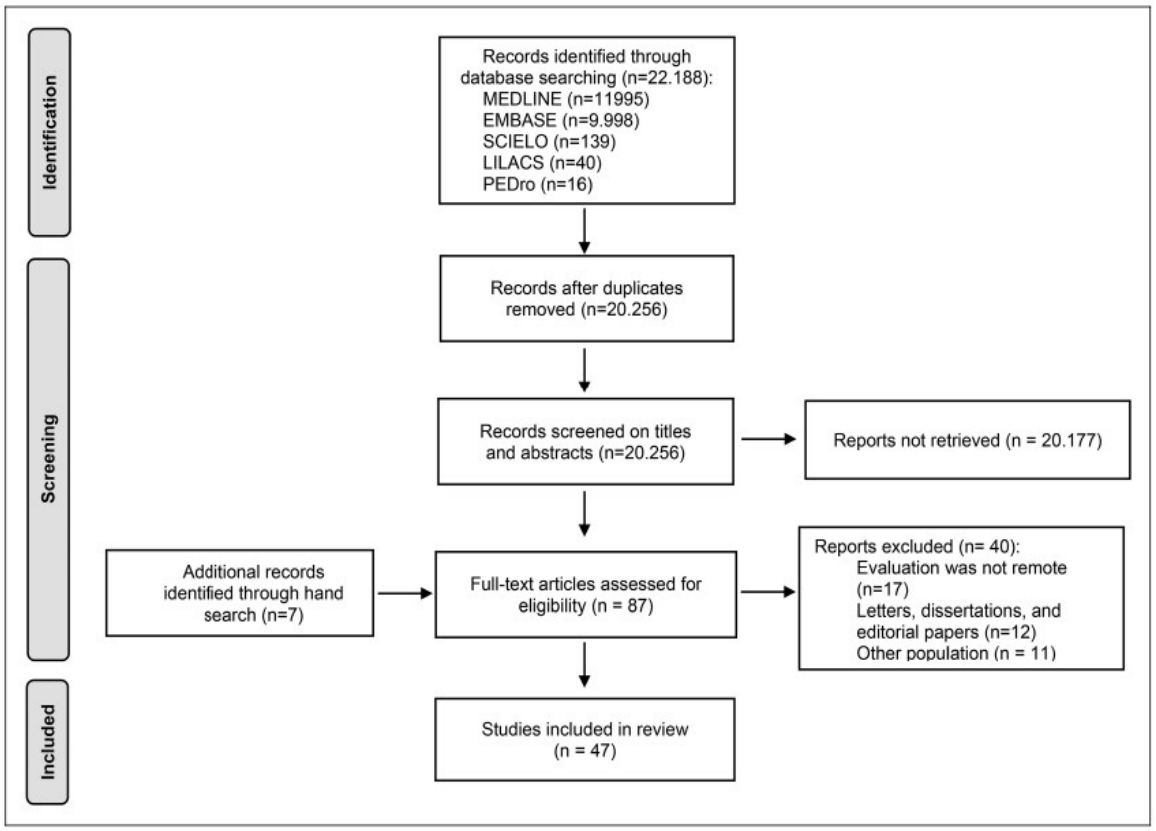


Figure 1. Flowchart presenting the research database, the screening process, and the number of included studies with reasons of exclusion.

detailed information about criteria for good measurement properties can be found.

- Assessment of the clinical utility: The clinical utility was assessed using the Tyson & Connell scale.[19] This is a 10-point scale composed of factors that may influence whether professionals would use measurement tools in their clinical practice: application time (0–3 points), cost (0–3 points), need of specialized equipment/training (0–2 points), portability and accessibility (0–2 points).[19] When information was not found (unknown), the item scored zero.[19,28,29]

Recommended measurement tools

Recommended measurement tools in telerehabilitation were selected considering the methodological quality of the study, the quality of the measurement property as well as the clinical utility of the tool,[24,25] based upon the following criteria:

(a) Methodological quality of the study classified as "adequate" or "very good."[24,25]
(b) Quality of the measurement property classified as "sufficient."[24,25]
(c) Clinical utility ≥ 9, according to the Tyson & Connell scale.[19,28,29]

Data synthesis

A narrative synthesis to present the main results of the included studies was performed. Text and tables were used to summarize and discuss the relevant data extracted from the studies.

Moreover, these resources were used to summarize and report the methodological quality, quality of measurement properties, and clinical utility. All these procedures were performed following the COSMIN guideline for systematic reviews of patient-reported outcome measures.[24,25]

Results

The flow of identification and screening of the studies through review, including the reasons for exclusion, is presented in Figure 1. As can be observed, 47 studies were included in this systematic review.

In total, 43 different measurement tools were identified,[30–76] five of them in different versions.[32,35,36,39,40,41,46,47,50,51,63,64,65,67–74] Description of these measurement tools is presented in Table 1. The modes of administration of tools used in telerehabilitation were: telephone[30,31,33,34,35,36,39,40,44,46–51,56,58,59,62–75] (Supplemental material 2), e-mail,[52] videoconferencing,[37,38,41,43,53,54,55] online assessments,[42,57] smartphone application,[60,61] online software,[45,76] and multimedia system[32] (Supplemental material 3).

The 47 included studies involved a total of 3891 individuals with eight different neurological conditions: stroke (20 studies, n = 1567),[30,31,33,34,35,38,50,51,53–55,57,59,63,64,67,68,72,73,75] multiple sclerosis (nine studies, n = 1130),[32,39,40,41,42,44,52,60,61] Alzheimer's disease (seven studies, n = 339),[36,43,46,47,65,70,71] Parkinson's disease (three studies, n = 183),[37,45,76] transient ischemic attack or stroke (three studies, n = 270),[58,69,74] spinal cord injury (three studies, n = 125),[48,62,66] traumatic brain injury (one study, n = 194),[56] and aneurysmal subarachnoid hemorrhage (one study, n = 83).[49] Supplemental material 2 and 3 presents the characteristics of the studies, as well as the investigated measurement properties and the results found.

Assessment of the methodological quality and clinical utility

- Assessment of the methodological quality of the included studies: The methodological quality of the included studies ranged from "inadequate" to "very good," based upon the COSMIN scores. Fourteen studies investigated internal consistency[34,39,40,42,44,48,52,58,63,70,72,74,76]: eight were classified as "very good,"[39,44,48,52,58,63,76] four as "doubtful,"[34,40,42,74] and two as "inadequate."[70,72] The reliability was investigated in 27 studies[32–37,39,42,44,47,50,51,53,54,56,57,60–63,65,66,68,70–72,74,75]: 4 were classified as "very good"[44,53,63,66], 1 as "adequate,"[75] and 22 as "doubtful."[32–37,39,42,47,50,51,54,56,57,60–62,68,70–72,74,75] Two studies investigated the measurement error and were classified as "doubtful."[60,61] Two studies investigated the content validity[39,75]: one was classified as "doubtful,"[75] and one as "inadequate."[39] Three studies investigated structural validity[44,52,72]: one was classified as "very good,"[52] and two as "inadequate."[44,72] The hypotheses testing was investigated in 16 studies,[39,42,44–46,48,50,57,58,60,64,65,68,70,71,75,76] of which five were classified as "very good,"[44,48,60,71,76] two as "adequate,"[68,75] six as "doubtful,"[39,45,50,58,65,70] and three as "inadequate."[42,57,64] Thirty-three studies investigated the criterion validity,[30–34,38–43,45–49,51,52,55,57,59,60,62,65–74] the vast majority (25) was classified as "very good,"[30,31,33,34,39–43,47–49,51,52,55,59,60,62,65,66,69–72,74] seven were classified as "doubtful,"[32,38,45,46,57,67,73] and one as "inadequate."[68] Supplemental material 4 presents the methodological quality of all included studies, according to the COSMIN. Table 2 presents only the measurement tools with studies that have methodological quality rated as "very good" or "adequate" and measurement properties rated as "sufficient," according to the COSMIN.[25]

- Assessment of the quality of the measurement property: Based upon the criteria to assess the quality of the measurement property, 67 were classified as "sufficient" measurement properties[30–37,39,41–44,46–48,50–55,57–72,74–76]: 12 on internal consistency,[34,39,42,44,48,52,58,63,70,72,74,76] 22 on reliability,[35–37,39,42,44,50,51,53,54,57,60–63,66,68,70–72,74,75] 1 on structural validity,[44] 8 on hypotheses testing,[44,48,50,60,64,65,68,71] and 24 on criterion validity[30–32,34,39,41,43,46–48,55,57,59,60,62,65–67,69,70,71,72,73,74]. Eleven measurement properties were classified as "indeterminate"[38,39,45,47,49,57,58,60,61,70,72]: one on reliability[47], two on measurement error,[60,61] one on structural validity,[72] five on hypotheses testing,[39,45,57,58,70] and two on criterion validity.[38,49] Eleven measurement properties were classified as "insufficient"[32,34,40,42,44,45,51,52,56,60,72,75,76]: one

Table 1. Description of the identified measurement tools used in telerehabilitation in individuals with neurological diseases.

Measurement tool	Outcomes	Type of measurement tool	Time of administration	Scoring
ADAS-Jcog[43]	Cognitive decline	Observation	-	Number of items: NR. Scoring: NR. Total score: NR.
BCRS[36]	Magnitude of cognitive impairment	Observation	-	Number of items: NR. Scoring: it has 10 axes, and each axis is scored using a 7-point scale. Total score: NR.
FAST[36]	Progressive functional decline	Observation	-	Number of items: 16 successively enumerated stages. Scoring: functional staging score is the highest ordinally enumerated number. Total score: NA.
GDS[36]	Magnitude of cognitive and functional capacity	Observation	-	Number of items: 7-point rating scale. Scoring: a stage is defined. Total score: NA.
ESS[38]	Physical function	Observation	<30 min	Number of items: 14. Scoring: NR. Total score: NR.
Kinovea version 0.8.15 software[37]	Range of motion	Observation	-	Number of items: NA. Scoring: NR. Total score: NR.
MMSE: original[36]; telephone (TMMSE)[46]; Brazilian telephone (Braztel-MMSE)[47]	Cognitive status[36]; Mental status[46]; Screening measure for dementia[47]	Observation	5–10 min[46]; 5 min[47]	-Telephone and Modified version: Number of items: NR. Scoring: each item answered correctly receives a score of 1. Total score: is the sum of correct answers (maximum score of 29 or 26).[36,46] -Braztel-MMSE: Number of items: NR. Scoring: each item answered correctly receives a score of 1. Total score: is the sum of correct answers (maximum score of 22).[47]
Montreal Cognitive Assessment 5-min protocol[74]	Cognitive screening	Observation	5 (5–12) min	Number of items: NR. Scoring: NR. Total score: it ranges from 0 to 30.
NIHSS[53–55]	Stroke severity	Observation	9.7 (6–18) min[53]; 9 (5–12) min[54]; 9 (4–19) min[55]	Number of items: 13. Scoring: NR. Total score: NR.

(Continued)

Table 1. (Continued)

Measurement tool	Outcomes	Type of measurement tool	Time of administration	Scoring
OL-RBMT[57]	Functional memory	Observation	15–30 min	Number of items: 11. Scoring: NR. Score total: it ranges from 0 to 24.
Six-item screener[59]	Cognitive screening	Observation	57.30 ± 17.70 s	Number of items: 6. Scoring: NR. Total score: 6 points.
TELE[65]	Cognitive screening	Observation	-	Number of items: 12. Scoring: there are different scores for each item. Total score: it has a maximum score of 20.
TCOVS[66]	Mobility	Observation	5 min	Number of items: 13. Scoring: each item is scored using a scale ranging from 1 (fully dependent mobility) to 7 (normal independent mobility). Total score: it ranges from 13 to 91.
TICS: original[67]; Finnish (TICS)[65]; German[73]; Italian (I-TICS)[70]; Japanese (TICS-J)[71]; modified 13-item (TICSm)[67,69]; modified Portuguese-Brazilian (TICS-M)[72]; Spanish[68]	Cognitive function	Observation	Approximately 5 min[68], approximately 10 min[70], 5–10 min[72]	-Original, Spanish, Italian, Japanese, German: Number of items: 11. Scoring: NR. Score total: it has a maximum score of 41.[67,68,70,71,73] -Finnish version: Number of items: 16. Scoring: there are different scores for each item. Total score: it has a maximum score of 38.[65] -TICSm, TICS-M: Number of items: 13. Scoring: NR. Total score: the score ranges from 0 to 39.[67,72]
T-MoCA: original[69,73]; short (T-MoCA-Short)[69]	Cognitive status	Observation	-	-Original: Number of items: NR. Scoring: NR. Total score: it has a maximum score of 22 points.[69,73] -T-MoCA-Short: Number of items: NR. Scoring: NR. Total score: it has a maximum score of 12 points.[69]
TRS[37]	Tremor	Observation	-	Number of items: NR. Scoring: NR. Total score: NR.
NINDS-CSN[59]	Cognitive screening	Observation	4.30 ± 1.00 min	Number of items: NR. Scoring: NR.

(Continued)

Table 1. (Continued)

Measurement tool	Outcomes	Type of measurement tool	Time of administration	Scoring
				Total score: it has a maximum score of 30 points.
6MWT[32]	Walking distance	Performance-based	6 min	Number of items: NA. Scoring: NR. Total score: NR
CRT[37]	Dexterity of upper limbs	Performance-based	-	Number of items: NA. Scoring: NR. Total score: NR.
FTT[37]	Motor speed	Performance-based	60 s	Number of items: NA. Scoring: using the right index finger, individuals tap a designated area as quickly as possible; the number of fingers taps in 60 s is counted. Score total: the mean count of three trials.
FRT[38]	Physical function	Performance-based	<30 min	Number of items: NA. Scoring: record of the identified maximal distance one can reaches forward beyond arm's length while maintaining a fixed base of support in the standing position (start: position 1, and end: position 2). Total score: the mean difference between the position 1 and position 2 over the last three trials (each subject performed five trials).
Smartphone-Based Self-Administered 2-Minute Walk Test[61]	Physical function and gait characteristics	Performance-based	2 min	Number of items: NA. Scoring: distance travelled in a fixed amount of time and gait characteristics (stance time, step time, stride time, swing time, step length, stride length, step velocity, stride velocity) are registered. Total score: NA.
sSDMT[60]	Cognitive function	Performance-based	90 s	Number of items: NA. Scoring: individuals tap the digits corresponding to each shown symbol on the smartphone screen;

(Continued)

Table 1. (Continued)

Measurement tool	Outcomes	Type of measurement tool	Time of administration	Scoring
				the number of correct responses after a 90-s trial is scored by the app. Total score: NA.
Ohio State University Traumatic Brain Injury Identification Method modified[56]	Maximum TBI severity incurred throughout the lifetime	Self-rating Outcome	5 (1–18) min	Number of items: NR. Scoring: the variables of each category (it has 3 categories) are scored in different ways. Total score: NR.
ABILHAND[30]	Manual ability	Self-rating Outcome	-	Number of items: 23. Scoring: each item is scored using a scale ranging from 0 to 2 (0 = impossible; 1 = difficult; 2 = easy). Total score: is obtained using the Rasch analysis.
ABILOCO[31]	Locomotion	Self-rating Outcome	-	Number of items: 13. Scoring: each item is scored as 0 = impossible or 1 = possible. Total score: is obtained using the Rasch analysis.
BEHAVE-AD[36]	Noncognitive disturbing behavioral symptoms	Self-rating Outcome	-	Number of items: 25. Scoring: each item is scored using a 4-point scale. Total score: NR.
BI[33,34,35]	Activities of daily living	Self-rating Outcome	5 min[34]	Number of items: 10. Scoring: it is scored in the increments of five points. Total score: it ranges from 0 to 100.
EDSS: Spanish[32,39]; Telemedicine-enabled (tele-EDSS)[41]; Telephone-based (T-EDSS)[40]	Disability status and disease progression	Self-rating Outcome	-	-Spanish: Number of items: NR. Scoring: NR. Total score: NR.[32,39] -Tele-EDSS: Number of items: NR. Scoring: NR. Total score: NR.[41] -T-EDSS: Number of items: NR. Scoring: NR. Total score: it ranges from 0 (normal neurological function) to 10 (death due to MS).[40]
eMSQOL-29[52]	Quality of life	Self-rating Outcome	-	Number of items: 25. Scoring: NR. Total score: an integrated scoring routine is available.

(Continued)

Table 1. (Continued)

Measurement tool	Outcomes	Type of measurement tool	Time of administration	Scoring
HUI2/3[75]	Quality of life	Self-rating Outcome	15–30 min	Number of items: 41. Scoring: NR. Total score: NR.
LE-MAL[44]	Quality of spontaneous leg use	Self-rating Outcome	-	Number of items: 14. Scoring: is done using three scales. Assistance Scale: average of the scores of three subscales, ranging from 0 to 10 10 (0 = unable to perform the task and 10 = no assistance needed). Functional Performance Scale and Confidence Scale: each item is scored using a scale ranging from 0 to 10 (0 = either inability to do the activity or no confidence at all, and 10 = normal ability or complete confidence). Total score: the average of the scores across the three scales.
MAM-16[37]	Hand function	Self-rating Outcome	-	Number of items: 16. Scoring: each item is scored using a 4-point scale ranging from "easy" to "cannot do." Total score: is derived by adding the scores for each item (maximum score: 64).
MEPA-III[45]	Monitor mediterranean diet	Self-rating Outcome	4.10 min (1.60–14.90)	Number of items: 21. Scoring: 1 = to any component for which the intake frequency met the pre-determined cutoff criterion; 0 = to any component do not meet the criterion. Total score: it has a maximum score of 21.
MFIS-SCI[48]	Fatigue	Self-rating Outcome	5–10 min	Number of items: 21. Scoring: each item is scored using a scale ranging from 0 (never) to 4 (almost always). Total score: it ranges from 0 to 84.

(Continued)

Table 1. (Continued)

Measurement tool	Outcomes	Type of measurement tool	Time of administration	Scoring
mRS: original[35,49,51]; simplified (smRSq)[50]	Functional outcome/ Degree of neurological disability	Self-rating Outcome	1.29 min (0.50–2.25)[50]	- Original: Number of items: 5. Scoring: each question is answered with "yes" or "no" and a grade is defined (0 = no symptoms to 6 = death). Total score: NA.[35] - smRSq: Number of items: 5. Scoring: each question is answered with "yes" or "no" and a grade is defined (≤3 = able to walk without assistance from one room to another in the patient's place of residence; ≤4 = able to go from lying to sitting under own power.). Total score: NA.[50]
MSNQ[42]	Screened for cognitive impairment	Self-rating Outcome	<45 min	Number of items: 15. Scoring: NR. Total score: NR.
PDDS[39]	Disability status	Self-rating Outcome	-	Number of items: NR. Scoring: a degree is defined. Total score: NA.
PDQ-39[76]	Quality of life	Self-rating Outcome	-	Number of items: 39. Scoring: 8 domain scores are coded on a scale of 0 (perfect health) to 100 (worst health). Total score: a summary index score is calculated.
PROMIS-10 Global Health[58]	Quality of life, physical and mental health	Self-rating Outcome	-	Number of items: 10. Scoring: can be calculated through an online scoring service. Total score: NR.
SCI-SCS[62]	Screening for secondary health conditions	Self-rating Outcome	Approximately 8 min	Number of items: 16. Scoring: each item is scored using a scale ranging from 0 to 3 (0 = the condition has not been experienced or has not been a significant problem in the last 3 months; 3 = the condition is chronic and/or a serious problem). Total score: is derived by adding the

(Continued)

Table 1. (Continued)

Measurement tool	Outcomes	Type of measurement tool	Time of administration	Scoring
				scores for each item (maximum score: 48).
SF-AI[32]	Walking distance	Self-rating Outcome	-	Number of items: NA. Scoring: a degree is defined to the walking distance according to ambulation index score (it ranges from 0 to 12). Total score: NA.
SIS: original[63]; version 3.0[64]	Physical disability and Stroke health status	Self-rating Outcome	30–40 min[63,64]	Number of items: 59. Scoring: NR. Total score: NR

6MWT: 6-min walk test; ADAS-Jcog: Japanese version of Alzheimer's Disease Assessment Scale Cognitive Subscale; BCRS: Brief Cognitive Rating Scale; BEHAVE-AD: Behavioral Pathology in Alzheimer's Disease Rating Scale; BI: Barthel Index; CRT: Coin Rotation Task; EDSS: Expanded Disability Status Scale; eMSQOL-29: electronic format Multiple Sclerosis Quality of Life; ESS: European Stroke Scale; FAST: Functional Assessment Staging; FTT: Finger Tapping Test; FRT: Functional Reach Test; GDS: Global Deterioration Scale; HUI2/3: Health Utilities Index Mark 2 and 3; I-TICS: Italian telephone interview for cognitive status; LE-MAL: Lower-Extremity Motor Activity Log; MAM: Manual Ability Measure; MEPA-III: Mediterranean Eating Pattern for Americans; MFIS-SCI: Modified Fatigue Impact Scale spinal cord injury; MMSE: Mini-Mental State Examination; MSNQ: Multiple Sclerosis Neuropsychological Questionnaire; mRS: Modified Rankin Scale; NA: not applicable, NIHSS: National Institutes of Health Stroke Scale; NINDS-CSN: National Institute of Neurological Disorders and Stroke and Canadian Stroke Network; NR: Not Reported; OL-RBMT: Online Rivermead Behavioral Memory Test; PDDS: Patient Determined Disease Steps; PROMIS-10: Patient-Reported Outcomes Measurement Information System 10-Question Short Form; PDQ-39: 39-item Parkinson's Disease Questionnaire; SCI-SCS: Spinal Cord Injury–Secondary Conditions Scale; SF-AI: self-reported ambulation index; SIS: Stroke Impact Scale; smRSq: Simplified Modified Rankin Scale Questionnaire; sSDMT: Smartphone-adapted Symbol Digit Modalities Test; TRS: Fahn-Tolosa-Marin Tremor Rating Scale; TBI-ID: Traumatic Brain Injury Identification; TCOVS: Telephone Clinical Outcome Variables Scale; T-EDSS: Telephone-based Expanded Disability Status Scale; tele-EDSS: Telemedicine-enabled Expanded Disability Status Scale; TICS: Telephone interview for cognitive status; TICS-J: Japanese version of the Telephone interview for cognitive; TICSm: Telephone interview for cognitive status modified 13-item; TICS-M: Brazilian version of the Modified Telephone Interview for Cognitive Status; TMMSE: Telephone Mini-Mental State Examination; T-MoCA: Telephone Montreal Cognitive Assessment; T-MoCA-Short: Telephone Montreal Cognitive Assessment (verbal fluency, recall and orientation; total 12 points).

study on internal consistency,[40] three on reliability,[32,56] three on hypotheses testing,[42,75,76] and four on criterion validity.[40,42,51,52] Supplemental material 4 presents the quality rating of the results on measuring properties of all included studies, according to the COSMIN.[25] Table 2 presents only the measurement tools with studies that have methodological quality rated as "very good" or "adequate" and measurement properties rated as "sufficient," according to the COSMIN.[25]

- Assessment of the clinical utility: Measurement tools scores on the scale of clinical utility ranged from 4 to 10 points. Twelve measurement tools scored 10,[33–37,45–48,50,59,62,65–73] 7 scored 9,[36,38,59] 4 scored 8,[53–56,63,64,75] 17 scored 7,[30–33,35,37,39–44,49,51,52,58,60,61,65,76] 2 scored 6,[37,57] and 1 scored 4[32] (Table 3).

Recommended measurement tools

As can be observed in Table 2, 22 measurement tools have at least one measurement property classified as "sufficient" in a study with methodological quality classified as "very good" or "adequate."[30,31,33,39,41,43,44,47,48,52,53,55,58–60,62–66,69–72,74–76] Criterion validity was the measurement property that most met these criteria.[30,34,39,41,43,47,48,55,59,60,62,65,66,69–72,74] No measurement tool presented measurement error, content validity, and structural validity classified as "sufficient" in studies with appropriate methodological quality. In addition, no study investigated responsiveness (Table 2, Supplemental material 4).

As can be observed in Table 2, 19 measurement tools, three in different versions, obtained scores ≥ 9, and, therefore, showed adequate clinical utility.[33–38,45,46,47,48,50,58,59,62,65–74] Most of these measurement tools are simple questionnaires, which are freely available.

Eight measurement tools were recommended to be used in telerehabilitation considering the three criteria selected:

- Barthel Index (BI),[33,34] Six-item screener, National Institute of Neurological Disorders and Stroke and Canadian Stroke Network (NINDS-CSN),[59] and Telephone Interview of Cognitive Status (TICS)[68,69,72] administered by telephone in individuals with stroke;
- Brazilian Telephone Mini Mental State Examination (Braztel-MMSE) and TICS[65,70,71] administered by telephone in individuals with Alzheimer's disease[47];
- Modified Fatigue Impact Scale Spinal Cord Injury (MFIS-SCI),[48] Spinal Cord Injury - Secondary Conditions Scale (SCI-SCS),[62] and Telephone Clinical Outcomes Variables Scale (TCOVS)[66] administered by telephone in individuals with spinal cord injury.

Discussion

To our knowledge, this is the first review to systematically summarize and discuss the evidence on measurement tools used in telerehabilitation in individuals with neurological conditions, as well as to analyze their methodological quality and clinical utility. Forty-three measurement tools were identified.[30–76] Twenty-two measurement tools have at least one measurement property classified as "sufficient" in studies with methodological quality classified as "very good" or "adequate."[30,31,33,39,41,43,44,47,48,52,53,55,58–60,62–66,69–72,74–76] Nineteen measurement tools showed adequate clinical utility.[33–38,45–48,50,58,59,62,65–74] Eight measurement tools, investigated in individuals with stroke, spinal cord injury, or Alzheimer's disease, all administered by telephone, were recommended.[33,34,47,48,59,62,65,66,68–72] However, it is important to consider that no study have already investigated the responsiveness of any measurement tool identified in the present systematic review. Therefore, these tools cannot be used in telerehabilitation to assess the effectiveness of an intervention in individuals with neurological conditions.

Considering reliability, few studies investigated internal consistency. The main methodological flaws of these studies were not assessing the unidimensionality of the scale/subscale or not using recommended statistics.[25–27] For test-retest, inter-rater, and intra-rater reliability, it is important to guarantee the stability of individuals on the outcome to be measured, similar test conditions

Table 2. Measurement tools with studies that have methodological quality rated as "very good" or "adequate" and measurement properties rated as "sufficient," according to the COSMIN.[25]

		Measurement properties							
		Reliability			Validity				
						Construct validity			
Measurement tool	Neurological disease	Internal consistency	Test-retest, inter-rater, and intra-rater	Measurement error	Content validity	Structural validity	Hypotheses testing	Criterion validity	Responsiveness
E-mail with the link to the website									
eMSQOL-29[52]	Multiple Sclerosis	X				X			
Online software									
PDQ-39[76]	Parkinson's Disease	X							
Smartphone application									
sSDMT[60]	Multiple Sclerosis						X	X	
Telephone assessment									
Braztel-MMSE[47]	Alzheimer's Disease							X	
I-TICS[70]	Alzheimer's Disease							X	
TICS-J[71]	Alzheimer Disease						X	X	
TELE TICS[65]	Alzheimer's Disease							X	
	Alzheimer's Disease								
EDSS PDDS[39]	Multiple Sclerosis	X						X	
	Multiple Sclerosis								
LE-MAL[44]	Multiple Sclerosis	X	X				X		
MFIS-SCI[48]	Spinal Cord Injury	X					X	X	
SCI-SCS[62]	Spinal Cord Injury							X	
TCOVS[66]	Spinal Cord Injury		X					X	
ABILHAND[30]	Stroke							X	
ABILOCO[31]	Stroke							X	
BI[33]	Stroke							X	
HUI2/3[75]	Stroke		X						
NINDS-CSN[59]	Stroke							X	
Six-item screener[59]	Stroke							X	
SIS[64]	Stroke						X		
SIS[63]	Stroke	X	X						
TICS[68]	Stroke						X		
TICS-m[72]	Stroke							X	
MoCA 5-min protocol[74]	TIA or Stroke							X	
PROMIS-10 Global Health[58]	TIA or Stroke	X							
TICS-m T-MoCA T-MoCA-Short[69]	TIA or Stroke TIA							X	

(Continued)

Table 2. (Continued)

Measurement tool	Neurological disease	Measurement properties							
		Reliability		Validity					
		Internal consistency	Test-retest, inter-rater, and intra-rater	Measurement error	Content validity	Construct validity		Criterion validity	Responsiveness
						Structural validity	Hypotheses testing		
	or Stroke TIA or Stroke								
Videoconferencing assessment									
ADAS-Jcog[43]	Alzheimer's Disease							X	
tele-EDSS[41]	Multiple Sclerosis							X	
NIHSS[55]	Stroke							X	
NIHSS[53]	Stroke		X						

6MWT: 6-min walk test; ADAS-Jcog: Japanese version of Alzheimer's Disease Assessment Scale Cognitive Subscale; BCRS: Brief Cognitive Rating Scale; BEHAVE-AD: Behavioral Pathology in Alzheimer's Disease Rating Scale; BI: Barthel Index; CRT: Coin Rotation Task; EDSS: Expanded Disability Status Scale; eMSQOL-29: electronic format Multiple Sclerosis Quality of Life; ESS: European Stroke Scale; FAST: Functional Assessment Staging, FTT: Finger Tapping Test; FRT: Functional Reach Test; GDS: Global Deterioration Scale; HUI2/3: Health Utilities Index Mark 2 and 3; I-TICS: Italian telephone interview for cognitive status; LE-MAL: Lower-Extremity Motor Activity Log, MAM: Manual Ability Measure; MEPA-III: Mediterranean Eating Pattern for Americans; MFIS-SCI: Modified Fatigue Impact Scale spinal cord injury; MMSE: Mini-Mental State Examination; MSNQ: Multiple Sclerosis Neuropsychological Questionnaire; mRS: Modified Rankin Scale; NIHSS: National Institutes of Health Stroke Scale; NINDS-CSN: National Institute of Neurological Disorders and Stroke and Canadian Stroke Network; NR: Not Reported; OL-RBMT: Online Rivermead Behavioral Memory Test; PDDS: Patient Determined Disease Steps; PROMIS-10: Patient-Reported Outcomes Measurement Information System 10-Question Short Form; PDQ-39: 39-item Parkinson's Disease Questionnaire; SCI-SCS: Spinal Cord Injury–Secondary Conditions Scale; SF-AI: self-reported ambulation index; SIS: Stroke Impact Scale;[63,64] smRSq: Simplified Modified Rankin Scale Questionnaire; sSDMT: Smartphone-adapted Symbol Digit Modalities Test; T-EDSS: Telephone-based Expanded Disability Status Scale; tele-EDSS: Telemedicine-enabled Expanded Disability Status Scale; TRS: Fahn-Tolosa-Marin Tremor Rating Scale; TCOVS: Telephone Clinical Outcome Variables Scale; TIA: Transient Ischemic Attack; TICS: Telephone interview for cognitive status; TICS-J: Japanese version of the Telephone interview for cognitive; TICSm: Telephone interview for cognitive status modified 13-item; TICS-M: Brazilian version of the Modified Telephone Interview for Cognitive Status; TMMSE: Telephone Mini-Mental State Examination; T-MoCA: Telephone Montreal Cognitive Assessment; T-MoCA-Short: Telephone Montreal Cognitive Assessment (verbal fluency, recall and orientation; total 12 points).

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measurements, and an appropriate time interval.[25,26] The lack of evidence of compliance with these requirements, and the use of non-recommended statistical tests, were the main methodological flaws found.[25,26] Only two studies investigated measurement error, all classified as "doubtful" for methodological quality.[60,61] The measurement error is an important measurement property to increase confidence in the measurements obtained, and for their proper interpretation.[17,25,26]

Only two studies evaluated the content validity, both of them classified as "inadequate" methodological quality.[39,75] This measurement property is most useful for questionnaires,[25,26] which was the most prevalent type of measurement tool found in this review.[77,78] According to the COSMIN, the content validity assessment is not rated regarding the quality of the measurement property.[24,25]

Criterion validity was the most investigated measurement property and the vast majority of studies was classified as "very good" methodological quality and as "sufficient" quality of the measurement property.[30,31,33,34,39–43,47–49,51,52,55,59,60,62,65,66,69–72,74] Construct validity was mostly investigated by hypotheses testing.[39,42,44–46,48,50,57,58,60,64,65,68,70,71,75,76] To evaluate this measurement property, the formulation of a specific hypotheses is essential,[25–27] and this was the main methodological flaw found in the studies included in this review.

According to the results of this systematic review, responsiveness was not investigated. A measurement tool must have adequate responsiveness to be able to assess the effectiveness of an intervention.[17,25,26] Therefore, the results and effect size found in the studies that investigated the effectiveness of telerehabilitation[13–15] may have been affected by the use of a measurement tool that does not have adequate responsiveness to measure the outcome. Future studies must investigate the responsiveness to ensure the use of measurement tools able to detect changes over time in the construct to be measured.

In the clinical utility scale, the majority of the measurement tools included in the present review did not meet all the criteria to be recommended for use in clinical practice.[19] The main reason for this was the lack of information on application time and costs. The scientific literature already addresses that the choice of easy-to-use and cost-effective measurement tools are challenges for telerehabilitation.[16,21] Furthermore, one of the advantages of telerehabilitation is the possibility of being carried out in a community environment.[16,21] Thus, measurement tools should be portable and preferably not require specialized equipment or training. This highlights the importance of clinical utility criteria being carefully evaluated when choosing a measurement tool for use in telerehabilitation.

It is also important to point out that it was not found any study that have investigated the measurement property of measurement tools used in telerehabilitation in individuals with some neurological conditions, such as Huntington's disease. As can be observed in Supplemental material 1, the search strategy was elaborated to include studies developed in individuals with any neurological condition.[79]

It is possible that some relevant studies were not retrieved by the electronic searches, because of the variability in terminology. However, a manual search in the relevant papers was performed in an attempt to avoid the loss of information. In addition, many studies have not classified their measurement properties using the COSMIN taxonomy.[25] This made it difficult to define which measurement property was investigated, and also the methodological quality of the studies. Therefore, it is important to use standardized and recommended checklists in the literature to design and report on scientific studies.[24,25] COSMIN is the recommended reporting guideline for studies on measurement properties of patient-reported outcome measures. In addition, COSMIN checklists to assess methodological quality are recommended for systematic reviews of studies on measurement properties.[24,25]

In conclusion, a significant number of studies on telerehabilitation in individuals with neurological conditions was identified and included in this systematic review. This reflects the importance of this topic, especially after the COVID-19 pandemic. The results of the present systematic review should be used to guide clinicians and researchers to choose appropriate measurement tools, both in research and clinical practice,

Table 3. Clinical utility of the measurement tools used in telerehabilitation in individuals with neurological diseases, according to the Tyson & Connell scale.[19,28,29]

Measurement tool	Application time	Cost	Specialized equipment/ training	Portability	Total score
BI[33,34,35]	3	3	2	2	10
CRT[37]	3	3	2	2	10
FTT[37]	3	3	2	2	10
MEPA-III[45]	3	3	2	2	10
MMSE: original[36]; **Telephone**[46]; **Braztel-MMSE**[47]	3	3	2	2	10
MFIS-SCI[48]	3	3	2	2	10
smRSq[50]	3	3	2	2	10
Six-item screener[59]	3	3	2	2	10
SCI-SCS[62]	3	3	2	2	10
TCOVS[66]	3	3	2	2	10
TICS: original[67]; **Finnish (TICS)**[65]; **German**[73]; **Italian (I-TICS)**[70]; **Japanese (TICS-J)**[71]; **modified 13-item (TICSm)**[67,69]; **modified Portuguese-Brazilian (TICS-M)**[72]; **Spanish**[68]	3	3	2	2	10
NINDS-CSN[59]	3	3	2	2	10
BEHAVE-AD[36]	2	3	2	2	9
BCRS[36]	2	3	2	2	9
ESS[38]	2	3	2	2	9
FAST[36]	2	3	2	2	9
FRT[38]	2	3	2	2	9
GDS[36]	2	3	2	2	9
T-MoCA: original[69,73]; **T-MoCA-Short**[69]	2	3	2	2	9
NIHSS[53,54,55]	2	3	2	1	8
Ohio State University Traumatic Brain Injury Identification Method modified[56]	2	3	1	2	8
SIS: original[63]; **version 3.0**[64]	1	3	2	2	8
HUI2/3[75]	1	3	2	2	8
ABILHAND[30]	0	3	2	2	7
ABILOCO[31]	0	3	2	2	7
ADAS-Jcog[43]	0	3	2	2	7
EDSS: Spanish[32,39]; **T-EDSS**[40]; **tele-EDSS**[41]	0	3	2	2	7
TRS[37]	0	3	2	2	7
MSNQ[42]	1	2	2	2	7
LE-MA[44]	0	3	2	2	7
MAM-16[37]	0	3	2	2	7
mRS[35,49,51]	0	3	2	2	7
eMSQOL-29[52]	0	3	2	2	7
PDDS[39]	0	3	2	2	7
PROMIS-10 Global Health[58]	0	3	2	2	7
sSDMT[60]	3	0	2	2	7
Smartphone-Based Self-Administered 2-Minute Walk Test[61]	3	0	2	2	7
TELE[65]	0	3	2	2	7
6MWT[32]	3	0	2	2	7

(Continued)

Table 3. (Continued)

Measurement tool	Application time	Cost	Specialized equipment/ training	Portability	Total score
PDQ-39[76]	0	3	2	2	7
Kinovea version 0.8.15 software[37]	0	3	1	2	6
OL-RBMT[57]	2	0	2	2	6
SF-AI[32]	0	0	2	2	4

6MWT: 6-min walk test; ADAS-Jcog: Japanese version of Alzheimer's Disease Assessment Scale Cognitive Subscale; BCRS: Brief Cognitive Rating Scale; BEHAVE-AD: Behavioral Pathology in Alzheimer's Disease Rating Scale; BI: Barthel Index; CRT: Coin Rotation Task; EDSS: Expanded Disability Status Scale; eMSQOL-29: electronic format Multiple Sclerosis Quality of Life; ESS: European Stroke Scale; FAST: Functional Assessment Staging; FTT: Finger Tapping Test; FRT: Functional Reach Test; GDS: Global Deterioration Scale; HUI2/3: Health Utilities Index Mark 2 and 3; I-TICS: Italian telephone interview for cognitive status; LE-MAL: Lower-Extremity Motor Activity Log; MAM: Manual Ability Measure; MEPA-III: Mediterranean Eating Pattern for Americans; MFIS-SCI: Modified Fatigue Impact Scale spinal cord injury; MMSE: Mini-Mental State Examination; MSNQ: Multiple Sclerosis Neuropsychological Questionnaire; mRS: Modified Rankin Scale; NIHSS: National Institutes of Health Stroke Scale; NINDS-CSN: National Institute of Neurological Disorders and Stroke and Canadian Stroke Network; OL-RBMT: Online Rivermead Behavioral Memory Test; PDDS: Patient Determined Disease Steps; PROMIS-10: Patient-Reported Outcomes Measurement Information System 10-Question Short Form; PDQ-39: 39-item Parkinson's Disease Questionnaire; SCI-SCS: Spinal Cord Injury–Secondary Conditions Scale; SF-AI: self-reported ambulation index; SIS: Stroke Impact Scale; smRSq: Simplified Modified Rankin Scale Questionnaire; sSDMT: Smartphone-adapted Symbol Digit Modalities Test; TRS: Fahn-Tolosa-Marin Tremor Rating Scale; TCOVS: Telephone Clinical Outcome Variables Scale; T-EDSS: Telephone-based Expanded Disability Status Scale; tele-EDSS: Telemedicine-enabled Expanded Disability Status Scale; TICS: Telephone interview for cognitive status; TICSm: Telephone interview for cognitive status modified 13-item; TICS-M: Brazilian version of the Modified Telephone Interview for Cognitive Status; T-MoCA: Telephone Montreal Cognitive Assessment.
The instruments with a total score greater than or equal to nine should be shaded (first nineteen lines). (≥ 9 in the Tyson & Connell scale).[19,28,29]

during telerehabilitation in individuals with neurological conditions, ensuring greater precision and confidence in the outcomes. Measurement error, content validity, structural validity, and responsiveness need to be further investigated. In addition, the measurement properties of tools used in telerehabilitation in other neurological conditions, such as Huntington's disease, should also be investigated.

Clinical messages

It is essential that researchers and clinicians choose measurement tools that have adequate measurement properties as well as clinical utility. Eight measurement tools, used in individuals with stroke, spinal cord injury, or Alzheimer's disease, all administered by telephone, are recommended for use in telerehabilitation in clinical practice.

Author contributions

S.A.F.B: conceptualization, methodology, project administration, investigation, writing. A.A.S.: conceptualization, methodology, project administration, investigation, supervision, writing. P.C.P.: conceptualization, methodology, project administration, investigation, writing. C.D.C.M.F.: conceptualization, methodology, project administration, investigation, supervision, writing.

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Supplemental material

Supplemental material for this article is available online.

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Supplementary material 1. Search strategy

MEDLINE E EMBASE

1	Telerehabilitation.mp. or Telemedicine/ or Telerehabilitation/ or Remote Consultation/ or Home Care Services/ OR Telemetry.mp. or Telemetry/ OR Video.mp. OR Remote Sensing Technology.mp. or Remote Sensing Technology/ OR Text Messaging.mp. or Internet/ or Text Messaging/ or Cell Phone/ OR mobile health.mp. OR tele health.mp. OR Mobile Applications/ or mobile.mp. OR computer.mp. or Computers/ OR email.mp. or Electronic Mail/ OR Virtual Reality/ or virtual.mp. OR telecommunication.mp. or Telecommunications/ OR remotely.mp. OR telephone.mp. or Telephone/ OR social media.mp. or Social Media/ OR smartphone.mp. or Cell Phone/ or Computers, OR Handheld/ or Smartphone/ or Internet/ OR Web Browser/ or web.mp.
2	Agreement.mp. OR Psychometrics/ or "Reproducibility of Results"/ or Consistency.mp. OR Internal consistency.mp. OR Validity.mp. OR Reliability.mp. OR Ceiling effect.mp. OR Floor effect.mp. OR Sensitivity.mp. or "Sensitivity and Specificity"/ OR Accuracy.mp. or Data Accuracy/ OR "Reproducibility of Results"/ or Reproducibility.mp. OR Repeatability.mp. OR Applicability.mp. OR Responsiveness.mp. or Psychometrics/ OR Psychometric properties.mp. OR Clinimetric properties.mp. OR Psychometric data.mp. OR Instrument psychometrics.mp. OR Psychometric tests.mp. OR Change score.mp. OR Difference score.mp. OR Generalizability.mp. OR Minimal clinically important difference.mp. or Minimal Clinically Important Difference/MCID.mp. OR Feasibility Studies/ or Feasibility.mp.
3	Nervous System Diseases.mp. or Nervous System Diseases/ OR Brain disease.mp. or Brain Diseases/ OR Traumatic brain injury.mp. or Brain Injuries, Traumatic/ OR Cerebrovascular disorder.mp. or Cerebrovascular Disorders/ OR Stroke/ or Stroke.mp. OR Basal ganglia disease.mp. or Basal Ganglia Diseases/ OR Parkinson.mp. or Parkinson Disease/ OR Dystonia.mp. or Dystonia/ OR Cerebellar disease.mp. or Cerebellar Diseases/ OR Ataxia.mp. or Ataxia/ OR Multiple sclerosis.mp. or Multiple Sclerosis/ OR Spinal cord injury.mp. or Spinal Cord Injuries/ OR Myelitis, Transverse/ or Myelitis/ or Myelitis.mp. OR Poliomyelitis.mp. or Poliomyelitis/ OR Peripheral nerve injury.mp. or Peripheral Nerve Injuries/ OR Neuromuscular disease.mp. or Neuromuscular Diseases/ OR Alzheimer Disease/ or Alzheimer.mp. OR Movement disorder.mp. or Movement Disorders/ OR Hemorrhagic Stroke/ or Stroke/ or Stroke.mp. or Ischemic Stroke/
4	1 AND 2 AND 3

PeDRO

1	Telemedicine or Telerehabilitation or "Remote Consultation" or "Home Care Services" or Telemetry or Video or "Remote Sensing Technology" or "Text Messaging" or "Cell Phone" or "Mobile Health" or "Tele Health" or "Mobile Applications" or Mobile or Computers or Email or "Electronic Mail" or "Virtual Reality" or Virtual or Telecommunications or Remotely or Telephone or "Social Media" or Smartphone or "Cell Phone" or Handheld or Smartphone or Internet or "Web Browser"
2	Agreement or Psychometrics or "Reproducibility of Results" or Consistency or "Internal Consistency or Validity or Reliability or "Ceiling Effect" or "Floor Effect" or Sensitivity or Specificity or Accuracy or Data Accurac or Reproducibility or Repeatability or Applicability or Responsiveness or "Psychometric Properties" or "Clinimetric Properties" or "Psychometric Data" or "Instrument Psychometrics" or "Psychometric Tests" or "Change Score" or "Difference Score" or Generalizability or "Minimal Clinically Important Difference" or MCID or Feasibility
3	"Nervous System Diseases" or "Brain Disease" or "Traumatic Brain Injury or "Cerebrovascular Disorders" or Stroke or "Basal Ganglia Diseases" or "Parkinson Disease" or Dystonia or "Cerebellar Diseases" or Ataxia or "Multiple Sclerosis" or "Spinal Cord Injuries" or Myelitis or Poliomyelitis or "Peripheral Nerve Injuries" or 'Neuromuscular Diseases' or "Alzheimer Disease" or "Movement Disorders" or "Hemorrhagic Stroke" or Stroke or "Ischemic Stroke"
4	Abstract & Title: [term of list 01] AND [term of list 02] AND [term of list 03] Methods: Clinical trial

SCIELO

1	Telemedicine or Telerehabilitation or "Remote Consultation" or "Home Care Services" or Telemetry or Video or "Remote Sensing Technology" or "Text Messaging" or "Cell Phone" or "Mobile Health" or "Tele Health" or "Mobile Applications" or Mobile or Computers or Email or "Electronic Mail" or "Virtual Reality" or Virtual or Telecommunications or Remotely or Telephone or "Social Media" or Smartphone or "Cell Phone" or Handheld or Smartphone or Internet or "Web Browser"
2	Agreement or Psychometrics or "Reproducibility of Results" or Consistency or "Internal Consistency or Validity or Reliability or "Ceiling Effect" or "Floor Effect" or Sensitivity or Specificity or Accuracy or Data Accurac or Reproducibility or Repeatability or Applicability or Responsiveness or "Psychometric Properties" or "Clinimetric Properties" or "Psychometric Data" or "Instrument Psychometrics" or "Psychometric Tests" or "Change Score" or "Difference Score" or Generalizability or "Minimal Clinically Important Difference" or MCID or Feasibility
3	"Nervous System Diseases" or "Brain Disease" or "Traumatic Brain Injury or "Cerebrovascular Disorders" or Stroke or "Basal Ganglia Diseases" or "Parkinson Disease" or Dystonia or "Cerebellar Diseases" or Ataxia or "Multiple Sclerosis" or "Spinal Cord Injuries" or Myelitis or Poliomyelitis or "Peripheral Nerve Injuries" or 'Neuromuscular Diseases' or "Alzheimer Disease" or "Movement Disorders" or "Hemorrhagic Stroke" or Stroke or "Ischemic Stroke"
4	Abstract & Title: [term of list 01] AND [term of list 02] AND [term of list 03] Methods: Clinical trial

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1	"Nervous System Diseases" OR "Brain disease" OR "Traumatic brain injury" OR "Cerebrovascular disorder" OR Stroke OR "Basal ganglia disease" OR Parkinson OR Dystonia OR Cerebellar disease OR Ataxia OR "Multiple sclerosis" OR "Spinal cord injury" OR Myelitis OR Poliomyelitis OR "Peripheral nerve Injuries" OR "Neuromuscular disease" OR "Alzheimer Disease" OR "Movement disorders" [Palavras]
2	Telerehabilitation OR Telemedicine OR "Remote Consultation" OR "Home Care Services" OR Telemetry OR Video OR "Remote Sensing Technology" OR "Text Messaging" OR "Cell Phone" OR "mobile health" OR "tele health" OR "Mobile Applications" OR Computers OR email OR virtual OR telecommunication OR remotely OR telephone OR "social media" OR smartphone OR web-based [Palavras]
3	Agreement OR Psychometrics OR "Reproducibility of Results" OR Consistency OR "Internal consistency" OR Validity OR Reliability OR "Ceiling effect" OR "Floor effect" OR Sensitivity OR "Sensitivity and Specificity" OR Accuracy OR "Reproducibility of Results" OR Repeatability OR Applicability OR Responsiveness OR Psychometrics OR "Psychometric properties" OR "Clinimetric properties" OR "Psychometric data" OR "Instrument psychometrics" OR "Psychometric tests" OR "Change score" OR "Difference score" OR Generalizability OR "Minimal clinically important difference" OR "Minimal Clinically Important Difference" OR MCID OR Feasibility [Palavras]
4	1 AND 2 AND 3

Supplementary material 2. Characteristics of the included studies and measurement properties of telephone-administered measurement tools for individuals with neurological conditions.

Measurement tool – Language	Study populations		Characteristics of the disease		Results
	n total; Gender, female: n (%)	Age, in years: mean±SD	Type of neurological disease	Disease duration: mean ± SD	
BCRS - English **BEHAVE-AD** -English **FAST** - English **GDS** - English **MMSE** – English [36]	30; 17 (56.70)	77.60±7.80	Alzheimer's Disease	NR	**BCRS:** ICC= 0.98 (**Test-retest**), 0.94 (**Inter-rater reliability**) **BEHAVE-AD:** ICC= 0.89 (**Test-retest**), 0.94 (**Inter-rater reliability**) **FAST:** ICC= 0.99 (**Test-retest**), 0.94 (**Inter-rater reliability**) **GDS:** ICC= 0.99 (**Test-retest**), 0.92 (**Inter-rater reliability**) **MMSE:** ICC= 0.98 (**Test-retest**), 0.98 (**Inter-rater reliability**) ($p \leq 0.05$ for all)
Braztel-MMSE – Portuguese [47]	Group 1: 17; 7 (47); Grupo 2: 17; 11 (65); Grupo 3: 17; 8 (47)	Group 1: 72.80±5.60; Group 2: 75.80±6.40; Group 3: 74.40±4.80	Alzheimer's Disease	NR	Spearman correlation= 0.92; test-t= –1.03 (p= 0.309) **(Test-retest reliability)** Spearman correlation= 0.92; test-t= 2.186 (p= 0.036); -4.022 (p<0.001); AUC = 0.98 (CI95% = 0.96–1.00). **(Criterion validity)** (p<0.01 for all)
I-TICS – Italian [70]	45; 28 (62)	73.90±8.80	Alzheimer's Disease	NR	Cronbach alpha= 0.91 **(Internal consistency)** ICC (MMSE)= 0.73 (p<0.001) **(Test-retest reliability)** Pearson correlation (MMSE)= 0.90 (p<0.001) **(CV: Hypotheses testing)** Cutoff score= 28, sensitivity= 84%, specificity= 86%, AUC-ROC= 0.89 (95%CI=0.83-0.96); Cohen's K= 0.72 **(Criterion validity)**
TELE – Finnish **TICS** – Finnish [65]	30; 15 (50)	70±6.30	Alzheimer's Disease	NR	**TELE:** Pearson correlation= 0.78 (MMSE, whole group and patient group), -0.71 (CDR-SB, patient group) (p<0.001 for all) (**CV: Hypotheses testing**); cutoff score= 17.0, sensitivity= 90%, specificity= 88.50%, AUC-ROC= 96% (SE= 2.40%) (**Criterion validity**) **TICS:** Pearson correlation= 0.86 (MMSE, whole group), 0.77 (MMSE, patient group), -0.75 (CDR-SB, patient group) (p<0.001 for all)) (**CV: Hypotheses testing**); cutoff score= 26, sensitivity= 86.70%, specificity=8 8.50%, AUC-ROC= 90.3% (SE= 4.2%) (**Criterion validity**)
TICS-J – Japanese [71]	49; 30 (61.2)	75.20±6.80	Alzheimer's Disease	NR	ICC= 0.95 (p<0.001) **(Test-retest reliability)** Pearson correlation= 0.74 (p<0.001) **(CV: Hypotheses testing)** Cutoff score= 33, sensitivity= 98%, specificity= 90.7%, AUC-ROC= 0.99 (95%CI= 0.98-1) **(Criterion validity)**

TMMSE – English [46]	46; 24 (52.2)	76.50	Alzheimer's disease	NR	Pearson correlation= 0.88 (p<0.001) (MMSE and TMMSE), 0.36-0.75 (p<0.05) (all sub scores for the in-person and telephone) **(Criterion validity)**
EDSS **PDDS** – Spanish [39]	103; 69 (67)	44.30±14.70	Multiple Sclerosis	12.80±14.30 years	**EDSS:** Cronbach alpha= 0.99 **(Internal consistency)** ICC 0.96 (95%CI= 0.92-0.98) **(Test-retest reliability)**; Kappa=0.37 (95%CI=0.26-0.48) **(Inter-rater reliability)** Spearman correlation= 0.68 **(CV: Hypotheses testing);** 0.94 **(Criterion validity)** **PDDS:** Cronbach alpha= 0.96 **(Internal consistency)** ICC=0.97 (95%CI= 0.94-0.99) **(Test-retest reliability)**; Kappa= 0.68 (95%CI=0.57-0.79) **(Inter-rater reliability)** Spearman correlation= 0.62 **(CV: Hypotheses testing)**; 0.88 **(Criterion validity)** **Content validity** was assessed by a panel of experts (p<0.001 for all)
LE-MAL – English [44]	43; 33 (76.70)	55.40±11.30	Multiple Sclerosis	NR	Cronbach alpha≥ 0.92 **(Internal consistency)** ICC> 0.94 **(Test-retest reliability)** CFA= 0.06-0.98; CFI= 0.99; TLI= 0.98; RMSEA= 0.13 **(CV: Structural validity)** Spearman correlation= -0.77 (MSWS-12), -0.72 (PDDS), -0.68 (Mobility Scale) (p<0.001 for all) **(CV: Hypotheses testing)**
T-EDSS – Urdu [40]	47; 30 (63.80)	38.70±10.30	Multiple Sclerosis	NR	Cronbach alpha=0.59 (score< 4.50), 0.79 (score> 4.5) **(Internal consistency)** Pearson correlation (EDSS) and ICC= 0.64**;** test-t: p<0.001 **(Criterion validity)**
MFIS-SCI – English [48]	42; 10 (23.80)	48±19	Spinal Cord Injury	336.50±55 days	Cronbach alpha=0. 97 (total), 0.96 (cognitive), 0.92 (physical), 0.82 (psychosocial) **(Internal consistency)** Pearson correlation= MFIS-SCI and FSS (r=0.69, p<0.01); MFIS-SCI AND FSS (r=0.64, p<0.0001) **(CV: Hypotheses testing)** Cutoff score= 24.5, sensitivity= 67%, specificity= 67%; AUC-ROC= 0.78 (95%CI= 0.65–0.92) **(Criterion validity)**
SCI-SCS [62]	40; 8 (20)	Median 54 (IQR=48-63)	Spinal Cord Injury	Median 28 (IQR=14-35) years	ICC (95%CI)= 0.96 (0.93-0.98) **(Inter-rater reliability)** ICC (95%CI)= 0.90 (0.83-0.95) **(Criterion validity)**
TCOVS – English [66]	Validity: 37; 6 (14) Reliability: 43; 8 (19)	Validity: 41±18 Reliability: 46±10	Spinal Cord Injury	Validity: 8±3.70 months	ICC= 0.98, Bland Altman: mean of the differences= -2 (95% limits of agreement= -9.80-6.50); mean of the differences= 0, 95% (limits of agreement= -4.10-3.7) **(Criterion validity)** ICC> 0.95 for all items **(Test-retest reliability)**

ABILHAND –Portuguese [30]	102; 52 (51)	65±13	Stroke	37±38 months	ICC= 0.90 (95%CI= 0.85-0.93) **(Criterion validity)**
ABILOCO –Portuguese [31]	92; 47 (51)	65±12	Stroke	37±40 months	ICC= 0.90 (95%CI= 0.84-0.93) **(Criterion validity)**
BI - Malay or English **Mrs** - Malay or English [35]	132; 34 (25.80)	52.20±13.76	Stroke	NR	**BI:** ICC= 0.99 **(Inter-rater reliability)** **mRs:** ICC= 0.96 (95%CI =0.94-0.97); Fleiss' κF, Conger's κC and Light's κL Kappa statistics= 0.72; Nelson's model based κm kappa statistic= 0.69 (95%CI=0.67-0.71); Nelson's model-based weighted kappa= 0.87 (95%CI= 0.86-0.89) **(Inter-rater reliability)**
BI [34]	120; NR	18-75	Stroke	7-30 days	3 months: Correlation= -0.90 (mRS), -0.40 (NIHSS) (p<0.05 for all); Test-t: p= 0.37; Weighted Kappa= 0.63 (95%CI= 0.61-0.68) **(Criterion validity)**; Cronbach alpha= 0.89 **(Internal consistency)** 6 months: Correlation= -0.90 (mRS), -0.40 (NIHSS) (p<0.05 for all); Test-t: p= 0.68; Weighted Kappa= 0.72 (95%CI= 0.70-0.77) **(Criterion validity)**; Cronbach alpha= 0.95 **(Internal consistency)**
BI – Italian [33]	131; NR	73.90±13.30	Stroke	7.50±5.20 days	Test-t: p= 0.76 (in-person first), p= 0.88 (telephone first); Weighted Kappa= 0.90 (95%CI= 0.85-0.94) **(Criterion validity)**
HUI2/3 – English [75]	76; 29 (40)	64±14	Stroke	99±125 days	Content validity was assessed as part of this study by interviewer impressions **(Content validity)** **HUI2:** ICC= 0.73 **(Inter-rater reliability)**; 0.76 **(Test-retest reliability)**; Pearson correlation= -0.18-0.70 (between interscale and overall HUI2), -0.77-0.14 (between interscale and overall HUI3), 0.88 (HUI2 and HUI3) **(CV: Hypotheses testing)** **HUI3:** ICC= 0.79 **(Inter-rater reliability)**, 0.75 **(Test-retest reliability)**; Pearson correlation=-0.74 to -0.07(between interscale and overall HUI3) **(CV: Hypotheses testing)**
mRS – Portuguese [51]	50; 24 (48)	62.80±14.70	Stroke	171±137 days	Kappa= 0.61; Quadratic Kappa= 0.63 **(Inter-rater reliability)** In-person and telephone versions: Kappa= 0.34 (unweighted), 0.82 (quadratic), Kappa (caregivers)= 0.30 (unweighted), 0.61 (quadratic), Wilcoxon test: p= 0.35, Quadratic Kappa= 0.93 **(Criterion validity)**
NINDS-CSN -Chinese **Six-item screener** – Chinese [59]	89; 31 (34.80)	62.90±8.60	Stroke	2.80 (1.70–7) months	**NINDS-CSN:** Cutoff score= 23.5/24, sensitivity= 87-100%, specificity= 56-73%, PPV= 68-76%, NPV= 86-100%, AUC-ROC= 0.86 (95%CI=0.78-0.94) **(Criterion validity)** **SIS:**

					Cutoff score= 4/5, sensitivity= 46-85%, specificity= 34-90%, PPV= 55-82%, NPV= 64-70%, AUC-ROC= 0.74 (95%CI=0.63-0.85) **(Criterion validity)**
SIS – English [63]	234; 4 (1.70)	68.84±12.20	Stroke	10-13 weeks	Cronbach alpha≥ 0.76 **(Internal consistency)** ICC=0.68-0.98 **(Test-retest reliability)**
SIS – English [64]	136; 3 (2.20)	68.04±12	Stroke	12–16 weeks	Pearson correlation= 0.40-0.86 (FIM domains), 0.36-0.77 (SF-36V domains) (p<0.001) **(CV: Hypotheses testing)**
SmRSq – English [50]	50; 26 (52)	61±14	Stroke	4.83±3 months	Kappa= 0.76-0.77 (95%CI= 0.63-0.90); Weighted Kappa= 0.87-0.89 (95%CI= 0.79-0.96) **(Inter-rater reliability)** Biserial correlation= r= -0.50 (p< 0.005) (physical component-SF-12v2), r= -0.36 (p=0.048) (mental component-SF-12v2) **(CV: Hypothesis testing)**
TICS – English [68]	36; 22 (61.10)	72.30±8.90	Stroke	NR	Pearson correlation= 0.90 (p<0.001) **(Test-retest reliability)**; 0.86 (p<0.001) **(CV: Hypothesis testing)** Cutoff score (dementia)< 25, sensitivity= 100%, specificity= 83% **(Criterion validity)**
TICS - English **TICSm** – English [67]	64; NR	Median 72 (IQR=63-80)	Stroke	Median 118 (IQR=84-142) days	**TICS:** Pearson correlation (R-CAMCOG)= 0.83 (95%CI= 0.74-0.90, p<0.001); cutoff score≤ 28, sensitivity= 88%, specificity= 85%, AUC-ROC (dementia)= 0.94 **(Criterion validity)** **TICSm:** Pearson correlation (R-CAMCOG)= 0.86 (95%CI=0.77-0.91, p<0.001); cutoff score≤ 20, sensitivity= 92%, specificity= 80%, AUC-ROC (dementia)= 0.94 **(Criterion validity)**
TICS - German **T-MOCA** – German [73]	96; 32 (33.3)	69±8.90	Stroke	NR	**T-TICS:** Multiple-Tests Definition: AUC-ROC= 0.76 (95%CI= -0.88-0.83) (any MCI); 0.83 (95%CI= 0.62-1) (Multidomain) **(Criterion validity)** **T-MoCA:** Multiple-Tests Definition: AUC-ROC= 0.82 (95%CI= 0.71-0.94) (any MCI); 0.94 (95%CI= 0.88-1) (multidomain) **(Criterion validity)**
TICS-M-Brazilian – Portuguese [72]	61; 22 (36.10) (with cognitive impairment: 8 (57.10); without cognitive impairment: 14 (29.80))	61.90±12.3 (with cognitive impairment: 69.6±10.50; without cognitive impairment: 59.7±11.9)	Stroke	6 months	Cronbach alpha= 0.96 **(Internal consistency)** ICC= 0.87-0.97 **(Intra-rater reliability and Test-retest reliability)** (p<0.001 for all) **(Criterion validity)** Pearson correlation=0.87-097 **(Intra-rater reliability and Test-retest reliability)**, Pearson= 0.88-0.90 (in-person and telephone) (p<0.001 for all); Cutoff score= 14-15, sensitivity= 91.50%, specificity= 71.40%, AUC-ROC (MMSE)= 0.89 (95%CI=0.80-0.98) **(Criterion validity)** Factor loading>0.30 for all items **(Structural validity)**

mRS – Dutch [49]	83; 64 (77)	56 (28-84)	Subarachnoid Haemorrhage	5 months (1-114)	Kappa= 0.41 (95%CI= 0.26-0.55), Weighted Kappa= 0.71 (95%CI= 0.59-0.82), Wilcoxon test for matched pairs: *p*=0.33 **(Criterion validity)**
MoCA 5-minute protocol –Cantonese [74]	Normal: 53; 27 (51); Cognitively Impaired: 51; 19 (37)	Normal: 68.90±10.10; Cognitively Impaired: 70.80±9.2	TIA or Stroke	39.40±7.60 months	Cronbach alpha= 0.79 **(Internal consistency)** ICC=0.89 (95%CI=0.77-0.95, *p*<0.001) **(Test-retest reliability)** Bland Altman (MoCA 5-minute protocol and MoCA): mean of the differences=-1.8, 95% limits of agreement= -7.4-3.8; Pearson correlation (MoCA)= 0.87 (*p*<0.001); AUC-ROC=0.78 (SE=0.05) **(Criterion validity)**
PROMIS-10 Global Health – Dutch [58]	75; 24 (32)	68.90±11.20	TIA or Stroke	NR	Cronbach alpha= 0.77 (physical-RAND-36), 0.80 (mental-RAND-36) **(Internal consistency)** Pearson correlation= 0.77 (95%CI=0.54, 0.91) (physical-PROMIS 10 and physical-RAND-36), 0.70 (95%CI=0.50, 0.86) (mental-PROMIS 10 and mental-RAND-36) (*p*<0.001 for all) **(CV: Hypotheses testing)** Bland Altman: mean of the differences=-1.90, 95% limits of agreement=-14.80, 11 (physical-RAND-36); mean of the differences=0.10, 95% limits of agreement=-13.70, 14 (mental-RAND-36) **(Criterion validity)**
TICSm - English **T-MoCA** - English **T-MoCA-Short** –English [69]	91; 37 (40.60)	73.40±7	TIA or Stroke	>1 year	**TICSm:** Detection of MCI: Cutoff score< 24 (sensitivity= 78%, specificity= 61%, PPV= 57%, NPN= 81%), <25 (sensitivity= 85%, specificity= 56%, PPV= 56%, NPN= 85%), AUC-ROC= 0.79 (CI95%= 0.68-0.90) **(Criterion validity)** **T-MoCA:** Detection of MCI: Cutoff score< 18 (sensitivity= 81%, specificity= 59%, PPV= 56%, NPN= 83%), <19 (sensitivity= 89%, specificity= 46%, PPV= 52%, NPN= 86%), AUC-ROC= 0.75 (CI95%= 0.64-0.87) **(Criterion validity)** **T-MoCA-Short:** Detection of MCI: Cutoff score< 10 (sensitivity= 70%, specificity= 51%, PPV= 49%, NPN= 72%), <11 (sensitivity= 96%, specificity= 39%, PPV= 51%, NPN= 94%), AUC-ROC= 0.72 (CI5%= 0.60-0.84) **(Criterion validity)**
Ohio State University Traumatic Brain Injury Identification Method modified – English [56]	194; 134 (69.10)	NR	Traumatic Brain Injury	NR	ICC=0.06-0.78; Kappa= 0.32-0.62 **(Test-retest reliability)**

Legend: 95%CI: 95% confidence interval; AUC-ROC: area under the ROC curve; BCRS: Brief Cognitive Rating Scale; BEHAVE-AD: Behavioral Pathology in Alzheimer's Disease Rating Scale; BI: Barthel Index; CDR-SB: Clinical Dementia Rating scale; CFA: Confirmatory factor analyses; CFI: comparative fit index; CV: Construct validity; EDSS: Expanded Disability Status Scale; FAST: Functional Assessment Staging; FIM: Functional Independence Measure; FSS: Fatigue Severity Scale; GDS: Global Deterioration Scale; HUI2/3: Health Utilities Index Mark 2 and 3; ICC: Intraclass coefficient correlation; IQR: interquartile range; I-TICS: Italian telephone interview for cognitive status; LE-MAL: Lower-Extremity Motor Activity Log; MCI: mild cognitive impairment; MFIS-SCI: Modified Fatigue Impact Scale spinal cord injury; MMSE: Mini-Mental State Examination; mRS: Modified Rankin Scale; MSWS-12: Multiple Sclerosis Walking Scale-12; NIHSS: National Institutes of Health Stroke Scale; NINDS-CSN: National Institute of Neurological Disorders and Stroke

and Canadian Stroke Network; NPV: negative predictive value; NR: Not Reported; PDDS: Patient Determined Disease Steps; PPV: positive predictive value; PROMIS-10: Patient-Reported Outcomes Measurement Information System 10-Question Short Form; RAND-36: measure of health-related quality of life; RMSEA: root mean square error of approximation; R-CAMCOG: a modified version of the cognitive and self-contained part of the Cambridge Examination for Mental Disorders of the Elderly; SCI-SCS: Spinal Cord Injury-Secondary Conditions Scale; SE: standard error; SF-12v2: Short-Form-12 version 2; SF-36V: Short Form-36 for Veterans; SF-AI: self-reported ambulation index; SIS: Stroke Impact Scale; smRSq: Simplified Modified Rankin Scale Questionnaire; TCOVS: Telephone Clinical Outcome Variables Scale; T-EDSS: Telephone-based Expanded Disability Status Scale; tele-EDSS: Telemedicine-enabled Expanded Disability Status Scale; TIA: Transient Ischemic Attack; TICS: Telephone interview for cognitive status; TICS-J: Japanese version of the Telephone interview for cognitive; TICSm: Telephone interview for cognitive status modified 13-item; TICS-M: Brazilian version of the Modified Telephone Interview for Cognitive Status; TLI: Tucker-Lewis index; TMMSE: Telephone Mini-Mental State Examination; T-MoCA: Telephone Montreal Cognitive Assessment; T-MoCA-Short: Telephone Montreal Cognitive Assessment (verbal fluency, recall and orientation; total 12 points)

Supplementary material 3. Characteristics of the included studies and measuring properties of the measurement tools administered by e-mail, videoconference, online assessment, online software, smartphone and multimedia system in individuals with neurological diseases.

Measurement tool – Language	Populations of the study		Characteristics of the disease		Results
	n total; Gender, female: n (%)	Age, in years: mean±SD	Type of neurological disease	Duration of disease: mean±SD	
E-mail with the link to the website					
eMSQOL-29 –Italian [52]	623; 424 (68.10)	44.30±11.50	Multiple Sclerosis	10 (1-47) years	Cronbach alpha= 0.88-0.90 **(Internal consistency)** CFA= 0.06 (RMSEA), 0.99 (CFI), 0.04 (SRMR) (**CV: Structural Validity)** Pearson correlation= 0.62-0.86; ICC= 0.52-0.95**;** Cohen's *d*= 0.30-2.43 (**Criterion validity)**
Multimedia system					
6MWT **SF-AI** **EDSS** – Spanish [32]	23; 12 (52.20)	46.70±10	Multiple Sclerosis	14.20±9.90 years	**6MWT:** Pearson correlation= 0.76 (p<0.01) **(Criterion validity)** **SF-AI:** Kappa=0.50 (95%CI=0.30, 0.70) **(Inter-rater reliability)** **EDSS:** Kappa=0.40 (95%CI=0.30, 0.50) (conventional and multimedia), 0.30 (95%CI=0.10, 0.50) (conventional and telephonic) **(Inter-rater reliability)**
Online assessment					
MSNQ [42]	82; 64 (78)	44.50±8.90	Multiple Sclerosis	114.50±89.10 months	**Patient self-report version MSNQ:** Cronbach alpha= 0.91 **(Internal consistency)** ICC=0.82 (p<0.001), *t* (scores)= -1.10 (p= 0.285) **(Test-retest reliability)** Pearson correlation=0.62 (CES-D), -0.23 (SRT-D), -0.27 (PASAT 3 s and 2 s) (p<0.05 for all) **(CV: Hypotheses testing)** AUC-ROC (BRB-N)= 0.57; cutoff≥ 29; sensitivity= 69; specificity= 41.5 **(Criterion validity)** **Informant version MSNQ:** Cronbach alpha=0.93 **(Internal consistency)** ICC=0.77 (p<0.001), *t*=1.32 (p=0.200) **(Test-retest reliability)** Pearson correlation=0.44 (CES-D), -0.42 to -0.23 (all measures of the BRB-N) (p<0.05 for all) **(CV: Hypotheses testing)** AUC-ROC= 0.71; cutoff≥ 26; sensitivity= 72.4; specificity= 60.4 **(Criterion validity)**
OL-RBMT –Chinese [57]	30; NR	NR	Stroke	NR	ICC= 0.94 (0.46-0.97) **(Test-retest reliability)** Mann-Whitney U test (stroke and non-stroke group): Z=-4.04 (p<0.001) **(CV: Hypotheses testing)**

					ICC: 0.90 (in-person and online RBMT, total score), 0.90 (in-person and online RBMT=screening score), Spearman correlation (NCSE)=0.80 (p<0.001) (**Criterion validity)**
Online software					
MEPA-III – English [45]	44; 22 (50)	62.40±12.10	Parkinson's Disease	Median 6 (IQR=4-12) years	Pearson correlation (FFQ)=0.50 (p<0.001); Kappa≥ 0.31 (p< 0.05) **(Criterion validity)**
PDQ-39 – English [76]	118; 52 (44.1)	63.48±8.66	Parkinson's Disease	5.73±4.34 years	Cronbach alpha=0.64-0.95; Item-total correlations=0.34-0.90 **(Internal consistency)** Pearson correlation=0.27 (p<0.01) (disease duration), -0.27 (p<0.01) (age at diagnosis) **(CV: Hypotheses testing)**
Smartphone application					
Smartphone-Based Self-Administered 2-Minute Walk Test [61]	76; 53 (69.70)	39.50±7.90	Multiple Sclerosis	11.30±7.00 years	Temporal gait characteristics: ICC=0.68-0.94 (p<0.001) **(Test-retest reliability)** SEM=0.01-0.08, SEM%=2.35-67.33; MDC=0.02-0.23, MDC%=6.88-186.63 **(Measurement error)** Spatial and spatiotemporal gait characteristics: ICC=0.53-0.96 (p<0.001) **(Test-retest reliability)** SEM=0.02-0.25, SEM%=4.16-53.39; MDC=0.05-0.69, MDC%=1.53-148.00 **(Measurement error)**
sSDMT [60]	92; 68 (73.9)	46.90±10.10	Multiple Sclerosis	Median 6.3 (IQR=3.10-4.10) years	ICC=0.88-0.93; Bland-Altman: mean of the differences= -0.2, 95% limits of agreement=-6.70-6.20 **(Test-retest reliability)** SEM= 2.33-3.12, SDC= 6.47-8.58 **(Measurement error)** Correlation coefficients= 0.69-0.69 (SDMT), 0.49-0.50 (CVLT), 0.54-0.56 (BVMT-R), -0.48-0.49 (EDSS) (p<0.001 for all) **(CV: Hypotheses testing)** Bland-Altman (clinical and smartphone): mean of the differences=9.40, 95% limits of agreement=-5.60-24.30; AUC= 0.92 (p< 0.001) **(Criterion validity)**
Videoconferencing assessment					
ADAS-Jcog –Japanese [43]	73; 37 (50.70)	76.30±7.60	Alzheimer's Disease	NR	ICC=0.86; Subgroups: 0.63 (MCI), 0.80 (dementia) **(Criterion validity)**
tele-EDSS –Japanese [41]	41; 33 (80)	47±11.60	Multiple Sclerosis	13.40±9.60 years	Pearson correlation= 0.89 (p<0.001) (in-person and tele) Bland Altman: mean of the differences= 0.34, 95% limits of agreement= -1.30-1.99 ICC= 0.89 (95%CI= 0.80-0.94, p<0.001); Kappa= 0.72 (p<0.001) **(Criterion validity)**
CRT **FTT**	21; 9 (44.70)	70.90±9.60	Parkinson's Disease	8±5.50 years	ICC> 0.75 (for the four instruments) (**Inter-rater reliability)** Mean difference (95%CI) (in-person and tele): **CRT**: 0.30±1.20 (-0.20, 0.80) (most affected upper limb), 0.30±1.40 (-0.40,0.90) (least affected

Kinovea version 0.8.15 software **MAM-16** - Spanish **TRS** – Spanish [37]					upper limb); **FTT**: 0.00 (0.00, 0.00) (both: most and least affected upper limb); **TRS:** 0.80±1.30 (0.30, 1.40) **MAM-16** (in-person and tele): Bland Altman: mean of the differences = 0.25±1.45, 95% limits of agreement = -2.59, 3.09
NIHSS – English [55]	100; 45 (45)	72 (30–96)	Stroke	NR	Pearson correlation= 0.95 (p<0.001); Bland Altman (95% limits of agreement)= -4.44-5.61 **(Criterion validity)**
NIHSS – English [53]	20; 8 (40)	70.50±9.50	Stroke	Median 16.50 days (IQR=NR)	ICC= 0.97 (p<0.001); Kappa=-0.07-0.83 (each item) (**Inter-rater reliability)**
NIHSS [54]	20; 9 (45)	NR	Stroke	NR	Test-t: p= 0.13, p= 0.90 (probability value); Pearson correlation= 0.96 (p= 0.001) **(Test-retest reliability)**
FRT **ESS** – English [38]	26; 8 (30.80)	64 (25-81)	Stroke	2.70 years (2 months to 15 years)	Wilcoxon signed rank test: Z= -0.24 (p>0.05) **(Criterion validity)**

Legend: 6MWT: 6-min walk test; 95%CI: 95% confidence interval; ADAS-Jcog: Japanese version of Alzheimer's Disease Assessment Scale Cognitive Subscale; AUC-ROC: area under the ROC curve; BRB-N: Brief Repeatable Battery of Neuropsychological Tests; BVMT-R: Brief Visuospatial Memory Test-Revised; CES-D: Center for epidemiological studies depression scale; CFA: Confirmatory factor analyses; CFI: comparative fit index; CRT: Coin Rotation Task; CV: Construct validity; CVLT: California Verbal Learning Test; EDSS: Expanded Disability Status Scale; eMSQOL-29: electronic format Multiple Sclerosis Quality of Life; ESS: European Stroke Scale; EQ-5D: European quality of life five dimensions; EQ-5D-3L: European Quality of life Five Dimensions-3L; FAMS: Functional Assessment of Multiple Sclerosis; FFQ: Food Frequency Questionnaire; FRT: Functional Reach Test; FTT: Finger Tapping Test; HADS: Hospital Anxiety and Depression Scale; ICC: intraclass coefficient correlation; IQR: interquartile range; MAM: Manual Ability Measure; MCI: mild cognitive impairment; MD: mean difference; MDC: minimum detectable change; MEPA-III: Mediterranean Eating Pattern for Americans; MSNQ: Multiple Sclerosis Neuropsychological Questionnaire; NCSE: Neurobehavioral Cognitive Status Examination; NIHSS: National Institutes of Health Stroke Scale; NR: not reported; OL-RBMT: Online Rivermead Behavioral Memory Test; PASAT: Paced Auditory Serial Addition Test; PDQ-39: 39-item Parkinson's Disease Questionnaire; RMSEA: root mean square error of approximation; SDC: Smallest detectable change; SDMT: Symbol Digit Modalities Test; SEM: standard error of measurement; SRMR: standardized root mean square residual; SRT-D: Selective Reminding Test-Delayed; sSDMT: Smartphone-adapted Symbol Digit Modalities Test; tele-EDSS: Telemedicine-enabled Expanded Disability Status Scale; TRS: Fahn-Tolosa-Marin Tremor Rating Scale; VAS: visual analogue scale

Supplementary material 4. Methodological quality of the included studies (very good: ; adequate: ; doubtful: ; inadequate:) and quality rating of the results on measuring properties (sufficient, insufficient, indeterminate) using the COSMIN [25].

Measurement tool	Neurological disease	Measurement properties							
		Reliability			Validity				
						Construct validity			
		Internal consistency	Reliability	Measurement error	Content validity	Structural validity	Hypotheses testing	Criterion validity	Responsiveness
E-mail with the link to the website									
eMSQOL-29 [52]	Multiple Sclerosis	Sufficient	-	-	-	Sufficient	-	Insufficient	-
Multimedia system									
6MWT	Multiple Sclerosis	-		-	-	-	-	Sufficient	-
SF-AI	Multiple Sclerosis	-	Insufficient	-	-	-	-		-
EDSS [32]	Multiple Sclerosis	-	Insufficient	-	-	-	-		-
Online assessment									
MSNQ [42]	Multiple Sclerosis	Sufficient	Sufficient	-	-	-	Insufficient	Insufficient	-
OL-RBMT [57]	Stroke	-	Sufficient	-	-	-	Indeterminate	Sufficient	-
Online software									
MEPA-III [45]	Parkinson's Disease	-	-	-	-	-	Indeterminate	Insufficient	-
PDQ-39 [76]	Parkinson's Disease	Sufficient	-	-	-	-	Insufficient	-	-
Smartphone application									
Smartphone-Based Self-Administered 2-Minute Walk Test [61]	Multiple Sclerosis	-	Sufficient	Indeterminate	-	-	-	-	-
sSDMT [60]	Multiple Sclerosis	-	Sufficient	Indeterminate	-	-	Sufficient	Sufficient	-
Telephone assessment									
BCRS	Alzheimer's Disease	-	Sufficient	-	-	-	-	-	-
BEHAVE-AD	Alzheimer's Disease	-	Sufficient	-	-	-	-	-	-
FAST	Alzheimer's Disease	-	Sufficient	-	-	-	-	-	-
GDS	Alzheimer's Disease	-	Sufficient	-	-	-	-	-	-
MMSE [36]	Alzheimer's Disease	-	Sufficient	-	-	-	-	-	-
Braztel-MMSE [47]	Alzheimer's Disease	-	Indeterminate	-	-	-	-	Sufficient	-
TMMSE [46]	Alzheimer's Disease	-	-	-	-	-	-	Sufficient	-
I-TICS [70]	Alzheimer's Disease	Sufficient	Sufficient	-	-	-	Indeterminate	Sufficient	-
TICS-J [71]	Alzheimer Disease	-	Sufficient	-	-	-	Sufficient	Sufficient	-
TELE	Alzheimer's Disease	-	-	-	-	-	Sufficient	Sufficient	-
TICS [65]	Alzheimer's Disease	-	-	-	-	-	Sufficient	Sufficient	-
EDSS	Multiple Sclerosis	Sufficient	Sufficient	-	-	-	Indeterminate	Sufficient	-
PDDS [39]	Multiple Sclerosis	Sufficient	Sufficient	-	-	-	Indeterminate	Sufficient	-
LE-MAL [44]	Multiple Sclerosis	Sufficient	Sufficient	-	-	Sufficient	Sufficient	-	-

MFIS-SCI [48]	Spinal Cord Injury	Sufficient	-	-	-	-	Sufficient	-	-
SCI-SCS [62]	Spinal Cord Injury	-	Sufficient	-	-	-	-	Sufficient	-
TCOVS [66]	Spinal Cord Injury	-	Sufficient	-	-	-	-	Sufficient	-
T-EDSS [40]	Multiple sclerosis	Insufficient	-	-	-	-	-	Insufficient	-
ABILHAND [30]	Stroke	-	-	-	-	-	-	Sufficient	-
ABILOCO [31]	Stroke	-	-	-	-	-	-	Sufficient	-
BI [34]	Stroke	Sufficient		-	-	-	-	Sufficient	-
BI [33]	Stroke	-		-	-	-	-	Sufficient	-
BI	Stroke	-	Sufficient	-	-	-	-	-	-
mRS [35]	Stroke	-	Sufficient	-	-	-	-	-	-
HUI2/3 [75]	Stroke	-	Sufficient	-	-	-	Insufficient	-	-
NINDS-CSN [59]	Stroke	-	-	-	-	-	-	Sufficient	-
mRS [51]	Stroke	-	Sufficient	-	-	-	-	Insufficient	-
Six-item screener [59]	Stroke	-	-	-	-	-	-	Sufficient	-
SIS [64]	Stroke	-	-	-	-	-	Sufficient	-	-
SIS [63]	Stroke	Sufficient	Sufficient	-	-	-	-	-	-
smRSq [50]	Stroke	-	Sufficient	-	-	-	Sufficient	-	-
TICS [68]	Stroke	-	Sufficient	-	-	-	Sufficient	Indeterminate	-
TICS	Stroke	-	-	-	-	-	-	Sufficient	-
TICS-m [67]	Stroke	-	-	-	-	-	-	Sufficient	-
TICS-m [72]	Stroke	Sufficient	Sufficient	-	-	Indeterminate	-	Sufficient	-
TICS	Stroke	-	-	-	-	-	-	Sufficient	-
T-MOCA [73]	Stroke	-	-	-	-	-	-	Sufficient	-
mRS [49]	Subarachnoid Hemorrhage	-	-	-	-	-	-	Indeterminate	-
MoCA 5-minute protocol [74]	TIA or Stroke	Sufficient	Sufficient	-	-	-	-	Sufficient	-
PROMIS-10 Global Health [58]	TIA or Stroke	Sufficient	-	-	-	-	Indeterminate	-	-
TICS-m	TIA or Stroke	-	-	-	-	-	-	Sufficient	-
T-MoCA	TIA or Stroke	-	-	-	-	-	-	Sufficient	-
T-MoCA-Short [69]	TIA or Stroke	-	-	-	-	-	-	Sufficient	-
Ohio State University Traumatic Brain Injury Identification Method modified [56]	Traumatic Brain Injury	-	Insufficient	-	-	-	-	-	-
Videoconferencing assessment									
ADAS-Jcog [43]	Alzheimer's Disease	-	-	-	-	-	-	Sufficient	-
tele-EDSS [41]	Multiple Sclerosis	-	-	-	-	-	-	Sufficient	-
CRT	Parkinson's Disease	-	Sufficient	-	-	-	-	-	-

Kinovea version 0.8.15 software	Parkinson's Disease	-	Sufficient	-	-	-	-	-	-
MAM-16	Parkinson's Disease	-	Sufficient	-	-	-	-	-	-
FTT	Parkinson's Disease	-	Sufficient	-	-	-	-	-	-
TRS [37]	Parkinson's Disease	-	Sufficient	-	-	-	-	-	-
ESS	Stroke	-	-	-	-	-	-	Indeterminate	-
FRT [38]	Stroke	-	-	-	-	-	-	Indeterminate	-
NIHSS [55]	Stroke	-	-	-	-	-	-	Sufficient	-
NIHSS [53]	Stroke	-	Sufficient	-	-	-	-	-	-
NIHSS [54]	Stroke	-	Sufficient	-	-	-	-	-	-

Legend: 6MWT: 6-min walk test; ADAS-Jcog: Japanese version of Alzheimer's Disease Assessment Scale Cognitive Subscale; BCRS: Brief Cognitive Rating Scale; BEHAVE-AD: Behavioral Pathology in Alzheimer's Disease Rating Scale; BI: Barthel Index; CRT: Coin Rotation Task; EDSS: Expanded Disability Status Scale; eMSQOL-29: electronic format Multiple Sclerosis Quality of Life; ESS: European Stroke Scale; FAST: Functional Assessment Staging; FTT: Finger Tapping Test; FRT: Functional Reach Test; GDS: Global Deterioration Scale; HUI2/3: Health Utilities Index Mark 2 and 3; I-TICS: Italian telephone interview for cognitive status; LE-MAL: Lower-Extremity Motor Activity Log; MAM: Manual Ability Measure; MEPA-III: Mediterranean Eating Pattern for Americans; MFIS-SCI: Modified Fatigue Impact Scale spinal cord injury; MMSE: Mini-Mental State Examination; MSNQ: Multiple Sclerosis Neuropsychological Questionnaire; mRS: Modified Rankin Scale; NIHSS: National Institutes of Health Stroke Scale; NINDS-CSN: National Institute of Neurological Disorders and Stroke and Canadian Stroke Network; NR: Not Reported; OL-RBMT: Online Rivermead Behavioral Memory Test; PDDS: Patient Determined Disease Steps; PROMIS-10: Patient-Reported Outcomes Measurement Information System 10-Question Short Form; PDQ-39: 39-item Parkinson's Disease Questionnaire; SCI-SCS: Spinal Cord Injury–Secondary Conditions Scale; SF-AI: self-reported ambulation index; SIS: Stroke Impact Scale[63,64]; smRSq: Simplified Modified Rankin Scale Questionnaire; sSDMT: Smartphone-adapted Symbol Digit Modalities Test; T-EDSS: Telephone-based Expanded Disability Status Scale; tele-EDSS: Telemedicine-enabled Expanded Disability Status Scale; TRS: Fahn-Tolosa-Marin Tremor Rating Scale; TCOVS: Telephone Clinical Outcome Variables Scale; TIA: Transient Ischemic Attack; TICS: Telephone interview for cognitive status; TICS-J: Japanese version of the Telephone interview for cognitive; TICSm: Telephone interview for cognitive status modified 13-item; TICS-M: Brazilian version of the Modified Telephone Interview for Cognitive Status; TMMSE: Telephone Mini-Mental State Examination; T-MoCA: Telephone Montreal Cognitive Assessment; T-MoCA-Short: Telephone Montreal Cognitive Assessment (verbal fluency, recall and orientation; total 12 points)

"-": absence of data (measurement properties that were not investigated), except for content validity, for what quality rating of the results on measuring properties can not be determined.

Sufficient or sufficient are the classifications which support the conclusion that the measurement property has adequate property quality stablished by a study with adequate methodological quality according to the COSMIN checklist

CAPÍTULO 3

MÉTODOS DO ENSAIO CLÍNICO ALEATORIZADO E ARTIGO 3

4 MÉTODOS

4.1 Desenho do estudo

O estudo principal desta tese é um ECA, prospectivo, controlado, de superioridade, com grupos paralelos, alocação oculta, proporção de alocação 1:1, avaliações cegadas e análise por intenção de tratar. As avaliações presenciais foram realizadas no Laboratório de Avaliação e Pesquisa em Desempenho Cardiorrespiratório (LabCare) e no Laboratório de Estudos em Reabilitação Neurológica do Adulto (NEUROLAB), ambos pertencentes ao Departamento de Fisioterapia da Escola de Educação Física, Fisioterapia e Terapia Ocupacional da Universidade Federal de Minas Gerais (EEFFTO/UFMG). Todas as anuências necessárias para o desenvolvimento deste estudo foram obtidas (ANEXO D). Além disso, o estudo foi aprovado pela câmara departamental do Departamento de Fisioterapia (EEFFTO/UFMG) (ANEXO E).

Este estudo também foi aprovado pelo Comitê de Ética em Pesquisa da Universidade Federal de Minas Gerais (COEP/UFMG) (CAAE: 53970421.0.0000.5149; parecer nº 5.356.570), registrado prospectivamente no site www.ClinicalTrials.gov (NCT05608941), e o protocolo foi publicado (Brito *et al.*, 2023). Não houve alterações em relação ao protocolo original (Brito *et al.*, 2023). O estudo foi conduzido em um ambiente comunitário, entre dezembro de 2022 e abril de 2024. Os participantes incluídos residiam em Belo Horizonte/MG e em outras três cidades da região metropolitana (Contagem, Vespasiano e Santa Luzia). O *Consolidated Standards of Reporting Trials* (CONSORT) foi utilizado para a produção deste estudo (Schulz; Altman; Moher, 2010). Todos os indiv foram devidamente informados sobre os procedimentos realizados e incluídos apenas após concordarem voluntariamente e assinarem o Termo de Consentimento Livre e Esclarecido (TCLE) (APÊNDICE B). Durante a condução do estudo, foram seguidas as medidas de prevenção à disseminação do Coronavírus (Comitê Permanente de Enfrentamento do Novo Coronavírus da UFMG, 2020; Ministério da Saúde, 2020).

4.2 Participantes

Uma amostra não probabilística foi recrutada na comunidade geral da cidade de Belo Horizonte/Brasil e de suas regiões metropolitanas a partir de contato com ambulatórios, clínicas, hospitais, centros de saúde, associações, grupos de pesquisa e projetos de extensão desenvolvidos com a população de interesse. Os participantes foram incluídos segundo os seguintes critérios: DP idiopática diagnosticada por um neurologista; idade ≥ 50 anos; em uso de medicação antiparkinsoniana, estáveis por pelo menos 6 meses; com capacidade de deambular de forma independente; classificados entre os estágios 1 a 3 da escala de Hoehn e Yahr modificada (Schenkman *et al.*, 2001); que apresentassem pressão inspiratória máxima <80cmH_2O ou pressão expiratória máxima <90cmH_2O (Farrero *et al.*, 2013). Os participantes foram excluídos segundo os seguintes critérios: estivessem realizando TMR ou o tivessem realizado nas últimas quatro semanas; possível comprometimento cognitivo determinado pelos pontos de corte do Mini-Exame do Estado Mental de acordo com o nível educacional (analfabetos: 13 pontos; ensino fundamental e médio: 18 pontos; ensino médio: 26 pontos) (Bertolucci; Brucki; Campacci; Juliano, 1994); uso de estimulação cerebral profunda (DBS); fumantes ou que tivessem parado de fumar há menos de seis meses; acometidos por infecções respiratórias ou cardíacas no último mês; outros distúrbios neurológicos, musculoesqueléticos, cardiorrespiratórios ou outras condições de saúde que interferissem ou impossibilitassem a execução dos testes e intervenções propostas.

4.3 Randomização

Os participantes foram alocados em dois grupos (experimental e controle). Antes do início do estudo, a sequência de alocação foi gerada por um website (www.randomization.com) em blocos de seis participantes (Brito *et al.*, 2023). Um assistente de pesquisa, não envolvido no recrutamento, fez a aleatorização e colocou a sequência em envelopes opacos, numerados e selados (Brito *et al.*, 2023). Medidas pré-intervenção foram coletadas por um examinador treinado, cegado para a sequência de alocação dos grupos. Posteriormente, um assistente de pesquisa treinado revelou o conteúdo desses envelopes. Algumas medidas foram tomadas na tentativa de cegamento dos voluntários quanto à intervenção recebida/alocação do grupo (Brito *et al.*, 2023). Na avaliação inicial, foi explicado aos participantes que havia dois grupos no estudo, mas as diferenças entre os

grupos não foram detalhadas. Além disso, todos os dispositivos foram envolvidos com um material opaco, para que a carga de treinamento respiratório não fosse visualizada (Brito *et al.*, 2023).

4.4 Intervenção

Os participantes foram submetidos a um treinamento muscular inspiratório e expiratório de alta intensidade (grupo experimental) ou a uma intervenção placebo, que consistiu no mesmo protocolo de exercícios do grupo experimental, porém sem a carga para o treinamento muscular (grupo controle) (Brito *et al.*, 2023). A única diferença entre os dois grupos foi a presença/ausência da carga imposta durante o treinamento (Brito *et al.*, 2023).

A intervenção foi realizada por 40 minutos, divididos em dois blocos de 20 minutos, um realizado pela manhã e outro à tarde, sete vezes por semana, durante oito semanas (Brito *et al.*, 2023). Em cada turno, a intervenção foi dividida em quatro blocos de três minutos, com dois minutos de descanso entre os blocos (Brito *et al.*, 2023). Para a realização da intervenção, foi utilizado o dispositivo Orygen-Dual Valve®, que fornece uma carga inspiratória de até 70 cmH_2O e expiratória de até 80cmH_2O, com uma vedação adequada, através de um bocal confortável e flexível (Menezes *et al*., 2018). Segundo uma revisão da literatura conduzida por Menezes *et al.* (2018), dentre os dispositivos utilizados para realizar o TMR, este apresenta as vantagens de ter baixo custo, ser portátil e fácil de usar, permitindo o treinamento da musculatura respiratória em ambiente domiciliar. Além disso, este foi o único que apresentou ajustes de cargas independentes para o treinamento dos músculos inspiratórios e expiratórios (Menezes *et al*., 2018). Por fim, os participantes foram orientados a utilizar um clipe nasal durante a realização dos exercícios para evitar escape de ar.

Os participantes foram treinados e instruídos a realizar o programa de exercícios por conta própria, sem supervisão (Brito *et al.*, 2023). Para acompanhar a adesão ao protocolo, os participantes receberam um diário de treinamento (APÊNDICE C), no qual deveriam registrar, para cada dia de intervenção, se realizaram os exercícios, a duração e a pontuação subjetiva de esforço segundo a Escala Categórica Modificada de Borg (Borg, 1982). Quando necessário, um acompanhante/cuidador foi instruído a auxiliar o indivíduo no preenchimento do diário (Brito *et al.*, 2023). Procedimentos similares já foram adotados em um estudo prévio

realizado com objetivo similar, porém em indivíduos pós-acidente vascular encefálico (Menezes *et al.*, 2019).

Figura 2. Dispositivo utilizado para o TMR, Orygen-Dual Valve®, acompanhado de bocal e clipe nasal.



Fonte: banco de imagens do autor

4.4.1 Grupo experimental

Os participantes do grupo experimental executaram o treinamento muscular inspiratório e expiratório de alta intensidade (60% da PImáx e PEmáx), sete vezes por semana, duas vezes ao dia (dois blocos de 20 minutos, totalizando 40 minutos diários) (Brito *et al.*, 2023). Semanalmente, um fisioterapeuta previamente treinado realizou visitas domiciliares na residência dos participantes para a realização dos procedimentos necessários para garantir a intensidade do treinamento (60% da PImáx e PEmáx) (Brito *et al.*, 2023). Nesta visita, a carga de treinamento foi ajustada individualmente e progressivamente para garantir a manutenção de 60% dos novos valores de pressão (Reyes; Castillo; Castillo; Cornejo, 2018; Reyes *et al.*, 2019). Além disso, a percepção de esforço pela Escala Categórica Modificada de Borg (Borg, 1982) foi considerada para ajustar a intensidade do treinamento, objetivando manter pontuações entre 4 e 6 pontos (Brito *et al.*, 2023). A pontuação da escala

de Borg foi avaliada após uma série de três minutos. Se a pontuação fosse inferior a 4 ou superior a 6, a carga de treinamento era ajustada para o valor mais próximo de 60% das pressões respiratórias máximas, de modo a garantir que a intensidade-alvo fosse mantida (Brito *et al.*, 2023; Reyes; Castillo; Castillo; Cornejo, 2018; Reyes *et al.*, 2019). Todos os dispositivos foram envolvidos com um material opaco para que a carga ou possível carga de treinamento respiratório não fosse visualizada (Brito *et al.*, 2023).

4.4.2 Grupo controle

Os participantes alocados no grupo controle realizaram o mesmo protocolo de intervenção para os músculos respiratórios proposto para o grupo experimental (Brito *et al.*, 2023). Entretanto, no grupo controle foi implementada uma intervenção placebo: a resistência inicial do dispositivo foi de 0 cmH_2O e foi mantida dessa forma durante todo o período da intervenção, ou seja, não houve progressão de cargas (Brito *et al.*, 2023). Todos os procedimentos adotados com os participantes do grupo experimental, incluindo a visita domiciliar semanal realizada pelo fisioterapeuta, também foram realizados com o grupo controle, porém sem alteração real da carga imposta pelo equipamento para o treinamento muscular (Brito *et al.*, 2023). Todos os dispositivos foram envolvidos com um material opaco para que a carga ou possível carga de treinamento respiratório não fosse visualizada (Brito *et al.*, 2023).

4.5 Mensuração dos desfechos

As avaliações dos desfechos primários (força muscular inspiratória e expiratória) e dos desfechos secundários (*endurance* muscular inspiratória, pico de fluxo da tosse, dispneia, fadiga, capacidade de exercício e qualidade de vida) de interesse foram realizadas no LabCare e no NEUROLAB. As mensurações foram realizadas na avaliação inicial (semana 0), imediatamente após o término do treinamento (semana 8) e um mês após o término do treinamento (semana 12) (Brito *et al.*, 2023).

Na avaliação inicial (semana 0), foram coletados dados clínicos e demográficos de todos os participantes para fins de verificação dos critérios de elegibilidade, identificação e caracterização da amostra. Para isso, foi utilizada uma ficha de avaliação (APÊNDICE D), a

escala de Hoehn e Yahr modificada (Schenkman *et al.*, 2001) e o instrumento clínico *Unified Parkinson's Disease Rating Scale* (UPDRS), especificamente os domínios de atividade de vida diária e exploração motora (Nieuwboer *et al.*, 2000).

Em todas as três avaliações, foram realizadas as medidas de PImáx e PEmáx, *endurance* muscular inspitatória, pico de fluxo da tosse, dispneia, fadiga, capacidade de exercício e qualidade de vida. Antes e ao final das medidas respiratórias (PImáx, PEmáx, *endurance* muscular inspiratória e o pico de fluxo da tosse) e dos testes de caminhada (TC6), foram monitorizados alguns dados clínicos do paciente (frequência cardíaca (FC), pressão arterial (PA), saturação periférica de oxigênio (SpO_2) e percepção subjetiva de esforço). Entre esses testes, foi ofertado um intervalo de pelo menos 10 minutos e/ou até os dados (FC, FR, PA, SpO_2 e Borg) retornarem aos valores basais (Brito *et al.*, 2023).

Inicialmente, foram realizadas as medidas de PImáx e PEmáx, e a ordem dos testes foi aleatorizada. Foram coletadas, no mínimo, cinco medidas aceitáveis e reprodutíveis, e os valores da maior medida foram registrados. Entre cada uma das medidas, foi dado um intervalo de, no mínimo, um minuto (Laveneziana *et al.*, 2019). Em seguida, foi realizada a avaliação do *endurance* muscular inspiratória. Testes com uma duração de pelo menos dois e no máximo sete minutos foram considerados adequados. Na reavaliação e no *follow-up*, a duração máxima do teste foi de 15 minutos (Laveneziana *et al.*, 2019). Durante todo o teste, a SpO_2 foi monitorizada. Posteriormente, foi mensurado o pico de fluxo da tosse. Foram coletadas pelo menos três medidas que deviam ter no máximo 5% de diferença entre elas, e a maior medida foi registrada. Um minuto de descanso foi ofertado durante cada uma das repetições (Laveneziana *et al.*, 2019). Por fim, foram realizados dois TC6, com um intervalo de 30 minutos entre eles e/ou até os dados clínicos (FC, FR, PA, SpO_2 e Borg) retornarem aos valores basais (Holland *et al.*, 2014). Durante os testes, a FC, SpO_2 e Borg foram monitorizados. Todos os procedimentos específicos para a realização de cada um desses testes serão detalhados no tópico de instrumentos.

Para manter a padronização na aplicação e considerando a heterogeneidade no nível de escolaridade da população brasileira, a avaliação da dispneia, fadiga e qualidade de vida foi realizada no formato de entrevista (Brito *et al.*, 2023). Todas as avaliações foram realizadas pelo mesmo examinador, devidamente treinado e familiarizado com os instrumentos, e cegado para a alocação dos grupos. Durante a reavaliação e *follow-up*, todos os participantes foram instruídos a não comentar informações sobre o treinamento recebido (Brito *et al.*, 2023).

4.6 Instrumentos

4.6.1 Desfechos Primários

4.6.1.1 Força muscular inspiratória

A força muscular inspiratória foi mensurada por meio da PImáx gerada durante a inspiração. As medidas foram realizadas no LabCare utilizando um manovacuômetro digital (LEB-LABCARE/UFMG, Brasil) e reportadas em cmH_2O (Laveneziana *et al.*, 2019; Pessoa *et al.*, 2014; Pessoa *et al.*, 2015). A determinação das variáveis do manovacuômetro foi realizada por meio do *software* MANOVAC 4.0. Nesse *software* é possível realizar o cadastro dos participantes e acompanhar o teste em modo gráfico em tempo real (Pessoa *et al.*, 2014). Para registrar as pressões inspiratórias, os participantes realizaram inspirações contra uma via aérea obstruída dentro do bocal (Laveneziana *et al.*, 2019; Pessoa *et al.*, 2014; Pessoa *et al.*, 2015).

A coleta foi realizada com o indivíduo sentado em uma cadeira, com os pés e costas apoiados e o tronco em um ângulo de 90 graus em relação ao quadril. Um bocal de silicone tipo mergulhador e clipe nasal foram utilizados (Laveneziana *et al.*, 2019; Pessoa *et al.*, 2015). Os participantes foram instruídos a respirar confortavelmente duas a três vezes, em nível de volume corrente, e, posteriormente, "colocar todo o ar para fora", ou seja, realizar uma expiração máxima (nível de volume residual) (Laveneziana *et al.*, 2019; Pessoa *et al.*, 2015). Além disso, foi solicitado que o participante levantasse a mão ao final da expiração para permitir o fechamento do orifício de oclusão do equipamento. Por fim, foi dado o comando (com tom de voz mais alto e enfático) para que o indivíduo "encha o peito de ar", ou seja, que ele realize uma inspiração máxima (Pessoa *et al.*, 2015).

Foram realizadas cinco medidas, no mínimo, com intervalo de um minuto entre elas, sendo que deveriam ser obtidas três manobras aceitáveis (sem escape de ar pelo clipe nasal ou pelos lábios e com duração de pelo menos 1,5 segundos). Foi registrada e utilizada para análise a maior pressão de três medidas reprodutíveis (com menos de 10% de variabilidade, sendo que a maior medida não deverá ser a última) (Laveneziana *et al.*, 2019; Pessoa *et al.*, 2014; Pessoa *et al.*, 2015). As coletas foram realizadas seguindo procedimentos já

estabelecidos e adotados por estudos prévios e recomendados pela *European Respiratory Society* (Laveneziana *et al.*, 2019; Pessoa *et al.*, 2014; Pessoa *et al.*, 2015). O valor da Pimáx foi utilizado para cálculo da carga de treinamento (Brito *et al.*, 2023).

4.6.1.2 Força muscular expiratória

A força muscular expiratória foi avaliada por meio da PEmáx gerada durante a expiração e mensurada com o mesmo manovacuômetro digital utilizado para mensurar a PImáx (LEB-LabCare/UFMG, Brasil), e reportada em cmH_2O (Laveneziana *et al.*, 2019; Pessoa *et al.*, 2014; Pessoa *et al.*, 2015). Para registrar as pressões expiratórias, os particpantes realizaram expirações contra uma via aérea obstruída dentro do bucal (Laveneziana *et al.*, 2019; Pessoa *et al.*, 2014; Pessoa *et al.*, 2015).

A coleta também foi realizada com o indivíduo sentado em uma cadeira, com os pés e costas apoiados e o tronco em um ângulo de 90 graus em relação ao quadril. Um bocal de silicone tipo mergulhador e clipe nasal foram utilizados (Laveneziana *et al.*, 2019; Pessoa *et al.*, 2015). Além disso, o avaliador segurou a bochecha dos participantes com as mãos, visando evitar fugas de ar entre os lábios e o bocal (Pessoa *et al.*, 2014; Pessoa *et al.*, 2015). Os participantes foram instruídos a respirar confortavelmente duas a três vezes, em nível de volume corrente, e, posteriormente, “encher o peito de ar”, ou seja, realizar uma inspiração máxima (capacidade pulmonar total). Além disso, foi solicitado que o indivíduo levantasse a mão ao finalizar a inspiração para permitir o fechamento do orifício de oclusão do equipamento. Por fim, foi dado o comando (com tom de voz mais alto e enfático) para que o indivíduo “solte o ar”, ou seja, realizasse uma expiração máxima (Pessoa *et al.*, 2015). Os critérios de aceitabilidade e reprodutibilidade foram os mesmos descritos anteriormente para avaliação da força muscular inspiratória (Laveneziana *et al.*, 2019; Pessoa *et al.*, 2014; Pessoa *et al.*, 2015). As coletas foram realizadas seguindo procedimentos já estabelecidos e adotados por estudos prévios e recomendados pela *European Respiratory Society* (Laveneziana *et al.*, 2019; Pessoa *et al.*, 2014; Pessoa *et al.*, 2015). O valor da PEmáx foi utilizado para cálculo da carga de treinamento (Brito *et al.*, 2023).

Figura 3. Examinador realizando a avaliação das pressões respiratórias máximas de um participante do estudo utilizando o LEB-LABCARE/UFMG



Fonte: banco de imagens do autor

4.6.2 Desfechos Secundários

4.6.2.1 *Endurance* muscular inspiratória

A *endurance* muscular inspiratória foi avaliada utilizando o POWERbreathe® KH2, e foram seguidas recomendações para o uso do equipamento (Charususin *et al.*, 2013). A coleta foi realizada com o indivíduo sentado em uma cadeira, com os pés e costas apoiados e o tronco em um ângulo de 90 graus em relação ao quadril. Um clipe nasal foi utilizado, e o indivíduo foi orientado a realizar respiração oral no equipamento. Os participantes foram instruídos a respirar contra uma carga inspiratória submáxima (50% da pressão inspiratória máxima avaliada anteriormente) até ocorrer a fadiga ou até o limite de sete minutos (Charususin *et al.*, 2013).

A SpO_2 foi monitorada durante todo o tempo de teste. O teste foi interrompido por solicitação do indivíduo. Para ser considerado adequado, o teste deveria ter uma duração entre dois e sete minutos (Charususin *et al.*, 2013; Laveneziana *et al.*, 2019). O teste foi interrompido quando não ocorreu a abertura da válvula do aparelho por duas vezes consecutivas ou quando solicitado pelo indivíduo. Se o indivíduo não conseguisse atingir o tempo determinado, este foi convidado a retornar para repetir o teste com uma nova carga objetivando alcançar a duração alvo. Quando isso ocorreu, a carga utilizada foi registrada para que o teste fosse realizado da mesma forma na reavaliação e *follow-up* (Charususin *et al.*, 2013). As coletas foram realizadas seguindo procedimentos já estabelecidos e adotados por estudos prévios e recomendados pela *European Respiratory Society* (Laveneziana *et al*., 2019). O número total de repetições e o tempo total de teste que o indivíduo conseguiu realizar foram utilizados nas análises (Brito *et al.*, 2023; Charususin *et al.*, 2013).

Figura 4. Examinador realizando a avaliação da *endurance* musculaar respiratória de um participante do estudo utilizando o POWERbreathe® KH2



Fonte: banco de imagens do autor

4.6.2.2 Pico de Fluxo da Tosse

As medidas de pico de fluxo da tosse foram realizadas com o medidor de pico de fluxo expiratório máximo (*Mini-Wright Peak Expiratory Flow Meter*) (Freitas *et al.*, 2010; Laveneziana *et al.*, 2019). O equipamento fornece um intervalo de mensuração variando de 60 a 880 L/min. A avaliação do pico de fluxo da tosse também foi realizada com o indivíduo sentado, conforme previamente descrito (Laveneziana *et al.*, 2019). O indivíduo foi instruído a realizar uma inspiração profunda, ou seja, na capacidade pulmonar total, e, em seguida, realizar uma tosse sendo a mais vigorosa possível (Bach *et al.*, 2006). Foram realizadas pelo menos três medidas que deveriam ter uma diferença máxima de 5% entre elas (Freitas *et al.*, 2010; Laveneziana *et al.*, 2019; Souza; Pereira, 2002). O valor mais alto, em L/min, foi registrado e utilizado nas análises (Brito *et al.*, 2023; Freitas *et al.*, 2010; Souza; Pereira, 2002).

Figura 5. Examinador realizando a avaliação do pico de fluxo da tosse de um participante do estudo utilizando o medidor de pico de fluxo expiratório máximo (*Mini-Wright Peak Expiratory Flow Meter*)



Fonte: banco de imagens do autor

4.6.2.3 Dispneia

A dispneia foi avaliada utilizando o instrumento *Medical Research Council* (MRC) (Kovelis *et al.*, 2008). A MRC é um instrumento em que o indivíduo relata o seu grau de dispneia para realizar atividades de vida diária. O indivíduo foi orientado a escolher qual nível representa melhor o quanto a dispneia (falta de ar) limita suas atividades de vida diária (Kovelis *et al.*, 2008). Os valores variam de 1 a 5, sendo que em 1 o indivíduo só sente falta de ar durante exercícios intensos e em 5 sente tanta falta de ar que não sai mais de casa, ou sente falta de ar quando está se vestindo (Kovelis *et al.*, 2008). Este instrumento já foi traduzido e adaptado para o português e apresenta adequada validade para a população brasileira (Kovelis *et al.*, 2008). Considerando a heterogeneidade de nível de escolaridade da população brasileira e para garantir a adequada aplicação do instrumento, este foi administrado no formato de entrevista (Kovelis *et al.*, 2008). A pontuação do instrumento foi utilizada nas análises (Brito *et al.*, 2023).

4.6.2.4 Fadiga

Para avaliar a fadiga foi utilizado o instrumento *Fatigue Severity Scale* (FSS) (Friedman *et al.,* 2010; Valderramas; Feres; Melo, 2012). Este instrumento mensura o impacto da fadiga nas atividades de vida diária. Na FSS, são apresentadas nove afirmações, e o indivíduo é orientado a pontuar o quanto concorda com cada afirmação. A pontuação varia de 1 a 7, onde 1 indica que ele discorda completamente e 7 indica que ele concorda plenamente. A FSS é recomendada para a avaliação da fadiga em participantes com DP (Friedman *et al.,* 2010) e sua versão adaptada transculturalmente para o português apresenta adequadas propriedades de medida para mensuração da fadiga nessa população (Friedman *et al.,* 2010; Valderramas; Feres; Melo, 2012). Considerando a heterogeneidade de nível de escolaridade da população brasileira e para garantir a adequada aplicação do instrumento, este também foi administrado no formato de entrevista (Kovelis *et al.*, 2008). A pontuação total foi utilizada nas análises (Brito *et al.*, 2023).

4.6.2.5 Capacidade de exercício

A capacidade de exercício foi avaliada utilizando o teste de caminhada de seis minutos (TC6). O TC6 foi realizado em um corredor de 30 metros, delimitado por dois cones. Os participantes foram orientados a caminhar a maior distância possível em seis minutos, e a cada minuto de teste foram fornecidos estímulos padronizados (Holland *et al.*, 2014). Foram realizados dois testes com intervalo de 30 minutos ou até os valores de pressão arterial, saturação de oxigênio, frequência cardíaca e respiratória retornarem ao basal, de acordo com as diretrizes da *European Respiratory Society/American Thoracic Society* (Holland *et al.*, 2014). Caso a diferença entre os dois testes excedesse 10%, um terceiro teste era realizado (Holland *et al.*, 2014).

Antes e ao final dos testes, foram mensuradas FC, FR, PA, SpO_2 e percepção de esforço (Borg, 1982). A cada minuto de teste foi monitorada a frequência cardíaca. O teste foi interrompido se o indivíduo atingisse 85% da frequência cardíaca máxima, definida pela fórmula de 220-idade (Wasserman *et al.*, 2005). O TC6 apresenta adequadas propriedades de medida para avaliação deste desfecho em participantes com DP (Bloem *et al.*, 2016; Steffen; Seney, 2008). A melhor distância total percorrida, em metros, foi utilizada nas análises (Brito *et al.*, 2023).

Figura 6. Participante do estudo realizando o teste de caminhada de seis minutos acompanhado do examinador



Fonte: banco de imagens do autor

4.6.2.6 Qualidade de Vida

A qualidade de vida foi avaliada utilizando um questionário específico para avaliação de participantes com DP, o *Parkinson's Disease Questionnaire-39* (PDQ-39) (Jenkinson *et al.*, 1997). Este instrumento é composto por 39 itens e é dividido em oito dimensões: mobilidade, atividades de vida diária, bem-estar emocional, estigma, suporte social, cognição, comunicação e desconforto corporal. Cada item apresenta cinco opções de resposta, e os escores variam de 0 (nunca) a 4 (sempre ou é impossível para mim) (Jenkinson *et al.*, 1997). A pontuação para cada domínio varia de 0 (zero) a 100 (cem), onde zero significa melhor e cem, uma pior qualidade de vida (Jenkinson *et al.*, 1997). A versão traduzida para o português e adaptada transculturalmente para a população brasileira apresenta adequadas propriedades de medida para avaliação da qualidade de vida em participantes com DP (Carod-Artal; Martinez-Martin; Vargas, 2007; Lana *et al.*, 2007). A pontuação total foi calculada utilizando a seguinte fórmula: 100 x (soma dos escores dos voluntários nas questões / 4 x número de itens) (Jenkinson *et al.*, 1997). A pontuação total foi utilizada para as análises (Brito *et al.*, 2023).

Figura 7. Examinador aplicando o questionário *Parkinson's Disease Questionnaire-39* em formato de entrevista com um participante do estudo



Fonte: banco de imagens do autor

4.7 Cálculo amostral

O cálculo do tamanho da amostra foi realizado considerando as medidas de desfecho primárias (força muscular inspiratória e expiratória). O tamanho da amostra foi estimado considerando dados fornecidos por ensaios clínicos aleatorizados que investigaram os efeitos do TMR na força muscular respiratória em participantes com DP (Inzelberg *et al.*, 2005; Sapienza; Troche; Pitts; Davenport, 2011).

O tamanho do efeito (*f*) de 1,00 para o treinamento muscular inspiratório foi derivado do estudo de Inzelberg *et al.* (2005) (Inzelberg *et al.*, 2005). Nesse estudo, a PImáx no grupo experimental (n=10) aumentou de 62±8,2 para 78±7,5, e o grupo controle (n=10) não apresentou diferença estatisticamente significativa (51±8,0) (Inzelberg *et al.*, 2005). Considerando um nível de significância (α) de 5% e um poder de 0,90, foi estimado um tamanho de amostral de 10 participantes.

O tamanho do efeito (*f*) de 0,54 para o treinamento muscular expiratório foi derivado do estudo de Sapienza, Troche, Pitts e Davenport (2011). Nesse estudo, o MEP no grupo experimental (n=30) aumentou de 105,29±28,81 para 133,26±35,53, e o grupo controle (n=30) reduziu de 103,65±24,82 para 99,23±27,46 (Sapienza; Troche; Pitts; Davenport, 2011). Considerando um nível de significância (α) de 5% e um poder de 0,90, foi estimado um tamanho de amostral de quatorze participantes por grupo (um total de 28 participantes).

Levando em consideração os dois desfechos primários do estudo, o cálculo amonstral apontou a necesidade de 28 participantes. Assumindo uma taxa de abandono esperada de 20%, foi estabelecido um tamanho amostral total de 34 participantes (17 em cada grupo).

4.8 Análise estatística

Todas as análises estatísticas foram realizadas por um examinador independente, cegado quanto a todos os procedimentos realizados no estudo, inclusive com relação à alocação dos grupos. Foi atribuído um código exclusivo para cada participante, impossibilitando a identificação (Brito *et al.*, 2023). A normalidade da distribuição dos dados foi testada para todas as variáveis numéricas contínuas utilizando o teste Shapiro-Wilk. Estatísticas descritivas foram utilizadas para caracterização da amostra (Field, 2009; Portney, 2020).

As análises foram realizadas com intenção de tratar: para os desistentes, os dados da última avaliação disponível foram interpolados para sessões perdidas (Field, 2009; Portney, 2020). ANOVA two-way com medidas repetidas (2*3) foi utilizada para avaliar as diferenças entre grupos, considerando o fator tempo (semana 0, semana 8 e semana 12), seguido de testes *post-hoc* (Field, 2009; Portney, 2020). As diferenças entre os grupos ao longo do tempo (semana 8 subtraída da semana 0 e semana 12 subtraída da semana 0) foram relatadas como diferenças médias e intervalos de confiança de 95% (IC 95%), conforme recomendado (Field, 2009; Portney, 2020). Todas as análises foram realizadas com o programa estatístico SPSS 20.0 (Field, 2009) e foi considerado um α=0,05.

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STUDY PROTOCOL

Effects of high-intensity respiratory muscle training on respiratory muscle strength in individuals with Parkinson's disease: Protocol of a randomized clinical trial

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Abstract

Objective

To investigate the efficacy of high-intensity respiratory muscle training (combined inspiratory and expiratory muscle training) in improving inspiratory and expiratory muscle strength, inspiratory muscle endurance, peak cough flow, dyspnea, fatigue, exercise capacity, and quality of life in this population.

Methods

A randomized controlled trial, concealed allocation, blinded assessments, and intention-to-treat analysis will be carried out. Altogether, 34 individuals with PD (age $\geq$ 50 years old, with maximum inspiratory pressure (MIP) <80cmH_2O or maximum expiratory pressure (MEP) <90cmH_2O) will be recruited. Patients will be randomly assigned to either (1) high-intensity respiratory muscle training (experimental group, 60% of MIP and MEP) or (2) sham training (control group, 0cmH_2O). Individuals will perform a home-based intervention, with indirect home supervision, consisting of two daily 20-min sessions (morning and afternoon), seven times a week, during eight weeks. Primary outcomes are MIP and MEP. Secondary outcomes are inspiratory muscle endurance, peak cough flow, dyspnea, fatigue, exercise capacity, and quality of life. The effects of the training will be analyzed from the collected data using intention-to-treat. Between-group differences will be measured using a two-way ANOVA with repeated measures (2*3), considering baseline, post-intervention, and 12-week follow-up.

Impact

The results of this trial will provide valuable new information on the efficacy of high-intensity respiratory muscle training in improving muscle strength, functional outcomes, and quality of life in individuals with PD. Performing combined inspiratory and expiratory muscle training

relevant data from this study will be made available upon study completion.

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Competing interests: The authors have declared that no competing interests exist.

using a single equipment is cheaper and feasible, takes less time and is easy to use. In addition, this intervention will be carried out in the home environment that increases accessibility, reduces time, and costs of transport, which increases the feasibility to reproduce their findings in clinical practice.

Trial registration

NCT05608941. Registered on November 8, 2022.

Introduction

Parkinson's disease (PD) is the second most prevalent neurodegenerative disease worldwide [1]. Individuals with PD commonly have a significant reduction in respiratory muscle strength [2, 3] and inspiratory muscle endurance [3], and it can intensify with the disease progression [2]. Reduced respiratory muscle strength is associated with an impaired cough efficacy [4]. Cough is the main mechanism of protection of the airways, a process that occurs through a high-velocity airflow. This airflow is generated by the contraction of the expiratory muscles while the glottis is closed [4, 5]. Expiratory muscle weakness results in reduced subglottic pressure during the compression phase, decreased expiratory airflow, and inadequate clearance of material from the airway [4, 5]. This favors the aspiration of foreign bodies and accumulation of mucus, and consequently, the occurrence of respiratory infections, such as pneumonia [5]. Individuals with PD have a significant reduction of cough efficacy when compared to controls [5]. This is especially important for these individuals since pneumonia is the leading cause of death in this population [6].

Decreased respiratory muscle strength and endurance may be also associated with dyspnea perception on exertion (minimum or average) and orthostatic dyspnea [7]. Dyspnea is an underestimated symptom in individuals with PD [8]. Studies suggested that around 40% these individuals have dyspnea [8, 9]. Dyspnea is multifactorial and arises from the interaction of several factors, such as the effects of the disease on the respiratory and cardiovascular systems, sensory and perceptual changes, and other associated comorbidities [7]. This may result from a mismatch between central respiratory motor activity and income afferent information from receptors in the airways, chest wall structures, and respiratory muscles [7, 10]. The inability of the respiratory muscles to meet the increased respiratory demand, as occurs during activity performance, can cause dyspnea [7]. Finally, respiratory muscle weakness has already been associated with the occurrence of fatigue, reduced exercise capacity and quality of life in this population [2, 11].

Respiratory muscle training has been used to increase inspiratory and expiratory muscle strength in people with PD [12, 13]. It was found only three randomized controlled trials that have investigated the effects of respiratory muscle training in individuals with PD [14–16]. These studies showed low methodological quality when evaluated by the PEDro scale [12, 14–16]. To our knowledge, only one study investigated the effects of inspiratory muscle training for the following outcomes (inspiratory muscle endurance, dyspnea and quality of life). However, this study did not show the effect size and the data provided did not allow its calculation [12, 14, 17]. The effect size provides information about the magnitude of the effects of an intervention, being an estimate of the size of the difference between groups [18]. Interventions that have larger effect sizes are more likely to produce significant outcomes for patients. Therefore, it is essential to determine the effect size of the interventions that will be used in clinical practice [18]. Finally, although respiratory muscle weakness is associated with the fatigue and

reduced exercise capacity in individuals with PD [2, 11], the effects of respiratory muscle training on these outcomes have not yet been investigated.

Respiratory muscles respond to training stimuli in a similar fashion to other skeletal muscles, so when their fibers are overloaded, both the ratio of Type I and the size of Type II fibers are increased [19]. Previous studies that investigated the effects of inspiratory muscle training in individuals with PD, showed increases in MIP, ranging from -1.28cmH_2O [14] to -16cmH_2O [16]. In addition, increases in MEP from 15.5cmH_2O [16] to 27.97cmH_2O [15] was observed when expiratory muscle training was performed. In a study that have investigated the effect of high-intensity respiratory muscle training in individuals after stroke, an improvement in MIP of -43cmH_2O and MEP of 51cmH_2O was found, that is, approximately a double [20]. Similar results were observed in other populations when training of higher intensities were applied, such as heart failure and chronic obstructive pulmonary disease [21, 22]. In addition, the benefits of respiratory muscle training on other functional outcomes (perception of dyspnea, fatigue, and exercise capacity) seem to be obtained when a high training volume (load, duration, and frequency) is applied [21, 22]. However, the effects of respiratory muscle training of higher intensities (load, intensity, and volume) still need to be investigated in individuals with PD.

Finally, respiratory muscle training is task-specific, so the increase in inspiratory and expiratory pressure depends on training the inspiratory and expiratory muscles, respectively. Combined inspiratory and expiratory muscle training seems to be more effective, since with elevated breathing, both muscle groups are increasingly recruited [23]. In addition, initiation of a cough usually results in a large inspiration followed by expulsive events, in which the expiratory muscles contract. Therefore, so for an effective cough, the coordination between inspiratory and expiratory muscles is necessary [4]. Therefore, it is important to investigate the effects of including both types of exercises to obtain the full benefits of training [12]. In addition, performing combined inspiratory and expiratory muscle training using a single equipment is cheaper and feasible, takes less time and is easy to use. To the best of our knowledge, no study has investigated the effects of combined inspiratory and expiratory muscle training.

Thus, the primary aim of this study will be to investigate the effects of high-intensity respiratory muscle training (combined inspiratory and expiratory muscle training) on inspiratory and expiratory muscle strength in individuals with PD. The secondary aim of this study will be to investigate the efficacy of high-intensity respiratory muscle training (combined inspiratory and expiratory muscle training) in improving inspiratory muscle endurance, peak cough flow, dyspnea, fatigue, exercise capacity, and quality of life in this population.

Materials and methods

Design

A prospective, superiority parallel-group randomized controlled trial, with concealed allocation, allocation ration 1:1, blinded assessments, and intention-to-treat analysis will be carried out in a community-based setting in the city of Belo Horizonte/Brazil. Community-dwelling individuals with PD will be recruited and randomly assigned to receive either (1) high-intensity respiratory muscle training (experimental group) or (2) sham training (control group). Fig 1 shows the schedule of enrolment, interventions, and assessments [24].

All subjects will be informed of the study procedures and will provide written consent. A trained examiner will collect the outcome measures at baseline (week-0), post-intervention (after the 8-week intervention), and one month after the cessation of the intervention (12-week follow-up) (Fig 2) [24, 25]. Data collection and analysis will be carried-out by a researcher, blinded to the group allocation. All individuals will receive an identification code

	STUDY PERIOD				
	Enrolment	Allocation	Post-allocation		Close-out
TIMEPOINT**	$-t_1$	0	t_1	t_2	t_x
ENROLMENT:					
Eligibility screen	X				
Informed consent	X				
Allocation		X			
INTERVENTIONS:					
[Experimental group]			←	→	
[Control group]			←	→	
ASSESSMENTS:					
[Sociodemographic data]	X				
[Primary outcomes variables]	X			X	X
[Secondary outcomes variables]	X			X	X

Fig 1. Schedule of enrolment, interventions, and assessments.

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to ensure anonymity. The study obtained ethical approval from the Institutional Research Ethical Committee (CAAE: 53970421.0.0000.5149; number: 5.356.570) of the [information was included in the unmasked version]. The trial was prospectively registered at the ClinicalTrials.gov (NCT05608941).

Participants

A non-probabilistic sample will be recruited from the community through contact with health centers, research groups and university extension programs. Individuals will be included according to the following criteria: age $\geq$50 years; idiopathic PD diagnosed by a neurologist; taking anti parkinsonian medication, and who have been medically stable for at least six months; classified between stages 1–3 of the modified Hoehn & Yahr Scale; ability to walk independently, with or without assistive devices [26]; MIP $<80cmH_2O$ or MEP $<90cmH_2O$ (suggested values to eliminate significant muscle weakness) [27].

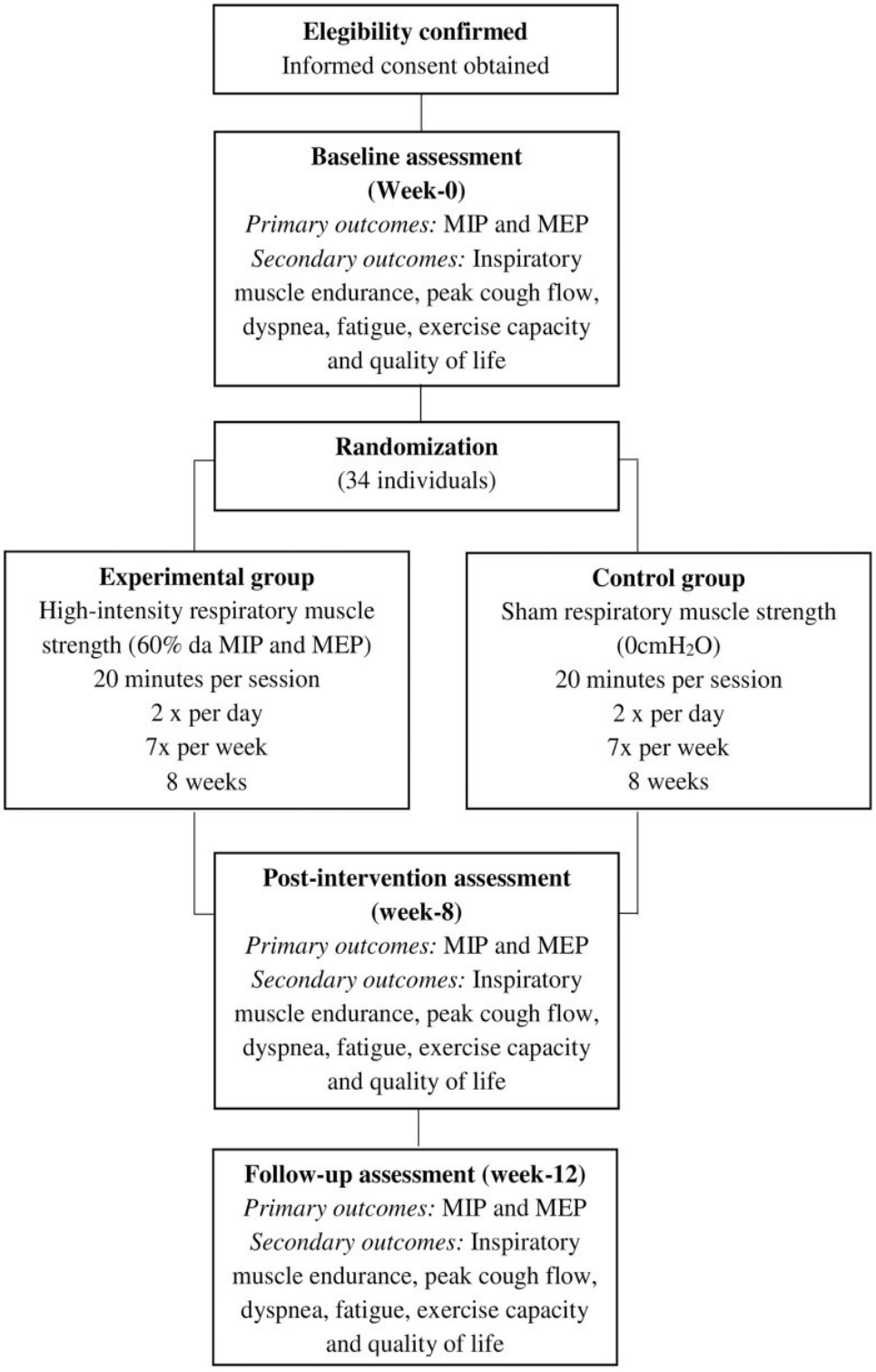


Fig 2. Flow diagram of the planned protocol. MIP: Maximum Inspiratory Pressure; MEP: Maximum Expiratory Pressure.

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Individuals will be excluded according to the following criteria: if they were engaged in a respiratory muscle training protocol in the last four weeks; possible cognitive impairment as determined by cutoff scores (in points) of the Mini-Mental Status Examination according to education level reference [28] use deep brain stimulation (DBS); smokers or who stopped smoking less than six months ago; have been affected by respiratory or cardiac infections in the last month; had any other neurological, musculoskeletal, cardiovascular or respiratory disorders that could affect their ability to perform the tests [14–16, 20].

Physical therapists, who will monitor both interventions (experimental and control), will be eligible to work with the participants if they have at least two years of professional experience in the area of neurological or respiratory rehabilitation. In addition, these physical therapists will be trained by experts in this type of training.

Participant withdrawal

Participants may withdraw from the study for any reason at any time. Researchers can withdraw participants from the trial for safety reasons or not conducting training. A maximum of one week of non-performance will be allowed [25].

Randomization

A trained research assistant will generate the randomization sequence prior to the commencement of the study. Individuals will be randomly allocated through blinded, computer-generated randomization in six-participant blocks. Group assignment will be concealed in sequentially numbered and sealed opaque envelopes. After the baseline measures, eligible participants will be randomly allocated (experimental or control groups), when the contents of the envelopes will be revealed by the trained treating therapist [25].

Intervention

Participants will undergo high-intensity inspiratory and expiratory muscle training (experimental group), or a sham training, which will consist of the same protocol, but without load (control group). The training load will be the only difference between the two groups. Individuals will receive a home-based intervention, split into two daily 20-min sessions (morning and afternoon), totaling 40 min per day, seven times a week, during eight weeks. Each daily session will be composed into four blocks of three minutes, with a two-minute rest between blocks. The Orygen Dual Valve® (Forumed S.L., Girona, Spain) device will be used to carry out the intervention, which provides inspiratory workloads from 0cmH_2O to 70cmH_2O and expiratory workloads from 0cmH_2O to 80cmH_2O.

Participants in the experimental group will perform a high-intensity inspiratory and expiratory muscle training (60% of MIP and MEP). The initial training load for each participant will be set at 60% of his/her maximal baseline MIP and MEP for both inspiratory and expiratory strength training, respectively. Once a week, the trained researcher will visit their homes to perform the necessary procedures to guarantee the intensity of the training. On this visit, MIP and MEP will be evaluated and the training load will be progressed to ensure that 60% of the new pressure values are maintained [16, 29]. Borg score of dyspnea and effort [30] will be considered for adjusting training intensity, and scores from 4 to 6 will be targeted. Borg score will be asked after one set of three minutes, and if Borg score is <4 or >6 the training load will be adjusted to higher or lower than 60% of MIP and MEP [31]. The participants will be trained and instructed to perform the exercise program on their own with no supervision. In order to maintain the participants blinded to the training load, the device will be covered with opaque material.

In the control group, a sham intervention will be implemented: the initial resistance of the device will be 0cmH_2O, and will be maintained throughout the intervention period—there will be no load progression. All procedures adopted with experimental group, including the weekly home visit, will also be performed with individuals in the control group. However, there will be no real change in the training load. All devices will be wrapped with an opaque material so that the load or possible respiratory training load is not visualized.

The protocol will be home-based intervention, meaning it will not be directly supervised. To monitor adherence to the protocol, individuals will receive a training diary, in which duration and subjective perception of effort will be recorded using the Borg scale [30], for each intervention day. A caregiver will be instructed to assist the individual in completing the diary, if necessary. In baseline, all the participants will be evaluated and receive all the information regarding the home-based training in a research laboratory.

Procedures

Demographic, anthropometric, and clinical information will be obtained, followed by the collection of the primary and secondary outcomes. These data will be collected by trained researcher, who will be blinded to the group allocation. Outcome measurement will be carried out in the university laboratory.

Primary outcomes measures

The primary outcomes to be measured are inspiratory and expiratory muscle strength. Maximum inspiratory and expiratory pressures (MIP and MEP, respectively) will be measured using a digital manovacuometer (LEB-LabCare/UFMG, Brazil) [32, 33]. To measure the MIP, individuals will be instructed to perform inspiratory maneuvers from residual volume to total lung capacity [34]. A minimum of five measurements will be performed, with a one-minute rest between them. A difference of less than 10% must be achieved among the three best measurements and the last measurement of the test cannot be the greatest [34].

To measure the MEP, individuals will be instructed to perform inspiratory maneuvers from total lung capacity to residual volume [34]. The number of measurements and the reproducibility criterion will be the same as previously described for inspiratory muscle strength [34].

The MIP and MEP values will be recorded and reported in cmH_2O. The measurement will be carried out following the recommended guideline for the use of the manovacuometer [34].

Secondary outcomes measures

The secondary outcomes to be measured are inspiratory muscle endurance, peak cough flow, dyspnea, fatigue, exercise capacity and quality of life. Inspiratory muscle endurance will be measured using a flow-resistive loading device (POWERbreathe® KH2). Individuals will be asked to breathe against a sub-maximal inspiratory load (50% of the maximal inspiratory pressure evaluated in baseline) until task failure [31]. Tests lasting from 2 to 7 minutes will be accepted. Tests that do not meet this criterion will be repeated in a different day with adjustments on resistance. Endurance test duration, number of breathes, total work, pressure, flow, power, volume, and tension time index will be recorded and used in the analyzes [31]. The measurement will be carried out following the recommended guideline for the flow-resistive loading tests [34].

Peak cough flow measurement will be performed with the peak expiratory flow meter (Mini-Wright Peak Expiratory Flow Meter) [34–37]. The individual will be asked to cough as vigorously as possible [36]. At least three measures will be taken, which must have a maximum difference of 5% between them. The highest value, in L/min, will be recorded and used in the

analysis [35, 36]. The measurement will be carried out following the recommended guideline for the flow-resistive loading tests [34].

Dyspnea will be measured using the instrument of the Medical Research Council (MRC) [38]. The participants will be asked to choose which level best represents how dyspnea limits their activities of daily living, in a 5-point scale, in which 0 indicates 'breathless only with strenuous exercise' and 4 indicates 'too breathless to leave the house'. This measurement tool has adequate measurement properties for assessing dyspnea in this population [38]. The MRC score will be used in the analyses.

Fatigue will be measured using the Fatigue Severity Scale (FSS) [39, 40]. The FSS is composed of nine statements, and participants will be asked to rate how much they agree with each of the statements. For each item, the scores range from 1 to 7, where 1 strongly disagrees and 7 strongly agrees. A higher score indicates a higher level of fatigue. The FSS is recommended by the Movement Disorders Society to assess fatigue in individuals with PD [39] and has adequate measurement properties for assessing this outcome in this population [39, 40]. The FSS score will be used in the analyses.

Exercise capacity will be measured using the Six-minute Walk Test (6MWT). Participants will be instructed to walk as far as possible in a 30-meter hallway for six minutes [41]. The 6MWT has adequate measurement properties for assessing exercise capacity in this population [42]. The test will be carried out using a standardized protocol for 6MWT [41]. Two tests will be performed on the same day, with a 30-min interval between them. The test with the greatest distance (in meters) walked will be considered and used in the analyses [41].

Quality of life will be measured using the Parkinson's Disease Questionnaire-39 (PDQ-39) [43]. The PDQ-39 is composed of 39 items divided into eight dimensions, and for each item the score ranges from 0 to 4 [43]. The score for each dimension varies from 0 to 100. The PDQ-39 has adequate measurement properties for assessing exercise capacity in this population [43].

Data monitoring

An independent researcher, who will be blind to the group allocation, will be responsible for monitoring any adverse effects, database management, and statistical analyses. Participants will be asked to report any adverse effects or discomfort, which will be registered and reported [25]. Physical therapists will be responsible for the monitoring of exercise intensity and participants program compliance.

Sample size

The sample size calculation was performed considering the primary outcome measures (inspiratory and expiratory muscle strength). The sample size was estimated using the G*Power Software® (version3.1) and considering data provided by previous randomized controlled trials that investigated the effects of respiratory muscle training on respiratory muscle strength in individuals with PD [14, 15].

The effect size (f) of 1.00 for inspiratory muscle training was derived from the study of Inzelberg et al. (2005) [14]. In that study, the MIP in the experimental group ($n = 10$) increased from 62±8,2 to 78±7,5, and the control group ($n = 10$) showed no statistically significant difference (51±8.0). Considering a significance level (α) of 5% and a power of 0.90, a sample size of ten participants are required. The effect size (f) of 0.54 for expiratory muscle training was derived from the study of Sapienza et al. (2011) [15]. In that study, the MEP in the experimental group ($n = 30$) increased from 105.29±28.81 to 133.26±35.53, and the control group ($n = 30$) reduced from 103.65±24.82 to 99.23±27.46. Considering a significance level (α) of 5%

and a power of 0.90, fourteen participants per group are required (a total of 28 participants). For analysis of variance, the power is approximately 90% for an effect size of 0.5, considering an $\alpha = 0.05$ and a sample size of 30 individuals [18]. This power was used aiming at a more conservative estimate since larger samples have greater statistical power [18].

Therefore, a sample size of 28 individuals (14 in each group) was defined (largest sample size calculated). Assuming an expected dropout rate of 20%, a total sample size of 34 individuals was set (17 in each group).

Statistical analysis

All statistical analyzes will be performed by an independent examiner, blinded to the group allocation. Each participant will be assigned to a unique code. All analyses will be performed using SPSS version 25.0 (SPSS Inc., Chicago, IL, USA). The distribution of continuous variables will be checked for normality using the Shapiro-Wilk test. Descriptive statistics will be calculated for all outcomes (means and standard deviations for normally distributed data; medians and interquartile range for continuous nonparametric data; frequency and percentages for categorical data).

The effects of the interventions will be analyzed from the collected data using intention-to-treat. All randomized individuals will be included in the analyses. For dropouts, data from the last available assessment will be used for missed sessions [17, 25]. Two-way ANOVA with repeated measures (2*3) will be used to evaluate the differences between groups, considering the time factor (baseline, post-intervention, and 12-week follow-up), followed by post hoc test selected based on final sample size and in the assumption of equal of variance [18]. If necessary, a similar nonparametric test will be used. The level of significance will be set at 5% [25].

The effect sizes will be calculated to determine the magnitude of the differences between the groups. The differences between the two mean values will be expressed in units of their SD, expressed as Cohen's d, or mean results for the experimental group minus the mean results for the control group, divided by the SD of the control group. Effect sizes between 0.2 and 0.5 will be considered small; between 0.5 and 0.8, medium; and above 0.8, large.

Ethics

The study obtained ethical approval from the Institutional Research Ethical Committee (CAAE: 53970421.0.0000.5149; number: 5.356.570) of the [information was included in the unmasked version]. All participants will be explained about the objectives and procedures of the study, and will sign a statement of informed consent. The researchers will take all appropriate customary steps to ensure the privacy and confidentiality of the participants, as well as the protection of data. After the publication of the results of this study and the secondary ones, the data underlying the findings will be available without restriction upon request. To ensure confidentiality, data will be blinded to any identifying participant information.

Discussion

To the best of our knowledge, this will be the first study to investigate the effects of high-intensity respiratory muscle training (combined inspiratory and expiratory muscle training) in individuals with PD. High-intensity respiratory muscle training has the potential to improve inspiratory and expiratory muscle strength in this population. In addition, this can improve inspiratory muscle endurance, dyspnea perception, fatigue, exercise capacity and quality of life. Finally, combined inspiratory and expiratory muscle training using a single device is cheaper and feasible, takes less time and is easily operated, as well as seem to be more effective.

The effect of respiratory muscle training in individuals with PD was already investigated by few studies [12, 17]. A systematic review with meta-analysis examined the effects of non-pharmacological intervention on respiratory impairments in individuals with PD [17]. Due to the small number of published studies and the undetermined effect size, it was not possible to perform a meta-analysis of the effect of respiratory muscle training on inspiratory muscle strength and endurance, and peak cough flow [17]. Therefore, further studies are needed to understand the effects of respiratory muscle training in this population.

In the studies that investigated the effects of respiratory muscle training in individuals with PD, the protocols were very variable. Two randomized clinical trials investigated the effect of inspiratory muscle training on inspiratory strength individuals with PD. Inzelberg et al. 2005 [14] started with an initial training load of 15% of MIP (initial training load), with an increase of 5–10% per week until reaching 60% of the MIP achieved at baseline, at the end of the first month [14]. Then, the training load was adjusted to 60% of the new MIP values, evaluated monthly [14]. The protocol was one daily 30-min sessions, six times a week, for 12 weeks [14]. Reyes et al. 2018 [16] started with an initial training load of 50% of MIP, adjusted every two weeks until reaching 75% of the initial training load. The duration was 5 cycles of 5 breaths per day, sex times a week, for 8 weeks [16].

Two studies investigated the effect of expiratory muscle training in individuals with PD. Sapienza et al. 2011 [15] started with an initial training load of 75% of MEP, 5 sets of 5 repetitions, five times for week, for four weeks [15]. Reyes et al. 2018 [16] started with an initial training load of 50% MIP, adjusted every two weeks until reaching 75% of the initial training load. The duration was 5 cycles of 5 breaths per day, six times for week, for 8 weeks [16].

In other populations, the effects of respiratory muscle training were increased when higher training intensities were applied [21, 22]. Results were better when higher loads (>50% of baseline), session duration (at least 30-min for day), training duration (eight weeks), and progressively increasing loads (adjusted weekly to the new MIP and MEP values) were used [20–22]. Therefore, in the present study the effects of a high-intensity training (60% of MIP and MEP, adjusted weekly to the new values of maximal respiratory pressures, two daily 20-min sessions, seven times a week, for eight weeks) will be examined in individuals with PD.

Individuals with PD commonly present respiratory muscle weakness, both inspiratory and expiratory muscle groups [2, 44]. Inspiratory muscle weakness can lead to impaired coughing, increased perception of dyspnea and reduced exercise capacity [7]. The reduction in expiratory muscle strength may result in decreased subglottic pressure during the compression phase of cough, reduced expiratory airflow, and inadequate airway clearance [4]. This favors the accumulation of secretions and the occurrence of infections, such as pneumonia [4]. Therefore, it is important to train both muscle groups in this population, and this training using a single piece of equipment is more cost-effective, simple and easy to use [20]. However, the effects of combined inspiratory and expiratory muscle training on respiratory muscle strength, inspiratory muscle endurance, peak cough flow, dyspnea, fatigue, exercise capacity, and quality of life have not yet been investigated in this population. In this study, this combination will be performed using the Orygen Dual Valve® device [14, 15, 29].

A recent systematic review showed that, among the instruments used to perform respiratory muscle training, only two allow inspiratory and expiratory muscle training with independent loads [45]. Among them, Orygen Dual Valve® had the advantage of being cost-effective (inexpensive), approximately $70 [45]. In addition, the Orygen Dual Valve® allows proper load adjustments and mouthpiece sealing, is easy to use, portable and allows home-based training [45].

Respiratory muscle training is simple, easy to understand, and can be performed in the community setting, reducing transportation difficulties [20]. Increasing the training volume

(load, duration, or frequency) can enhance the results already reported in the literature [20] and can also improve other important outcomes that have not been yet determined and/or investigated, such as inspiratory muscle endurance, fatigue, exercise capacity, and quality of life. The combined inspiratory and expiratory muscle training using a single device has the advantages of promoting the benefits in both inspiratory and expiratory muscle strengthening, being easier to use, saving time and cost-effective [20]. Clinicians will be able to use the results of this study to implement this training in clinical practice. In addition, researchers may use the results of this study to design other studies.

Strengthens and weakness of the proposed protocol

This study protocol proposes the use of simple and low-cost measures commonly used in clinical practice to measure outcomes. This intervention will be carried out in the home environment that increases feasibility, accessibility, reduces time, and costs of transport. This increases the feasibility to reproduce their findings in clinical practice. This protocol proposes a randomized clinical trial that is the best study design to investigate the intervention effect. The trial will also have blinded allocation, blinded evaluator, and intention-to-treat analysis. The therapist responsible for carrying out the training has experience in neurological and respiratory rehabilitation and a master's degree in neurological rehabilitation.

This trial also has some limitations. Due to the characteristics of the intervention, participants cannot be completely blinded. Some strategies will be used in an attempt to blind the participants, such as the device will be covered with opaque material to not allow the visualization of the training load. In addition, the intervention will be carried out in the home environment. This requires the commitment and motivation of the participant. Strategies to encourage complete exercise are also planned, such as completing the training diary and weekly visits.

Supporting information

S1 File. Complete protocol approved by the ethics committee.
(PDF)

S2 File. Complete protocol approved by the ethics committee (in Portuguese).
(PDF)

S3 File. SPIRIT checklist.
(PDF)

Author Contributions

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CAPÍTULO 4

ARTIGO 4

Full Title: **High-intensity combined inspiratory and expiratory training increases respiratory muscle strength in Parkinson's disease: a randomized clinical trial**

Short Title: **Respiratory muscle strength in Parkinson's disease**

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ABSTRACT

Background: Individuals with Parkinson's Disease (PD) commonly have reduced respiratory muscle strength and inspiratory muscle endurance, which impacts their health. Combining inspiratory and expiratory muscle training at high intensities can improve these results.

Purpose: To investigate the efficacy of home-based high-intensity combined inspiratory and expiratory muscle training on inspiratory and expiratory muscle strength (primary outcomes) and inspiratory muscle endurance, peak cough flow, dyspnea, fatigue, exercise capacity, and quality of life (secondary outcomes).

Methods: A double-blinded randomized controlled trial, with 34 individuals with PD was performed. Experimental group: home-based high-intensity combined inspiratory (60% of maximum inspiratory pressure (MIP)) and expiratory (60% maximum expiratory pressure (MEP)) muscle training, 40 minutes a day, 7 times a week, for 8 weeks. Control group: same protocol, but without load (0cm$H_2$0). Outcomes were measured at baseline, post-intervention, and 1 month after the cessation of the intervention (follow-up).

Results: Thirty-four individuals (22 men), 69.5±8.4 years of age and 73.3±60.7 months since diagnosis were included. Compared to the control group, the experimental group had an increase in MIP (19.56cmH_2O; 95%CI:9.67 to 29.45), MEP (24.29cmH_2O; 95%CI:9.87 to 38.71), inspiratory muscle endurance expressed by the test duration (1.21min; 95%CI:0.39 to 2.03), dyspnea (-0.71points; 95%CI -1.30 to -0.12), and exercise capacity (39.35meters; 95%CI:0.58 to 78.12). The effects on MIP, inspiratory muscle endurance, and dyspnea were maintained in follow-up. In addition, both groups had an increase in peak cough flow (mean difference=38.68L/min; 95%CI:17.24 to 60.11), and an improvement in quality of life (mean difference=-3.49points; 95%CI:-

5.89 to -1.08), which was maintained in follow-up. No significant effect was observed on fatigue. Finally, compliance and adherence were excellent, and no adverse effect was observed.

Conclusion: Home-based high-intensity combined inspiratory and expiratory muscle training improved inspiratory and expiratory muscle strength, inspiratory muscle endurance, dyspnea, and exercise capacity in individuals with PD.

Keywords: Breathing exercises; Clinical trial; Exercise; Muscle strength; Parkinson's disease; Rehabilitation.

INTRODUCTION

Parkinson's disease (PD) is the second most prevalent neurodegenerative disease worldwide and a major contributor to disability-adjusted life years among older adults with neurologic disorders.[1] Individuals with PD experience several non-motor symptoms, such as fatigue[2] and respiratory disorders.[3] A recent meta-analysis demonstrated that individuals with PD have a significant reduction in lung volumes, inspiratory and expiratory muscle strength, and peak cough flow compared to matched healthy controls.[3] Reduction in both inspiratory and expiratory muscle strength and endurance can have several impacts on the health of these individuals.[3;4] Inspiratory muscle weakness predisposes to the occurrence of dyspnea, impaired functional capacity, and poor exercise tolerance.[5;6] Expiratory muscle weakness can lead to ineffective coughing, which favors mucus retention and aspiration, thereby increasing the risk of pneumonia.[5;6]

Respiratory muscle training is widely used to improve respiratory muscle strength and endurance in several health conditions, such as respiratory conditions[7] and heart failure.[8] However, in individuals with PD, there is still a scarcity of studies. A meta-analysis investigated the effect of non-pharmacological interventions on respiratory outcomes in this population.[9] Twelve studies were included, five of which investigated the effects of isolated inspiratory or expiratory muscle training.[9;10-13] Due to the limited number of studies, it was not possible to analyze the effect of home-based inspiratory muscle training. Regarding home-based expiratory muscle training, a statistically significant improvement in expiratory muscle strength (MD 34.78; 95%CI 19.60 to 49.96) was found in favor of the experimental group; however, this analysis included only two studies with conflicting results.[9;12;13] Meta-analyses for other

outcomes, such as inspiratory muscle endurance, peak cough flow, and dyspnea, were not possible due to the lack of studies.[9]

Additionally, weakness of the respiratory muscles is associated with fatigue and predisposes to low exercise capacity, symptoms that are highly prevalent and often disabling in this population.[14-16] In other populations, such as individuals with stroke, respiratory muscle training has significantly improved these outcomes.[17] However, studies investigating the effects of respiratory muscle training on fatigue and exercise capacity in individuals with PD were not found.

As previously presented, studies examining the effects of respiratory muscle training in individuals with PD have performed inspiratory or expiratory training separately. Training the inspiratory and expiratory muscles within the same respiratory cycle, using a single device, is faster, easier and more economical than training them separately, and has the potential to optimize the benefits of training.[18] In addition, a possible reason for the lack of significant effects observed in some of these studies may be to inadequate load progression, insufficient training duration, and/or low training frequency.[18;19] Since respiratory muscles are skeletal muscles, increasing the training volume (load, duration and/or frequency) could improve the results found in the aforementioned studies.[18;19]

Finally, in previous studies, training was conducted in the individuals' homes. Respiratory muscle training is often conducted at home due to the high frequency of weekly sessions (e.g., 5 to 6 times per week),[9;20] which helps to overcome common barriers associated with community-based training, such as transportation challenges, less flexible schedules, and commute time.[21] However, the demands of high-intensity combined inspiratory and expiratory muscle training can make performing at home

more challenging. Therefore, it is essential to explore the effects of home-based high-intensity combined inspiratory and expiratory muscle training in this population.

In this context, the primary aim of this study was to investigate the efficacy of a home-based high-intensity combined inspiratory and expiratory muscle training on inspiratory and expiratory muscle strength in individuals with PD. The secondary aim of this study was to investigate the efficacy of home-based high-intensity combined inspiratory and expiratory muscle training on inspiratory muscle endurance, peak cough flow, dyspnea, fatigue, exercise capacity, and quality of life in this population.

METHODS

Design

A double-blinded, superiority parallel-group randomized controlled trial, with concealed allocation, allocation ratio of 1:1, blinded assessment, and intention-to-treat analysis was undertaken.[22] This trial received approval from the ethics review board of the Universidade Federal de Minas Gerais (CAAE: 53970421.0.0000.5149; number: 5.356.570), prospectively registered at www.ClinicalTrials.gov (NCT05608941), and its protocol was published.[22] There were no changes from the original protocol.[22] This study was carried out in a community-based setting in Belo Horizonte/Brazil, from December 2022 to April 2024, and reported following the CONSORT statement guidelines.[23]

A research assistant, unrelated to data collection, compiled a computer-generated random allocation sequence. The allocation sequence was placed in opaque, sequentially numbered, and sealed envelopes, which were held offsite by an independent researcher.[22] After the baseline assessment, the trained therapist revealed the envelope contents. Participants were randomly assigned to receive either (1) high-

intensity combined inspiratory and expiratory muscle training (experimental group) or (2) sham training (control group).[22] A trained examiner, blinded to group allocation, collected written consent and outcome measures at baseline (week 0), post-intervention (week 8), and follow-up (week 12).[18;22;24] These evaluations were carried out in the university laboratory.[22]

Participants

Participants were eligible if they had idiopathic PD diagnosed by a neurologist, were aged ≥50 years, were taking antiparkinsonian medication and had been medically stable for ≥6 months, were classified as stages 1–3 of the modified Hoehn & Yahr Scale,[25] had ability to walk independently (with or without assistive devices), and had Maximum Inspiratory Pressure (MIP) <80cmH_2O or Maximum Expiratory Pressure (MEP) <90cmH_2O.[22;26] They were excluded if they had engaged in respiratory muscle training in the past four weeks, had possible cognitive impairment according to education-adjusted scores on the Mini-Mental State Examination,[27] had been submitted to deep brain stimulation (DBS), were smokers or had stopped smoking ≤6 months ago, had experienced respiratory or cardiac infections in the last month, or had any other disorders that could affect their ability to perform the tests.[18;22]

Interventions

Participants undertook a home-based intervention using the Orygen Dual Valve® (Forumed S.L., Girona, Spain),[28] divided into two daily 20-minute sessions (morning and afternoon), totaling 40 minutes a day, seven times a week, for eight weeks. Each daily session was divided into four blocks of three minutes with 2 minutes of rest between them.[22] The training load for the experimental group was determined based on their MIP and MEP (60% of the maximum respiratory pressures), while no load was

used for the control group.[22] The Orygen Dual Valve® allows individual adjustment of inspiratory and expiratory loads, providing an inspiratory load of up to 70 cmH_2O and an expiratory load of up to 80 cmH_2O. Loads can be increased in 10 cmH_2O increments.[28]

After the baseline assessment, a trained therapist visited each participant's home to deliver the device and teach them how to perform the intervention. In addition, once a week, the therapist went to their homes to carry out the necessary procedures to ensure the intensity of the training.[22] The same procedures, including home visits, were followed for both groups (experimental and control), the only difference was the training load. All devices were wrapped in opaque material to keep participants blinded to the load.[22] To monitor compliance, participants were provided with a training diary to record all training sessions. When required, a proxy was instructed to help them.[22]

Experimental Group

The initial training load was set at 60% of the maximum respiratory pressures (MIP and MEP) measured at baseline (week 0).[18;22] During weekly home visits, current maximum respiratory pressures were measured, and the training load was adjusted accordingly to maintain the target training intensity (60% of the maximum respiratory pressures).[18;22] In addition, the subjective perception of effort, assessed by the modified Borg scale,[29] was used to determine the training load, aiming for a score between 4 and 6.[22]

Control Group

The control group performed the intervention without any load (0cmH_2O) or progression. They followed all the same procedures as the experimental group,

including the weekly measurement of maximum respiratory pressures during home visits, but no real load changes were made.[18;22]

Primary outcome measures

Primary outcomes included both inspiratory and expiratory muscle strength, measured as maximal respiratory pressures (MIP and MEP, respectively) in cmH_2O.[22] They were assessed using a digital manovacuometer (LEB-LabCare/UFMG, Brazil),[30;31] following the recommended guideline.[32] At least five measurements were taken.[32] The maneuvers were considered complete when three acceptable (no air escape and lasting at least 1.5 seconds) and reproducible (difference less than 10% and the last measurement of the test could not be the largest) maneuvers were obtained.[31;32] The highest MIP and MEP values among these three measurements were recorded and used in the analyses.[22]

Secondary outcome measures

Inspiratory muscle endurance was measured using a flow resistive load device (POWERbreathe KH2), following the recommended guideline.[32;33] Participants were instructed to breathe against a submaximal load (50% of the MIP at baseline) until task failure.[32;33] The test was deemed acceptable if it lasted between 2 to 7 minutes.[32;33]

Studies evaluating inspiratory muscle endurance using a constant external load, as in the present study, typically report the test duration.[18; 32] Accordingly, this variable was used to represent respiratory muscle endurance in this study. However, respiratory muscle training can also increase inspiratory volume and work per breath.[32] Additionally, muscle performance is influenced by various factors, including breathing patterns, such as time components and inspiratory volumes.[32] The POWERbreathe KH2 continuously records flow, volume, and pressure responses, providing a comprehensive

dataset.[32] Therefore, number of breaths, total work, pressure, flow, power, volume, and the tension time index were also recorded and analyzed, allowing for a detailed understanding and control of performance during the test.[22]

The peak cough flow (in L/min) was measured using the peak expiratory flow meter (Mini-Wright Peak Expiratory Flow Meter).[32;34-36] Three measurements were taken, with a maximum of 5% difference between them, and the largest measurement was recorded.[22;32]

Dyspnea was measured using the Medical Research Council (MRC) instrument, a 5-point scale where 0 indicates *'breathless only with strenuous exercise'* and 4 indicates *'too breathless to leave the house'*.[22;37]

Fatigue was measured using the Fatigue Severity Scale (FSS), a 9-item scale where scores for each item range from 1 to 7.[38;39] A higher score reflects a higher level of fatigue.[22;38;39] The total score was considered for analysis.

Exercise capacity was measured using the Six-Minute Walk Test (6MWT).[40] The test was conducted in a 30-meter corridor, and participants were instructed to walk as far as possible within 6 minutes.[40] Two tests were performed, with a 30-minute rest between them.[40] The greatest distance covered, in meters, was recorded and used for analysis.[22; 40]

Quality of life was measured using the Parkinson's Disease Questionnaire-39 (PDQ-39), a 39-item questionnaire divided into eight dimensions.[41] The total score ranges from 0 to 100, with lower scores indicating a higher quality of life.[22;41] The total score was considered for analysis.

Sample size calculation

The sample size was calculated for both primary outcomes (inspiratory and expiratory muscle strength) using the G*Power Software (version3.1), and the highest

calculated value was assumed. Previous randomized clinical trials that investigated the effects of respiratory muscle training on respiratory muscle strength in individuals with PD were used to perform the calculation.[10;13] Considering a significance level (α) of 5% and a power of 0.90, the minimum number of participants required was 14 individuals per group, totaling 28 participants.[13;42] Assuming an expected dropout rate of 20%, the total sample size was set at 34 individuals, with 17 in each group.[22;42]

Statistical analyses

Statistical analyses were conducted by an independent examiner based on intention to treat. For dropouts, data from the last available assessment were interpolated for missed sessions.[22;42] The normality of the distribution of continuous variables was analyzed using the Shapiro-Wilk test. Two-way ANOVA with repeated measures (2*3) was used to assess differences between groups over time, followed by post hoc tests.[22;42] Differences between groups over time (week 8 minus week 0 and week 12 minus week 0) were reported as mean differences and 95% confidence intervals (95%CI), as recommended.[22;42] The significance level was set at 5%, and all analyses were performed using SPSS version 25.0 (SPSS Inc., Chicago, IL, USA).[22]

Role of the Funding Source

The funders played no role in the design, conduct, or reporting of this study.

RESULTS

Flow of participants

Thirty-four individuals (22 men) were included in this study and randomized to two groups. Figure 1 provides a flow diagram of the participants' recruitment. The

mean age of the individuals was 69.5±8.4 years and the mean time since diagnosis was 73.3±60.7 months. Baseline characteristics are detailed in Table 1.

Compliance with the study protocol

Study compliance was excellent, with 33/34 participants receiving the training and attending the post-intervention assessment (week 8). One participant in the control group discontinued training due to gastrointestinal disorders. Two individuals, one from each group (experimental and control), did not attend the follow-up assessment (week 12) due to lack of time.

The 33 participants who completed the study protocol reported adhering to the home-based training as recommended. Among those who completed the training, three participants (9%) lost their training diaries (one from the experimental group and two from the control group). Analysis of the diaries revealed an overall adherence to the training sessions of 89% (range 73% to 100%): 90% in the experimental group (range 88% to 100%) and 89% in the control group (range 73% to 100%). The main reasons for missing a training session were lack of time (41%), travel (17%), and sickness (15%). The mean number of home visits was 7.5±0.8 out of the eight planned visits. Regarding training intensity, the target load of the experimental group was reached from the first week and maintained throughout the intervention.

Efficacy of the high-intensity combined inspiratory and expiratory muscle training

The means, standard deviation, within-group, and between-group differences (95%CI) for all outcomes over time are provided in Table 2.

Primary outcomes

The analysis of variance revealed a significant interaction effect (time*group) for MIP (F=12.34; p=0.001) and MEP (F=6.31; p=0.003), indicating that the groups showed different behaviors over time. In terms of inspiratory muscle strength, the experimental group had an increase in MIP values with a mean difference of 19.56cmH_2O (95%CI 9.67 to 29.45) compared with the control group at post-intervention (8 weeks). These results were maintained at follow-up (12 weeks), with a mean difference of 18.03cmH_2O (95%CI 7.73 to 28.33) (Figure 2).

Regarding expiratory muscle strength, the experimental group had an increase in MEP values with a mean difference of 24.29cmH_2O (95%CI 9.87 to 38.71) compared to the control group at post-intervention. These results were not maintained at follow-up, with a mean difference of 13.53cmH_2O (95%CI -1.37 to 28.43) (Figure 2).

Secondary outcomes

The analysis of variance revealed a significant interaction effect (time*group) for inspiratory muscle endurance expressed by the test duration (F=6.01; p=0.004), dyspnea (F=3.98; p=0.023), and exercise capacity (F=2.01; p=0.154). Regarding, inspiratory muscle endurance, the experimental group increased the test duration in the 1.21 minutes (95%CI 0.39 to 2.03) compared to the control group at post-intervention. These results were maintained at follow-up, with a mean difference of 1.16 minutes (95%CI 0.29 to 2.03) (Figure 3). The results of the number of breaths, total work, pressure, flow, power, volume, and the tension time index are presented in Table 2.

In terms of dyspnea, the experimental group reduced the MRC score by -0.71 points (95%CI -1.30 to -0.12) compared with the control group at post-intervention. These results were maintained at follow-up with a mean difference of -0.47 points

(95%CI -0.93 to -0.01). Regarding exercise capacity, the experimental group increased the distance walked in the 6MWT by 39.35 meters (95%CI 0.58 to 78.12) compared with the control group at post-intervention. These results were not maintained at follow-up with a mean difference of 40.24 (95%CI -17.73 to 98.21) (Figure 3).

Analysis of variance revealed no significant interaction effect (time*group) for peak cough flow (F=1.13; p=0.317), fatigue (F=0.19; p=0.820), and quality of life (F=0.27; p=0.973). For peak cough flow, the groups had similar results for both post-intervention (95%CI -17.63 to 67.63) and follow-up (95%CI -24.80 to 87.74). In addition, analysis of variance revealed statistically significant within-group differences (F=14.93; p=0.001). Both groups had an increase in peak cough flow with a mean difference of 38.68L/min (95%CI 17.24 to 60.11) post-intervention compared to baseline. These results were maintained at follow-up with a mean difference of 59.66L/min (95%CI 31.33 to 87.79). Regarding fatigue, the groups had similar results for both post-intervention (95%CI -1.21 to 0.65) and follow-up (95%CI -1.22 to 0.72). In addition, analysis of variance revealed no statistically significant within-group differences (F=0.23; p=0.798). In terms of quality of life, the groups had similar results for both post-intervention (CI95% -4.62 to 5.18) and follow-up (95%CI -5.42 to 4.92). In addition, analysis of variance revealed statistically significant within-group differences (F=14.93; p=0.001). Both groups had a reduction in quality of life scores, with a mean difference of -3.49 points (95%CI -5.89 to -1.08) post-intervention compared to baseline. These results were maintained at follow-up, with a mean difference of -3.13 points (95%CI -5.68 to -0.59) (Figure 3).

DISCUSSION

This randomized clinical trial provided evidence that home-based high-intensity combined inspiratory and expiratory muscle training increases inspiratory and

expiratory muscle strength and inspiratory muscle endurance, reduces dyspnea, and improves exercise capacity in individuals with PD, when compared to a sham intervention. These effects on inspiratory muscle strength, inspiratory muscle endurance, and dyspnea were maintained one month after intervention cessation (follow-up). In addition, both groups had an increase in peak cough flow, and an improvement in quality of life post-intervention (week 8), which was maintained at follow-up (week 12). There was no significant effect on fatigue post-intervention, neither at follow-up.

To the best of our knowledge, this was the first study that investigated the efficacy of combined inspiratory and expiratory muscle training in individuals with PD. Only three randomized clinical trials on the effects of respiratory muscle training in individuals with PD were found; all of them applied inspiratory or expiratory muscle training in isolation, and did not perform high-intensity training.[10;12;13] Additionally, this study employed a higher training volume (load, duration and/or frequency) than those employed in previous studies in this population,[10;12;13] which should enhance training benefits.

Despite the higher demands of high-intensity combined inspiratory and expiratory muscle training, this study successfully conducted it in participants' homes, similar to previous studies. This offers an important advantage by minimizing barriers to community-based exercises, such as transportation challenges, less flexible schedules, and commute time.[21] Remarkably, despite the greater demands of this protocol compared to previous studies (high-intensity combined inspiratory and expiratory muscle training), the study achieved excellent compliance and adherence rates, which have not been previously reported in this population. Therefore, this

intervention was feasible, safe, and has more advantages than previous interventions applied to these individuals that focused only on the inspiratory or expiratory muscles.

The primary outcomes of this study were inspiratory and expiratory muscle strength. Inzelberg et al. 2005 investigated the effect of inspiratory muscle training on inspiratory muscle strength compared with a sham intervention (same protocol, but without load) in individuals with PD.[10] Similar to the present study, a statistically significant difference in inspiratory muscle strength was found in favor of the experimental group.[10] In addition, Sapienza et al. 2018 examined the effect of expiratory muscle training on expiratory muscle strength compared with a sham intervention (same protocol, but without load) in this population.[13] Similar to the present study, in the study by Sapienza et al. (2018), a statistically significant increase in MEP was found in favor of the experimental group.[13]

Reyes et al. (2018) compared the effects of inspiratory versus expiratory muscle training on inspiratory and expiratory muscle strength, and peak cough flow in individuals with PD.[12] Participants were allocated into three groups: 1) inspiratory muscle training; 2) expiratory muscle training; 3) control (same protocol, but without load). In contrast to the present study, no significant differences were found in inspiratory muscle strength in either group (inspiratory or expiratory) when compared to the control group.[12] The higher training volume and weekly load adjustments used in the present study may explain the divergent results. In the study developed by Reyes et al. (2018), the training protocol consisted of 5 cycles of 5 breaths per day, 6 times per week, for eight weeks.[12] Additionally, the load was adjusted biweekly until reaching 75% of the basal MIP, with no further adjustments thereafter.[12] In contrast, the present study implemented 2 sessions of 20 minutes per day, 7 times per week, for 8 weeks, with a training load = 60% of the weekly adjusted maximum respiratory pressures.[22]

In addition, similar to the present study, Reyes et al. (2018) did not find significant differences in peak cough flow in either group (inspiratory or expiratory) when compared to the control group.[12] However, both training groups in this study did show a significant increase in peak cough flow. One possible reason for this is that the respiratory exercises implemented in this study, even without load, were sufficient to enhance peak cough flow. Future studies should explore the effects of breathing exercises similar to the present study compared with other types of sham intervention to better understand their impact.

Fatigue and exercise capacity were secondary outcomes in the present study. It was not found previous studies that have investigated the efficacy of respiratory muscle training on fatigue and exercise capacity in individuals with PD. In the present study, the proposed muscle training did not result in intra- or between-group differences in fatigue. One possible explanation is the characteristics of the sample. Based on the cutoff point of ≥4.67 points on the Fatigue Severity Scale proposed by Siciliano et al., 2019, the participants of the present study did not exhibit fatigue at baseline, making it unlikely to observe improvements in this outcome.[43] However, considering the progressive nature of PD, although the present study lasted only three months, the maintenance of unchanged fatigue levels can be interpreted as a positive result. Future studies aiming to investigate the efficacy of combined inspiratory and expiratory muscle training on fatigue should be designed to specifically include individuals who experience a reduction in this outcome.[12]

Regarding exercise capacity, a significant increase was found in the experimental group, compared to the control group at post-intervention. Individuals with PD commonly have reduced exercise capacity that is associated with limitations in daily activities and loss of independence.[44] Previous studies investigating the isolated

efficacy of inspiratory or expiratory muscle training on exercise capacity in other populations, such as individuals with ischemic heart disease[45] and chronic obstructive pulmonary disease,[46] did not find statistically significant differences. A possible explanation for the positive results observed in this study may be the combined training of inspiratory and expiratory muscles, which appears to be an effective strategy to optimize the benefits of training in this population.

Finally, in the present study, experimental and control groups improved their quality of life post-intervention compared to baseline, and these improvements were maintained during the follow-up period. Participants in both groups performed respiratory exercises for 20 minutes, twice a day, with the only difference between the groups being the intensity of the training. It is possible that respiratory exercises, even without load, were effective in improving quality of life, which may explain the observed results. A randomized controlled trial with individuals with epilepsy found that a 20-minute mindfulness respiratory exercise was effective in reducing levels of depression and improving the quality of life.[47] Another possible explanation for the results is the attention received by the participants during treatment, since both groups received weekly home visits from the therapist. Studies have shown that the therapist-patient relationship can influence outcomes in physical rehabilitation, including in individuals with PD.[48;49] Finally, the results can be explained by a placebo effect, as participants were blinded to group allocation. Therefore, individuals in both groups could believe that the intervention was working.[42] Future studies could explore the effects of respiratory exercises on the quality of life of individuals with PD, using a different control intervention.

Unfortunately, it is not possible to discuss whether the improvements observed in the present study are clinically significant in addition to be statistically significant.

The Standard Error of Measurement (SEM), Minimal Detectable Change (MDC), and Minimal Clinically Important Difference (MCID) for inspiratory and expiratory muscle strength have not yet been established for individuals with PD. Therefore, future studies should investigate SEM, MDC and MCID for inspiratory and expiratory muscle strength in individuals with PD.

Strengths and Limitations

The intervention of this study has several characteristics that enhance its clinical applicability: 1) home-based intervention with weekly monitoring; 2) uses outcome measures that are easy to perform in clinical practice; 3) training both the inspiratory and expiratory muscles within the same respiratory cycle using a single device is faster, easier and more cost-effective than training them separately ; and 4) utilizes only one equipment for the training, the Orygen Dual Valve®, which offers an adequate load range, supports both inspiratory and expiratory training, and is inexpensive (approximately $82).[22;28] Those characteristics, plus the positive effects observed in inspiratory and expiratory muscle strength, inspiratory muscle endurance, dyspnea, and exercise capacity, favor its use in clinical practice.

This study has some limitations. Despite efforts to include individuals at different stages of the Hoehn and Yahr scale, most participants were classified in stage 2, which reduces its external validity. In addition, participants classified in stages 4 and 5 were not included, so the results should be used cautiously for individuals in these stages. Finally, eligibility criteria aimed to control for the primary outcomes. Therefore, individuals without fatigue were included, which has the potential to influence the findings. Future studies must investigate the efficacy of combined inspiratory and expiratory muscle training, including individuals at other stages of the Hoehn and Yahr

scale. In addition, studies with specific eligibility criteria for other outcomes, such as fatigue, must be carried out.

CONCLUSION

Home-based high-intensity combined inspiratory and expiratory muscle training improved inspiratory and expiratory muscle strength, inspiratory muscle endurance, dyspnea, and exercise capacity of individuals with PD. Effects on inspiratory muscle strength, inspiratory muscle endurance and dyspnea were maintained in the follow-up period. In addition, both groups improved peak cough flow and quality of life, which was maintained in follow-up. The intervention performed is simple, quick, and cost-effective, which favors its use in clinical practice.

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CONFLICT OF INTEREST

None declared

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Table 1. Baseline characteristics of the participants of both the experimental and control groups

Characteristic	**Randomized (*n* = 34)**	
	Exp (*n* = 17)	**Cont (*n* = 17)**
Age (years), mean (SD)	70.6 (6.2)	68.5 (10.1)
Sex, *n* men (%)	11 (64.7)	10 (58.8)
Body mass index (kg/m^2), mean (SD)	28.4 (4.5)	26.2 (3.5)
Time since diagnostic onset (months), mean (SD)	75.9 (48.5)	100.3 (69.2)
Marital status, *n* (%)		
Single	2 (11.8)	3 (17.7)
Married	12 (70.6)	10 (58.8)
Widowed	1 (5.9)	1 (5.9)
Divorced	2 (11.8)	3 (17.7)
Education level, *n* (%)		
Incomplete elementary education	3 (17.7)	4 (23.5)
Elementary School	5 (29.4)	0 (0.0)
High school	5 (29.4)	5 (29.4)
Undergraduate	4 (23.5)	8 (47.1)

Modified H&Y scale, *n* (%)		
1.5	1 (5.9)	0 (0.0)
2.0	11 (64.7)	8 (47.1)
2.5	2 (11.8)	4 (23.5)
3.0	3 (17.7)	5 (29.4)
UPDRS, mean (SD)		
Activities of daily living	13.9 (5.2)	19.0 (8.1)
Motor	23.4 (5.9)	28.5 (8.8)

Cont: Control; Exp: Experimental; kg: Kilogram; n: Sample Size; m: Meter; SD: Standard Deviation

Table 2. Means (SD) of all outcomes for the experimental and control groups over time, mean (SD) within-group differences, and mean (95% CI) between-group differences

Outcomes	Groups						Difference within groups				Difference between groups	
	Week 0		Week 8		Week 12		Week 8 minus Week 0		Week 12 minus Week 0		Week 8 minus Week 0	Week 12 minus Week 0
	Exp (*n*=17)	Cont (*n*=17)	Exp (*n*=17)	Cont (*n*=17)	Exp (*n*=17)	Cont (*n*=17)	Exp	Cont	Exp	Cont	Exp-Cont	Exp-Cont
Primary												
Inspiratory muscle strength (MIP), cmH_2O	64.18 (10.53)	69.55 (26.21)	83.48 (18.07)	69.29 (29.46)	84.00 (16.69)	71.36 (29.68)	19.30 (19.15)	-0.26 (5.86)	19.83 (17.22)	1.80 (11.76)	19.56 (9.67 to 29.45)	18.03 (7.73 to 28.33)
Expiratory muscle strength (MEP), cmH_2O	96.27 (26.48)	98.34 (38.72)	123.06 (37.13)	100.85 (39.28)	119.00 (28.74)	107.54 (37.48)	26.80 (28.52)	2.51 (6.17)	22.74 (21.86)	9.21 (20.78)	24.29 (9.87 to 38.71)	13.53 (-1.37 to 28.43)
Secondary												
Inspiratory muscle endurance												
Test duration, min	2.82 (0.92)	3.62 (1.57)	4.25 (1.93)	3.84 (1.47)	3.82 (1.73)	3.46 (1.44)	1.43 (1.38)	0.22 (0.94)	1.00 (1.41)	-0.16 (1.06)	1.21 (0.39 to 2.03)	1.16 (0.29 to 2.03)
Number of breaths, n	20.35 (8.02)	27.12 (11.35)	31.47 (16.17)	29.24 (12.21)	27.53 (12.30)	28.53 (13.92)	11.12 (12.23)	2.12 (6.14)	7.18 (11.11)	1.41 (7.69)	9.00 (2.24 to 15.76)	5.77 (-0.91 to 12.45)
Total work, joules	42.59	50.06	93.71	67.18	88.00	62.18	51.12	17.12	45.41	12.12	34	33.29

	(36.86)	(36.92)	(81.43)	(46.23)	(64.43)	(46.77)	(60.89)	(27.42)	(47.65)	(37.18)	(1.01 to 66.99)	(3.43 to 63.15)
Pressure, cmH_2O	15.82 (2.81)	14.82 (4.08)	16.71 (3.10)	14.82 (4.56)	16.71 (3.08)	14.47 (6.67)	0.88 (1.90)	0.00 (1.00)	0.88 (1.69)	-0.35 (1.73)	0.88 (-0.18 to 1.94)	1.23 (0.04 to 2.42)
Flow, L/sec	0.25 (0.24)	0.27 (0.29)	0.28 (0.30)	0.31 (0.34)	0.34 (0.33)	0.30 (0.31)	0.03 (0.43)	0.04 (0.21)	0.09 (0.46)	0.03 (0.23)	-0.01 (-0.25 to 0.23)	0.06 (-0.19 to 0.31)
Power, watts	1.62 (1.18)	1.97 (1.36)	2.31 (1.21)	1.98 (1.41)	2.54 (1.66)	1.98 (1.73)	0.69 (0.85)	0.02 (0.24)	0.93 (1.17)	0.12 (1.05)	0.67 (0.23 to 1.11)	0.81 (0.03 to 1.59)
Volume, liters	1.10 (0.47)	1.34 (0.66)	1.41 (0.57)	1.32 (0.64)	1.56 (0.49)	1.31 (0.65)	0.31 (0.35)	-0.18 (0.21)	0.46 (0.39)	-0.02 (0.47)	0.49 (0.29 to 0.69)	0.48 (0.18 to 0.78)
TTI	0.05 (0.06)	0.03 (0.02)	0.03 (0.02)	0.03 (0.02)	0.03 (0.02)	0.03 (0.01)	-0.02 (0.06)	0.00 (0.00)	-0.02 (0.06)	0.00 (0.01)	-0.02 (-0.05 to 0.01)	-0.02 (-0.05 to 0.01)
Peak cough flow, L/min	363.53 (102.22)	351.47 (127.69)	414.71 (80.86)	377.65 (141.62)	438.82 (93.60)	395.29 (138.21)	51.18 (66.42)	26.18 (55.10)	75.29 (82.09)	43.82 (78.97)	25 (-17.63 to 67.63)	31.47 (-24.80 to 87.74)
Dyspnea (MRC dyspnea scale), score	1.88 (0.60)	1.65 (0.79)	1.82 (0.81)	2.29 (0.85)	1.76 (0.56)	2.00 (0.87)	-0.06 (0.90)	0.65 (0.79)	-0.12 (0.60)	0.35 (0.70)	-0.71 (-1.30 to -0.12)	-0.47 (-0.93 to -0.01)
Fatigue (FSS), score	2.97 (1.50)	2.95 (1.28)	2.70 (1.32)	2.94 (1.41)	2.82 (1.54)	3.06 (1.49)	-0.27 (1.16)	0.01 (1.47)	-0.14 (1.41)	0.11 (1.38)	-0.28 (-1.21 to 0.65)	-0.25 (-1.22 to 0.72)
Exercise capacity (6MWT), meters	390.41 (88.11)	354.94 (100.89)	420.94 (97.67)	346.12 (110.53)	420.94 (114.26)	345.24 (133.54)	30.53 (71.41)	-8.82 (32.57)	30.53 (84.58)	-9.71 (81.34)	39.35 (0.58 to 78.12)	40.24 (-17.73 to 98.21)
Quality of life (PDQ-39, score	18.61 (12.10)	30.10 (15.11)	15.26 (11.31)	26.47 (14.58)	15.34 (12.10)	27.09 (14.87)	-3.35 (7.30)	-3.63 (6.71)	-3.26 (7.49)	-3.01 (7.31)	0.28 (-4.62 to 5.18)	-0.25 (-5.42 to 4.92)

Cont: Control; Exp: Experimental; FSS: Fatigue Severity Score; L: liters; min: Minute; MRC: Medical Research Council; n: Sample Size; sec: Seconds; PDQ-39: Parkinson's Disease Questionnaire-39; SD: Standard Deviation; 95% CI: 95% confidence intervals; 6MWT: Six-Minute Walk Test

Figure 1. Flowchart through the randomized clinical trial

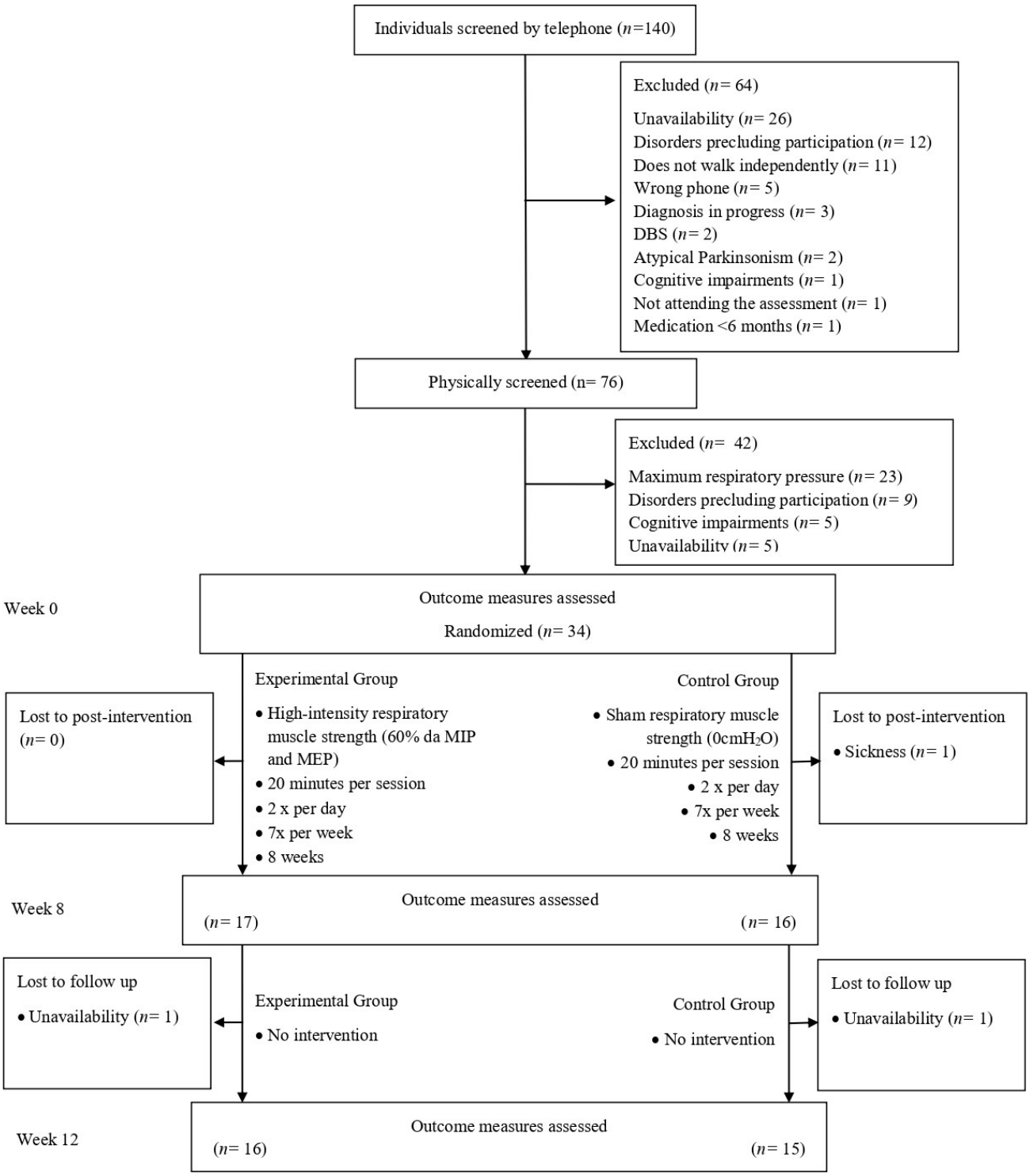


Figure 2. Inspiratory and expiratory muscle strength (in cmH_2O) of the experimental and control groups through the randomized clinical trial (baseline, post-intervention and follow-up) (n=34)

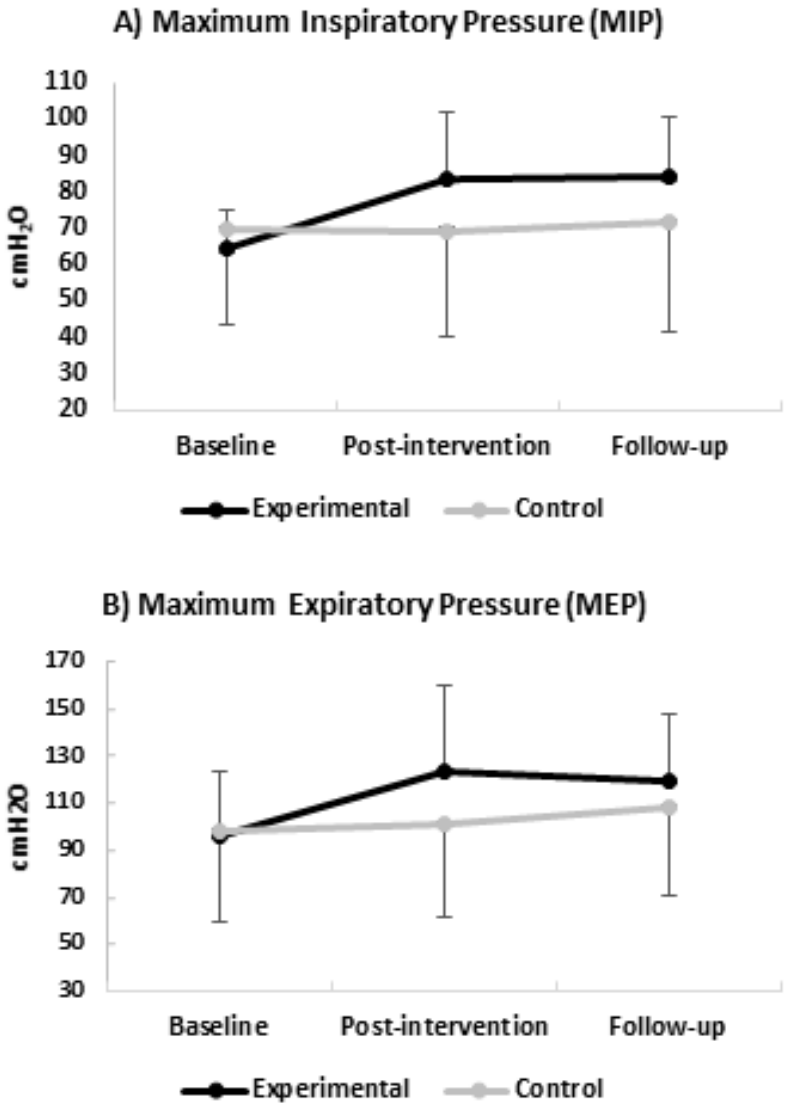
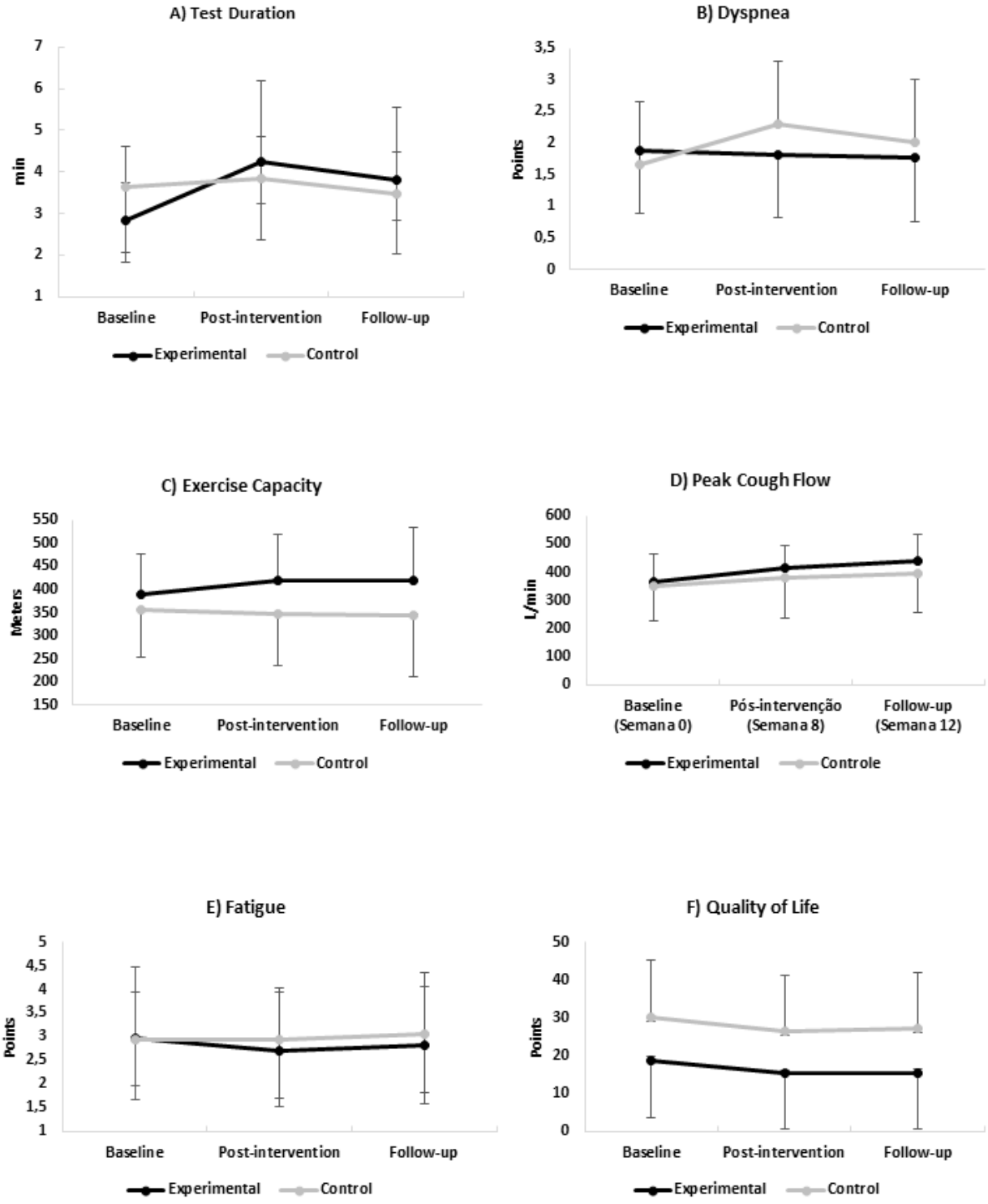


Figure 3. Inspiratory muscle endurance expressed by test duration (in minutes), dyspnea (in points), exercise capacity (in meters), peak cough flow (in L/min), fatigue (in points), and quality of life (in points) of the experimental and control groups through the randomized clinical trial (baseline, post-intervention and follow-up) (n=34)



CAPÍTULO 5

ARTIGO 5

Full Title: **Perspectives, self-efficacy, barriers and facilitators to home-based respiratory training in Parkinson Disease**

Short Title: **Home-based respiratory muscle training in Parkinson Disease**

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- Number of figures: 2

ABSTRACT

Background and purpose: To adequately implement home-based respiratory muscle training, it is important to describe the perceptions and self-efficacy, as well as to investigate the barriers and facilitators. To investigate, in individuals with Parkinson's Disease (PD) enrolled in a randomized clinical trial (RCT): their perspectives and self-efficacy towards respiratory muscle training, and barriers and facilitators to intervention.

Methods: Cross-sectional study was performed with individuals with PD who participated in a RCT. In the RCT, the individuals received an 8-week home-based high-intensity respiratory muscle training (40 minutes per day/7x per week, with training load=60% of maximum respiratory pressures) or a sham intervention (same protocol but without load). Outcomes were assessed through a standardized interview. Between-group comparisons were conducted using the Unpaired t-test and Fisher's exact test. After Bonferroni correction, the significance level was $p<0.002$.

Results: Thirty-one participants (69.68±8.31 years) were included. There were no between-group differences for any of the outcomes. On a scale of 0 to 100, individuals considered that the importance of training was 91.39 (IQR 20%). On a scale of 1 to 5, self-efficacy was 3.90±0.14. The main barriers reported were lack of equipment (n=29;93.5%), information (n=28;90.3%), support (n=28;90.3%), and knowledge from health professionals (n=28;90.3%). The main facilitators identified were exercises performed at home (n=04;12.9%) and the perceived effects of training (n=04; 12.9%).

Conclusion: Individuals considered respiratory muscle training to be highly important, and they had high self-efficacy. Participants' perspectives, self-efficacy, and identified barriers and facilitators can be used to develop the best strategies for implementing this training.

Keywords: Barriers; Clinical trial; Domiciliary care; Parkinson disease; Respiratory muscle training.

INTRODUCTION

Parkinson's disease (PD) is the second most prevalent neurodegenerative disease worldwide, with increasing in prevalence in recent decades.[1] Respiratory muscle weakness is a common non-motor symptom that can have several impacts on these individuals' function and quality of life.[2] Studies have shown that individuals with PD may experience a reduction in respiratory muscle strength from the early stages of the disease,[3] which intensifies as PD progresses.[2-4] Respiratory muscle training can improve respiratory muscle strength, expressed by increased maximal respiratory pressures, dyspnea, swallowing function, and phonatory measures in these individuals.[5;6] However, to carry out this training properly, factors that may affect its implementation must be considered.

Several factors can affect the success of implementing an intervention, including individuals' perceptions, exercise self-efficacy, as well as facilitators and barriers.[7-10] Schootemeijer et al. (2020) comprehensively reviewed the barriers and motivators for exercise in individuals with PD.[10] Several barriers and facilitators were found related to body structures and functions (i.e. PD non-motor symptoms), activity and participation (i.e. low previous physical activity level or sports participation), environmental (i.e. lack of social support), and personal factors (i.e. low self-efficacy).[10] However, these factors may vary depending on the population studied and the type of training implemented.

Respiratory muscle training is an intervention that is generally performed many days a week (i.e. 5 to 6 times a week).[5;6] Therefore, it is commonly carried out in the individual's home. Home-based exercise can be an effective strategy for improving exercise implementation.[11] Menezes et al. (2021) investigated completion rates of a randomized clinical trial RCT that delivered home-based respiratory muscle training in individuals after stroke.[11] High rates of enrollment, retention, adherence, delivery of

home visits, and collection of results were found.[11] However, home-based exercises can also be challenging, mainly because the individual performs the training alone. In a study conducted by Aguiar et al. (2020) on individuals after stroke, 83% agreed that group exercise is better than exercising alone.[12] In addition, the lack of an exercise partner has been identified as a barrier to exercise in this population, while social interaction with peers has been described as a facilitator to exercise.[10] These findings suggest that barriers and facilitators, as well as participants' preferences, should be carefully evaluated to ensure adequate exercise implementation, even home-based exercises.

To the best of our knowledge, no studies investigating perspectives and self-efficacy or identified barriers and facilitators related to home-based respiratory muscle training in individuals with PD were found. Long-term adherence to exercise can only be achieved when individuals have good perspectives on training and have high self-efficacy, as well as the barriers and facilitators to exercise are thoroughly examined.[10] By understanding these aspects, better strategies for implementing this intervention in research and clinical practice can be established. This is particularly important for individuals with PD, as exercises have the potential to modify disease progression and enhance both health and quality of life.[13] Therefore, this study aimed to investigate in individuals with PD enrolled in a RCT: 1) their perspectives and self-efficacy towards home-based respiratory muscle training and 2) barriers and facilitators to intervention.

METHODS

Study design

A cross-sectional study was conducted with individuals who had participated in a RCT, which was approved by the Ethics Committee of the Universidade Federal de

Minas Gerais (CAAE: 53970421.0.0000.5149; number: 5.356.570).[14] All individuals received detailed information regarding the study procedures and provided written consent.[14] This study was reported following the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement.[15] Data collections were conducted from December 2022 to January 2024.[14]

In the previously developed RCT, the participants were randomly assigned to receive: (1) high-intensity respiratory muscle training (experimental group) or (2) sham training (control group).[14] Participants received a home-based intervention, split into two daily 20-min sessions (morning and afternoon), totaling 40 min per day, seven times a week, during eight weeks.[14] Both groups performed the same procedures, with the training load being the only difference between the groups.[14] The experimental group performed training with a load of 60% of maximum respiratory pressures (maximum inspiratory pressure (MIP) and maximum expiratory pressure (MEP)). The load was adjusted weekly. In the control group, the same procedures were carried out with a load of $0cmH_2O$.[14] RCT assessments were performed in a university laboratory before the intervention, post-intervention, and one month after cessation of the intervention.[14]

Participants

Individuals who were included in this study were those who participated in the previous RCT. The inclusion criteria of the RCT were individuals who: had idiopathic PD diagnosed by a neurologist; age≥50 years; were taking anti-parkinsonian medication, and who have been medically stable for at least six months; classified between stages 1–3 of the modified Hoehn & Yahr Scale;[16] had ability to walk

independently, with or without assistive devices; and a MIP <80cmH_2O or MEP <90cmH_2O.[17]

Individuals were excluded from this previous RCT according to the following criteria: if they were engaged in a respiratory muscle training protocol in the last four weeks; possible cognitive impairment as determined by cutoff scores (in points) of the Mini-Mental Status Examination according to education level reference;[18] use deep brain stimulation (DBS); smokers or who stopped smoking less than six months ago; have been affected by respiratory or cardiac infections in the last month; had any other neurological, musculoskeletal, cardiovascular or respiratory disorders that could affect their ability to perform the tests.

Procedures

All participants who completed the RCT were invited to participate in this study at the post-training assessment (eight-week time point). Data were collected immediately after the end of training to avoid recall bias. A structured form was used and administered in an interview format by a trained examiner with experience in the rehabilitation of individuals with neurological conditions and blinded to the group allocation. The questionnaire consisted of questions in various formats (percentage, Likert scale, multiple choice).[7-10;12;19-22]

The clinical and sociodemographic characteristics of the participants were collected from the RCT database to avoid duplication of information. These characteristics included sex, age, marital status, education level, time since symptom onset, time since diagnosis, the severity of PD measured by the Hoehn and Yahr scale,[16] and the activities of daily living and motor function domains of the Unified Parkinson's Disease Rating Scale (UPDRS).[23]

Outcomes measures

Perspectives: Participants were asked to respond to the importance of home-based respiratory muscle training, using a scale from 0 (not important) to 100% (very important), following procedures according to a previous similar study developed with individuals with stroke.[12;20] In addition, individuals were asked to indicate their degree of agreement with 4 statements: 1) respiratory muscle training improves respiratory function in PD; 2) respiratory muscle training improves physical function in PD; 3) participating in home-based exercises is better than in other places; 4) respiratory muscle training is a necessary part of rehabilitation in PD.[20] Agreement degree was evaluated using a 7-point Likert scale, ranging from "strongly disagree" to "strongly agree". Finally, participants were asked whether they had already performed respiratory exercises before training and whether they intended to continue performing respiratory exercises after training, also following procedures according to a previous similar study developed with individuals with stroke.[12;20]

Self-efficacy: Self-efficacy for performing home-based respiratory muscle training was assessed using the Short Self-Efficacy for Exercise scale.[21] Individuals were asked to evaluate their confidence levels in performing the training across four scenarios: pain, fatigue, being alone, and depression. The degree of confidence was assessed using a 5-point scale, where one is "not confident" and five is "very confident".[21]

Barriers: A structured questionnaire was employed to evaluate barriers to home-based respiratory muscle training, following procedures according to previous studies.[7-10;12;20] Participants were instructed to indicate the degree of agreement with 25 statements about the training, using a 7-point Likert scale ranging from "strongly disagree" to "strongly agree".[12;20] In addition, a question was asked, in which

participants could indicate other barriers if they wished. The following question was asked: *"Do you notice any other aspect that makes it difficult/is a barrier to carrying out respiratory muscle training?",* also following procedures according to a previous similar study.[12;20] The aspects mentioned were recorded and analyzed.

Facilitators: At the end of the interview, participants could indicate the exercise facilitators, if they wished. The following question was asked: *"Do you notice any additional aspects or facilitators for carrying out respiratory muscle training?"* The aspects mentioned were recorded and analyzed, following the procedures of previous studies developed with individuals with stroke were followed.[19;22]

Statistical analyses

Descriptive statistics were used to analyze the clinical and demographic characteristics of the participants, patients' perspectives on the importance of training, and self-efficacy. Frequencies were calculated based on the total number of responses for participants' perspectives and expressed as counts and percentages. For the barriers identified, Likert scale responses were collapsed by combining “strongly agree,” “moderately agree,” and “agree” into an “agree” category. Similarly, “strongly disagree,” “moderately disagree,” and “disagree” responses were combined into a “disagree” category.[20] The frequencies were then calculated and expressed as counts and percentages. Between-group comparisons were conducted using unpaired t-test or Fisher's exact test for categorical variables.[24] Due to multiple comparisons, Bonferroni correction was applied[24] and the level of significance was $p<0.002$. Finally, content analysis of the barriers and facilitators identified by individuals was conducted, and all identified factors were categorized and reported in absolute frequency.[25]

RESULTS

Participants characteristics

Thirty-three individuals who completed the previously developed RCT were invited to participate in this study. Two did not agree to participate in the research due to other commitments. Therefore, 31 individuals with PD (experimental group: n=16; control group: n=15) were included. The mean age was 69.7±8.3 years, 20 (64.5%) were men, and the mean years since diagnosis was 7.4±6.2. The characteristics of the individuals are reported in Table 1.

Perspectives and self-efficacy

There were no statistically significant differences between the groups for any of the outcomes (p>0.002). On a scale of 0 (not important) to 100 (very important), the importance of training was 91.39 (IQR 20%) (experimental group=93.31% (IQR 18%); control group=89.33% (IQR 20%)). Ninety-seven percent (n=30) of participants agreed that respiratory muscle training improves respiratory function in PD (experimental group=100%; control group=93.3%). In addition, 90.3% of individuals agreed that this training improves physical function (experimental group=93.7%; control group=86.7%). Fifty-five percent of participants agreed that participating in home-based exercise is better than in other places (experimental group=43.8%; control group=66.7%). All individuals agreed that respiratory muscle training is a necessary part of rehabilitation in PD. Only 6.5% (n=2) of the individuals, all of the control group, had already performed respiratory muscle training before the study. In addition, 90.3% of participants reported that they wanted to continue performing respiratory muscle training after the end of the study (experimental group=93.7%; control group=86.7%).

The average self-efficacy was 3.90±0.14 (experimental group-3.58±0.27; control group=4.24±0.07). Individuals' perspectives and self-efficacy regarding home respiratory muscle training are in Table 2.

Barriers

There were no statistically significant differences between the groups for any of the identified barriers (p>0.002) (table 3). The main barriers identified were related to social support and respiratory muscle training.

Regarding aspects related to social support, three were reported as the main barriers: lack of support from healthcare professionals, reported by 90% of individuals (experimental group=100%; control group=83%); lack of companion for assessments, identified by 74% of participants (experimental group=63%; control group=87%); and lack of support from spouse, reported by 68% of individuals (experimental group= 56%; control group=80%) (figure 1).

In terms of aspects related to respiratory muscle training, three were identified as the main barriers: lack of equipment, reported by 94% of participants (experimental group=88%; control group=100%); lack of knowledge among healthcare professionals, identified by 90% of individuals (experimental group =100%; control group=80%); lack of information, reported by 90% of participants (experimental group=88%; control group=93%); and transport difficulties to assessments, identified by 68% of individuals (experimental group=56%; control group=80%). Regarding aspects related to the participant's abilities, dyspnea was reported by 68% of participants (experimental group=69%; control group=67%) (figure 1).

Finally, the participants, eight in each group (figure 2), identified other sixteen barriers to home-based respiratory muscle training. Transport difficulties (n=4) were the

most cited barrier in the experimental group. The most reported in the control group was other commitments (*n*=3).

Facilitators

Nineteen facilitators for home-based respiratory muscle training were identified, 10 in the experimental group and 9 in the control group (Figure 2). The exercises being performed at home (n=4) and motivation (n =3) were reported most frequently in the experimental group. The perceived positive effect of exercise on PD was the most reported in the control group (*n*=2).

DISCUSSION

According to our knowledge, this was the first study to investigate perspectives, self-efficacy, barriers, and facilitators regarding home-based respiratory muscle training in individuals with PD enrolled in a previously developed RCT. There were no between-group differences for any of the variables analyzed. Regarding the participants' perspectives, the majority of the participants rated respiratory muscle training as highly important for individuals with PD, and agreed that it increases respiratory and physical function. Fifty-five percent of participants agreed that participating in home-based exercise is better than in other places. In addition, most individuals had never experienced similar respiratory muscle training, but after participating, wanted to continue performing the exercises. In addition, self-efficacy was high. The main barriers reported were a lack of equipment and information, as well as lack of support and knowledge from health professionals. Conversely, the main facilitators identified were the convenience of performing exercises at home and the perceived positive effects of the training.

In this study, only two participants had prior experience with respiratory muscle training. Respiratory muscle training is more studied and widespread in individuals with respiratory, cardiac, and/or neuromuscular conditions.[26] Rehabilitation in PD typically focuses on improving motor symptoms,[27] and there is still a gap in research investigating the effects of respiratory muscle training in this population.[5;6] In addition, in clinical practice, respiratory muscle strength is not commonly assessed in these individuals, and respiratory muscle training is not yet widely undertaken. Corroborating this, in this study, ninety percent of participants reported a lack of support and knowledge from health professionals, as well as a lack of information, as barriers to home-based respiratory muscle training. These results indicate the imminent need to improve the education of patients, families, and health professionals about the possibilities, risks, and benefits of respiratory muscle training in PD.

After completing the training, most participants rated respiratory muscle training as highly important for individuals with PD and agreed that it increases respiratory and physical function. In addition, although most individuals had never experienced similar respiratory muscle training, after participating they wanted to continue performing the exercises. This suggests that first access to respiratory muscle training was essential for participants to learn about this type of training, recognize its importance and become motivated to continue.

In this study, 54.8% of the participants agree that participating in home-based exercise is better than in other places. One possible reason for this is the common difficulties associated with attending community-based exercise. Corroborating this, lack of companion for assessments and difficulties with transportation for assessments were reported as barriers to exercise, while home-based exercise was identified as a facilitator. Schootemeijer et al. (2020) provided a comprehensive review of the barriers

and motivators for exercise in individuals with PD. Similar to this study, several barriers associated with attending community-based exercises were identified: discomfort of seeing advancing symptoms of peers when exercising in a group; poor accessibility of the exercise location and lack of transportation to this location; bad weather; wariness of moving in a crowded environment.[10] The results of this study suggest that, despite performing the exercises at home without social interaction with peers, home-based training was an effective strategy for individuals with PD, reducing the barriers of community-based exercises.

Exercise self-efficacy is an important factor for both starting and maintaining long-term exercise engagement, especially when facing barriers to participation.[28] Interestingly, in the current study, self-efficacy was high in both groups, despite most individuals having no prior experience with home-based respiratory muscle training. One possible explanation for this finding is the close monitoring participants received during the intervention, including weekly home visits where they could address any questions about the training. Additionally, both patients and their families were encouraged to consistently fill out the training diary with details about the intervention, which could then be discussed with the therapist during the visits. Another potential explanation is the comprehensive information provided by the therapist regarding respiratory muscle training. The therapist clearly explained how the training should be performed, what symptoms were considered normal during the exercises, and when it would be appropriate to stop. These strategies may have made participants feel more confident in carrying out the intervention.

The lack of equipment was one of the main barriers identified. To perform respiratory muscle training, it is necessary to use a device. Respiratory muscle training requires specific devices, which can be costly, especially in developing countries.[29] In

addition, the device used in this study is not available for sale in Brazil, so it must be imported, adding to the expense.[29] Therefore, developing low-cost devices is essential for making this type of training more accessible. Additionally, incorporating such equipment into public healthcare system could significantly enhance access to training.

Regarding participant ability, dyspnea was one of the main barriers reported. Dyspnea is an often underestimated symptom in individuals with PD, with a prevalence estimated at around 40% according to previous studies.[30;31] Individuals with PD typically have reduced levels of physical activity[32] and may avoid activities that require sufficient physical effort to provoke respiratory symptoms, such as dyspnea. However, when performing respiratory exercises, even without load, this symptom may be exacerbated. Additionally, dyspnea may be related to anxiety in this population.[30] When practicing respiratory exercises at home without supervision, individuals may experience heightened anxiety, which can further intensify dyspnea. Based on the findings of this study, healthcare professionals should thoroughly assess dyspnea in individuals with PD, and consider implementing interventions to alleviate it, particularly during home-based respiratory exercises. In addition, the results highlight the need to educate patients and families about dyspnea, its occurrence during respiratory muscle training, strategies to alleviate these symptoms, and the signs that indicate the need to seek professional help.

Strengths and Limitations

This study has some limitations. A non-probabilistic sample was recruited, which may reduce the external validity of the study.[24] In addition, only individuals classified in stages 1 to 3 of the modified Hoehn & Yahr scale were included, suggesting caution in extrapolating these findings to those in stages 4 and 5. Future studies should describe the perspectives and self-efficacy regarding home-based

respiratory muscle training, as well as investigate the barriers and facilitators reported by these individuals.

Considering perspectives and self-efficacy regarding home-based respiratory muscle training, as well as identifying barriers and facilitators is essential for designing effective training protocols. Home-based exercise can be a valuable strategy to increase individuals' engagement, especially in protocols that require a high frequency of exercise, such as the present study, in which two daily sessions were held, seven days a week.[14] Clinicians can use the results of this study to design the best strategies for implementing home-based respiratory muscle training, considering the participants' perceptions and self-efficacy, seeking to minimize barriers and strengthen facilitators. Finally, the findings of this study can be used in the design of future studies, aiming to increase enrollment and adherence to exercise programs, as well as to reduce dropout rates.

CONCLUSION

Participants with PD rated respiratory muscle training as highly important and agreed that it increases respiratory and physical function. Most individuals had never experienced similar respiratory muscle training, but after participating, wanted to continue performing the exercises. This suggests that first access to respiratory muscle training was essential for participants to learn about this type of training and become motivated to continue. In addition, self-efficacy was high. The main barriers reported were the lack of equipment and information, and lack of support and knowledge from health professionals. These results indicate the need to improve the education of patients, families, and healthcare professionals about the possibilities, risks, and benefits of respiratory muscle training in PD. In addition, it highlights the importance of developing training protocols with simple and low-cost devices.

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Table 1. Clinical and demographic characteristics of included individuals

Characteristic	**Experimental Group (*n*=16)**	**Control Group (*n*=15)**	**Total (*n*=31)**
Sex, *n* (%)			
Men	11 (68.8)	9 (60.0)	20 (64.5)
Age, mean ± SD (range), years	70.1 ± 6.1 (59-83)	69.2 ± 10.4 (50-84)	69.7 ± 8.3 (50-84)
Marital status, *n* (%)			
Single	2 (12.5)	2 (13.3)	4 (12.9)
Married	11 (68.8)	10 (66.7)	21 (67.7)
Widowed	2 (12.5)	2 (13.3)	2 (6.5)
Divorced	1 (6.2)	1 (6.7)	4 (12.9)
Education level, *n* (%)			
Incomplete elementary education	4 (25.0)	2 (13.3)	6 (19.4)
Elementary education	3 (18.8)	2 (13.3)	5 (16.1)
High school	5 (31.2)	4 (26.7)	9 (29)
Higher education	4 (24.0)	7 (46.7)	11 (35.5)

Time since onset of symptoms, mean ± SD (range), years	7.9 ± 4.9 (2-19)	9.6 ± 7.3 (1-30)	8.7 ± 6.1 (1-30)
Time since onset of diagnosis, mean ± SD (range), years	3.5 ± 4.7 (1-17)	9.1 ± 7.3 (1-30)	7.4 ± 6.2 (1-30)
Modified Hoehn & Yahr scale, *n* (%)			
2	12 (75.0)	7 (46.7)	19 (61.3)
2.5	1 (6.3)	3 (20.0)	4 (12.9)
3	3 (18.8)	5 (33.3)	8 (25.8)
UPDRS, mean ± SD (range)			
Activities of daily living	13.9 ± 5.3 (6-28)	17.9 ± 6.3 (8-32)	15.9 ± 6.1 (6-32)
Motor function	23.4 ± 5.8 (16-38)	27.6 ± 8.8 (15-42)	25.4 ± 7.6 (15-42)

n: sample size; SD: standard deviation; UPDRS: Unified Parkinson's Disease Rating Scale

Table 2. Descriptive and inferential statistics of individuals' perspectives and self-efficacy regarding home-based respiratory muscle training

	Experimental Group (*n*=16)	**Control Group (*n*=15)**	**Total (*n*=31)**	***P***
Importance of training, median (IQR)	93.31 (18)	89.33 (20)	91.39 (20)	0.399
Respiratory muscle training improves respiratory function in PD, *n* (%)				
Agree	16 (100)	14 (93.3)	30 (96.8)	
Neutral	0 (0)	0 (0)	0 (0)	
Disagree	0 (0)	1 (6.7)	1 (3.2)	-
Respiratory muscle training improves physical function in PD, *n* (%)				
Agree	15 (93.7)	13 (86.7)	28 (90.3)	
Neutral	0 (0)	0 (0)	0 (0)	
Disagree	1 (6.3)	2 (13.3)	3 (9.7)	1.000
Participating in home-based exercises is better than in other places, *n* (%)				
Agree	7 (43.8)	10 (66.7)	17 (54.8)	
Neutral	3 (18.8)	1 (6.7)	4 (12.9)	
Disagree	6 (37.5)	4 (26.6)	10 (32.3)	0.895

Respiratory muscle training is a necessary part of rehabilitation in PD, *n* (%)				
Agree	16 (100)	15 (100)	31 (100)	
Neutral	0 (0)	0 (0)	0 (0)	
Disagree	0 (0)	0 (0)	0 (0)	-
Have you already performed respiratory muscle training before training? *n* (%)				
Yes	0 (0)	2 (13.3)	2 (6.5)	
Not	16 (100)	13 (86.7)	29 (93.5)	-
Do you want to continue performing respiratory muscle training? *n* (%)				
Yes	15 (93.7)	13 (86.7)	28 (90.3)	
Not	1 (6.3)	2 (13.3)	3 (9.7)	1.000
Self-efficacy, median (IQR)	3.58 (0.27)	4.24 (0.07)	3.90 (0.14)	0.039

IQR: Interquartile range; *n*: sample size; PD: Parkinson's disease

- No statistics are computed because is a constant

Table 3. Descriptive and inferential statistics of barriers to aerobic exercise reported by individuals in both groups

Category	Barriers	Agree *n* (%)	Neutral *n* (%)	Disagree *n* (%)	*p*
Participant ability	Motor symptoms (e.g. tremor and bradykinesia)				
	Experimental	7 (43.8)	1 (6.3)	8 (50)	1.000
	Control	2 (13.3)	1 (6.7)	12 (80)	
	Non-motor symptoms (e.g. excessive salivation and difficulty swallowing)				
	Experimental	10 (62.5)	1 (6.3)	5 (31.3)	0.895
	Control	6 (40)	2 (13.3)	7 (46.7)	
	Tiredness or fatigue				
	Experimental	6 (37.5)	3 (18.8)	7 (43.8)	0.080
	Control	6 (40)	1 (6.7)	8 (53.3)	
	Dyspnea				
	Experimental	11 (68.8)	0 (0)	5 (31.3)	0.451
	Control	10 (66.7)	1 (6.7)	4 (26.7)	
	Not being able to communicate properly				
	Experimental	1 (6.3)	2 (12.5)	13 (81.3)	1.000
	Control	3 (20)	0 (0)	12 (80)	
	Not being able to follow instructions				
	Experimental	4 (25)	2 (12.5)	10 (62.5)	1.000
	Control	4 (26.7)	1 (6.7)	10 (66.7)	
	Lack of motivation	6 (37.5)	2 (12.5)	8 (50)	1.000
	Experimental	10 (66.7)	1 (6.7)	4 (26.7)	

	Control				
	Lack of interest				
	Experimental	2 (12.5)	0 (0)	14 (87.5)	1.000
	Control	2 (13.3)	0 (0)	13 (86.7)	
	Embarrassment in attending face-to-face assessments				
	Experimental	2 (12.5)	0 (0)	14 (87.5)	
	Control	1 (6.7)	0 (0)	14 (93.3)	0.133
	Lack of time				
	Experimental	2 (12.5)	0 (0)	14 (87.5)	1.000
	Control	2 (13.3)	0 (0)	13 (86.7)	
	Lack of equipment				
	Experimental	14 (87.5)	1 (6.3)	1 (6.3)	-
	Control	15 (100)	0 (0)	0 (0)	
	Lack of information				
Respiratory	*Experimental*	14 (87.5)	1 (6.3)	1 (6.3)	1.000
muscle	*Control*	14 (93.3)	0 (0)	1 (6.7)	
training	Lack of knowledge among healthcare professionals				
	Experimental	16 (0)	0 (0)	0 (0)	-
	Control	12 (80)	0 (0)	3 (20)	
	Difficulties transporting to assessments				
	Experimental	9 (56.3)	0 (0)	7 (43.8)	0.569
	Control	12 (80)	0 (0)	3 (20)	
	Face-to-face evaluations	6 (37.5)	0 (0)	10 (62.5)	1.000
	Experimental	7 (46.7)	0 (0)	8 (53.3)	

	Control				
	Training is time-consuming				
	Experimental	4 (25)	0 (0)	12 (75)	0.516
	Control	3 (20)	0 (0)	12 (80)	
	Training is boring				
	Experimental	6 (37.5)	1 (6.3)	9 (56.3)	0.445
	Control	8 (53.3)	0 (0)	7 (46.7)	
	Training is tiring or painful				
	Experimental	8 (50)	0 (0)	8 (50)	0.315
	Control	6 (40)	0 (0)	9 (60)	
Social support	Lack of support from spouse				
	Experimental	9 (56.3)	0 (0)	7 (43.8)	1.000
	Control	12 (80)	0 (0)	3 (20)	
	Lack of support from family				
	Experimental	7 (44)	0 (0)	8 (50)	1.000
	Control	11 (73.3)	0 (0)	4 (26.7)	
	Lack of support from healthcare professionals				
	Experimental	16 (100)	0 (0)	0 (0)	-
	Control	12 (80)	0 (0)	3 (20)	
	Lack of companion for assessments				
	Experimental	10 (62.5)	0 (0)	6 (37.5)	1.000
	Control	13 (86.7)	1 (6.7)	1 (6.7)	
Safety	Home-based exercises are not safe	2 (12.5)	4 (25)	10 (62.5)	0.400
	Experimental	1 (6.7)	0 (0)	14 (93.3)	

Control				
Respiratory exercises are not safe				
Experimental	0 (0)	1 (6)	15 (94)	-
Control	0 (0)	0 (0)	15 (100)	
Makes symptoms of PD worse				
Experimental	0 (0)	0 (0)	16 (100)	-
Control	0 (0)	0 (0)	15 (100)	

- No statistics are computed because is a constant

Figure 1. Barriers to aerobic exercise reported by individuals

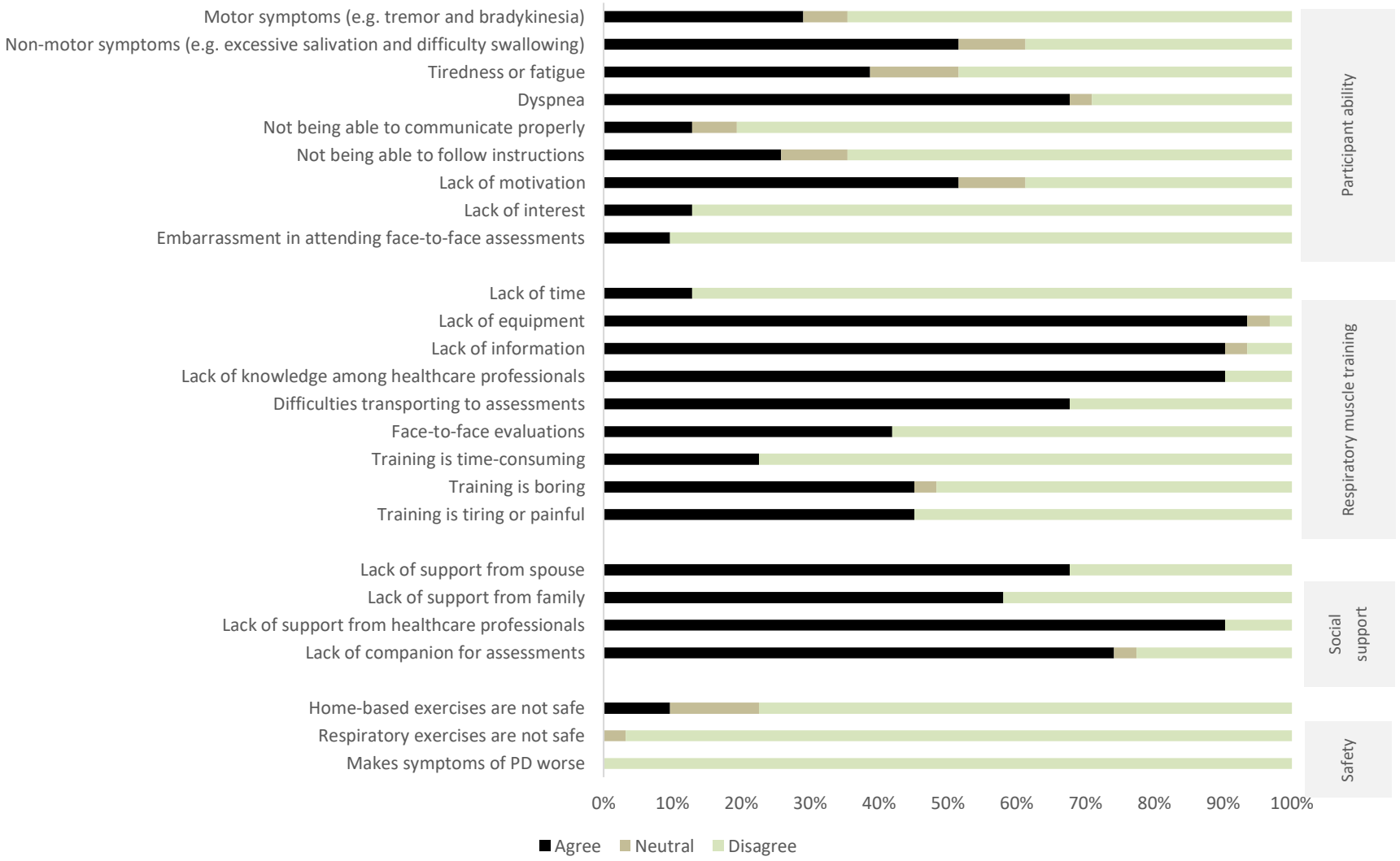


Figure 2. Categories of facilitators and barriers reported by participants

	EXPERIMENTAL	CONTROL
FACILITATORS	Exercises being performed at home (*n* = 4) Motivation (*n* = 3) Perceived positive effect of exercise on PD (*n* = 2) Professional support (*n* = 2) Weekly follow-up (*n* = 2) Device portability (*n* = 1) Equipment availability (*n* =1) Good service received (*n* = 1) Free training (*n* = 1) Information received (*n* = 1)	Perceived positive effect of exercise on PD (*n* = 2) Ease of contact with the professional (*n* = 1) Ease of using the device (*n* = 1) Family support (*n* = 1) Flexible hours (*n* = 1) Good relationship with the therapist (*n* = 1) Importance of exercise (*n* = 1) Motivation (*n* = 1) Spouse's help with exercises (*n* = 1)
BARRIERS	Transport difficulties (*n* = 4) Emotional (anxiety and stress) (*n* = 1) Exercise duration (*n* = 1) Fluctuations in health status (*n* = 1) Intense sweating (*n* = 1) Lack of companion (*n* = 1) Lack of dissemination of information about exercises (*n* = 1) Tiredness (*n* = 1)	Other commitments (*n* = 3) Exercise duration (*n* = 1) Forgetting to do exercises (*n* = 1) Fluctuations in health status (*n* = 1) Lack of support (*n* = 1) Lack of time (*n*= 1) Transport difficulties (*n* = 1) Work commitments (*n* = 1)

CAPÍTULO 6

CONSIDERAÇÕES FINAIS

Esta tese está de acordo com a linha de pesquisa “Estudos em Reabilitação Neurológica no Adulto” do Programa de Pós-graduação em Ciências da Reabilitação da UFMG, uma vez que seu objetivo principal foi compreender a eficácia do treinamento muscular inspiratório e expiratório domiciliar de alta intensidade em indivíduos com DP. Para alcançar uma compreensão mais abrangente da temática, foram desenvolvidos cinco estudos, publicados ou a serem publicados em cinco artigos distintos. Essa abordagem permitiu ampliar este campo de conhecimento, desde a avaliação até a implementação do treinamento, além de identificar as percepções dos participantes sobre o treinamento, autoeficácia, barreiras e facilitadores.

Considerando que o TMR é comumente realizado em ambiente domiciliar, inicialmente foi examinado se havia instrumentos com adequadas propriedades de medida e utilidade clínica para avaliação dos desfechos de interesse, em indivíduos com DP, por telereabilitação. Para isso, foi delineada e conduzida uma revisão sistemática com o objetivo de investigar as propriedades de medida e a utilidade clínica dos instrumentos utilizados na telereabilitação em indivíduos com condições neurológicas, incluindo a DP. A partir dos resultados dessa revisão sistemática, concluiu-se que para desenvolver o ECA seria necessária a realização de avaliações presencialmente. O ECA foi desenvolvido com o objetivo de investigar a eficácia de um programa domiciliar de TMR (inspiratório e expiratório realizados simultaneamente) de alta intensidade na força dos músculos inspiratórios e expiratórios (desfechos primários), *endurance* muscular inspiratória, pico de fluxo de tosse, dispneia, fadiga, capacidade de exercício e qualidade de vida (desfechos secundários) de indivíduos com DP. Este ECA forneceu evidências de que o programa domiciliar de treinamento combinado de alta intensidade dos músculos inspiratórios e expiratórios aumenta a força desses músculos e a *endurance* muscular inspiratória, reduz a dispneia e melhora a capacidade de exercício em indivíduos com DP, quando comparado a uma intervenção placebo. Esses efeitos na força dos músculos inspiratórios, *endurance* muscular inspiratória e dispneia foram mantidos um mês após a cessação da intervenção (acompanhamento). Além disso, ambos os grupos tiveram um aumento no pico de fluxo de tosse e uma melhora na qualidade de vida pós-intervenção (semana 8), que foi mantida no acompanhamento (semana 12). Não houve efeito significativo na fadiga pós-intervenção, nem no acompanhamento.

Segundo o nosso conhecimento, este foi o primeiro estudo que investigou a eficácia do TMR (inspiratório e expiratório realizados simultaneamente) de alta intensidade em indivíduos com DP. Este treinamento tem o potencial de otimizar os efeitos do tratamento direcionado à saúde, funcionalidade e qualidade de vida do indivíduo com DP, além de ter

várias características que aumentam a sua aplicabilidade clínica: 1) intervenção domiciliar com monitoramento semanal; 2) uso de medidas de resultado que são fáceis de executar na prática clínica; 3) treino dos músculos inspiratórios e expiratórios no mesmo ciclo respiratório, usando um único dispositivo, o que é mais rápido, fácil e econômico do que treiná-los separadamente; e 4) utilização de apenas um equipamento para o treinamento, o Orygen Dual Valve®, que oferece uma faixa de carga adequada, suporta tanto o treinamento inspiratório quanto o expiratório, e é mais barato quando comparado a outros equipementos disponíveis no mercado. Essas características, juntamente com os efeitos positivos observados na força muscular inspiratória e expiratória, resistência muscular inspiratória, dispneia e capacidade de exercício, apontam a sua indicação para uso na prática clínica.

Por fim, o último estudo desta tese permitiu expandir o conhecimento sobre as percepções, autoeficácia, barreiras e facilitadores ao TMR domiciliar em indivíduos com DP. Os participantes com DP classificaram o TMR como altamente importante e concordaram que ele aumenta a função respiratória e física. A maioria dos participantes nunca havia experimentado um TMR semelhante, mas, após a participação, desejava continuar realizando os exercícios. Isso sugere que o primeiro acesso ao TMR foi essencial para que os participantes aprendessem sobre esse tipo de intervenção e se motivassem a continuar. Além disso, a autoeficácia foi alta. As principais barreiras relatadas foram a falta de equipamentos e informações, e a falta de suporte e conhecimento dos profissionais de saúde. Esses resultados indicam a necessidade de melhorar a educação de pacientes, familiares e profissionais de saúde sobre as possibilidades, riscos e benefícios do TMR na DP. Além disso, destaca-se a importância de desenvolver protocolos de treinamento com dispositivos simples e de baixo custo.

Concluindo, ainda existem poucos estudos que investigaram as propriedades de medida e a utilidade clínica dos instrumentos utilizados na telereabilitação de indivíduos com DP, principalmente para avaliação de desfechos respiratórios. O programa domiciliar de TMR (inspiratório e expiratório realizados simultaneamente) de alta intensidade melhorou a força muscular inspiratória e expiratória, a *endurance* muscular inspiratória, reduziu a dispneia e aumentou a capacidade de exercício de indivíduos com DP. Por fim, a percepção e a autoeficácia dos participantes com DP sobre o treinamento muscular foram positivas, e a maioria relatou o desejo de continuar realizando os exercícios. As perspectivas dos participantes, a autoeficácia, bem como as barreiras e facilitadores identificados, podem ser utilizados para desenvolver estratégias eficazes para implementar o TMR domiciliar.

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APÊNDICES E ANEXOS

APÊNDICE A

DETERMINANTES PERCEBIDOS DURANTE E APÓS O TREINO MUSCULAR RESPIRATÓRIO

PONTO DE VISTA DOS PACIENTES

Uma vez que você participou do programa de treinamento muscular respiratório para indivíduos com Doença de Parkinson, todos os comentários que você possa dar será muito útil e nos ajudará a oferecer o melhor tratamento possível. Todas as respostas são voluntárias. Por favor fique à vontade para fazer perguntas a qualquer momento, e me diga se você quiser que eu repita uma pergunta.

Nesse questionário, estamos interessados em entender suas opiniões sobre exercício respiratório.

O objetivo do treinamento muscular respiratório é melhorar sua força e resistência muscular respiratória. Além disso, estamos pesquisando se ele é capaz de reduzir dispneia, fadiga e melhorar seu desempenho nas atividades de vida diária.

Indique a importância do treinamento muscular respiratório em uma escala de 0 a 100%, onde 0% não é importante, 50% é moderadamente importante e 100% é muito importante.

1. Antes do treinamento realizado na pesquisa, quão importante era o treinamento muscular respiratório para você? _____%

2. Após o seu diagnóstico de Doença de Parkinson e após sua experiência aqui na UFMG, quão importante é o treinamento muscular respiratório para você? _____%

Para entender melhor a sua confiança em participar do treinamento muscular respiratório, gostaríamos de fazer algumas perguntas. Indique seu nível de confiança em uma escala de 1 a 5, onde 1 é sem confiança e 5 é muito confiante.

Pergunta: quão confiante você é de que você poderia ...	A					B
Item	Não confiante				Muito confiante	Você já?
Realizar treinamento muscular respiratório apesar dos sintomas motores e não motores da doença	1	2	3	4	5	S/N
Realizar treinamento muscular respiratório sozinho	1	2	3	4	5	S/N
Realizar treinamento muscular respiratório mesmo que fique cansado	1	2	3	4	5	S/N
Realizar treinamento muscular respiratório mesmo que tenha fadiga	1	2	3	4	5	S/N
Realizar treinamento muscular respiratório mesmo que esteja deprimido	1	2	3	4	5	S/N

Agora eu vou ler uma série de declarações sobre treinamento muscular respiratório. Indique o grau em que você não concorda ou concorda com as declarações.

Item	Escala Likert de 7 pontos						
	Concordo totalmente	Concordo parcialmente	Concordo	Neutro	Discordo	Discordo parcialmente	Discordo totalmente
1. Após o diagnóstico da Doença de Parkinson, as pessoas estão cansadas demais para realizar exercícios (fadiga) *							
2. O treinamento muscular respiratório pode melhorar a função respiratória na DP							
3. Realizar exercícios domiciliares não é seguro para quem tem DP *							
4. O treinamento respiratório fará com que os sintomas da DP piorem *							
5. Realizar treinamento muscular respiratório não é seguro para indivíduos com DP *							
6. Sinais e sintomas não motores da DP (por exemplo, salivação excessiva e dificuldade de deglutição) limitam a realização do treinamento muscular respiratório na DP							
7. Sinais e sintomas motores da DP (por exemplo, tremor, lentidão e rigidez) limitam a realização do treinamento muscular respiratório na DP *							
8. Não poder comunicar adequadamente na DP (por exemplo, diminuição do volume da voz) limita a participação no treinamento muscular respiratório							
9. Não ser capaz de seguir as instruções (ou pensar corretamente) após a DP limitam a realização do treinamento muscular respiratório							
10. A dispneia (falta de ar) limita a realização no treinamento muscular respiratório							
11. Exercício respiratório melhora a função física (ex. capacidade de caminhada) na DP							
12. As pessoas **não estão motivadas** a participar de treinamento muscular respiratório após DP							
13. A falta de informações sobre como realizar exercícios respiratórios limita a participação após a DP							
14. A falta de conhecimento dos profissionais de saúde sobre os exercícios respiratórios limita a participação após a DP							
15. A falta de encorajamento do cônjuge (ou outra pessoa próxima) limita a participação no treinamento respiratório na DP							
16. A falta de encorajamento dos membros da família limita a participação no treinamento respiratório na DP							
17. Participar do **exercício em casa**, é melhor do que se exercitar em outros locais na DP							
18. O treinamento respiratório é uma parte necessária da reabilitação na DP							
19. Não tenho tempo para participar de exercícios (ocupado demais)							
20. O treinamento muscular respiratório **é demorado**							
21. A falta de apoio dos profissionais de saúde limita a participação treinamento respiratório na DP							
22. A falta de equipamentos limita a participação no treinamento respiratório na DP							
23. Problemas **de transporte** limita a participação de exercícios na DP							
24. O treinamento muscular respiratório **é chato**							
25. Eu acho o exercício respiratório cansativo ou doloroso							
26. O treinamento muscular respiratório é importante							

Item	Escala Likert de 7 pontos						
	Concordo totalmente	Concordo parcialmente	Concordo	Neutro	Discordo	Discordo parcialmente	Discordo totalmente
27. Eu **não tenho interesse** em realizar um treinamento respiratório							
28. Sinto-me **desconfortável ou constrangido** em ir nos momentos de avaliação							
29. A falta de acompanhantes para ir nas avaliações limita a participação no treinamento muscular respiratório na doença de Parkinson							
30. As **avaliações na univesidade** limitam a realização do treinamento muscular respiratório							

Você já tinha feito alguma avaliação respiratória após o diagnóstico da DP? ( ) Sim ( ) Não

Você já tinha feito algum treinamento respiratório após o diagnóstico da DP? ( ) Sim ( ) Não

Você pretende continuar realizando exercícios respiratórios após o final do treinamento? ( ) Sim ( ) Não

Você percebe algum outro aspecto ou facilitador para realização do treinamento muscular respiratório após a Doença de Parkinson?

_____

_____

_____

Você percebe algum outro aspecto que dificulte/seja uma barreira para realização do treinamento muscular respiratório após a Doença de Parkinson?

_____

_____

_____

APÊNDICE B

1

TERMO DE CONSENTIMENTO LIVRE E ESCLARECIDO Nº_____

Título do projeto de pesquisa: "Eficácia do treinamento muscular respiratório de alta intensidade na força e *endurance* muscular respiratória e pico de fluxo da tosse em indivíduos com doença de parkinson: um ensaio clínico aleatorizado"

Pesquisadoras responsáveis:
- Christina Danielli Coelho de Morais Faria, fisioterapeuta, Ph.D. Professora do Departamento de Fisioterapia da Universidade Federal de Minas Gerais (UFMG). Telefone: (31) 3409-7448; (31) 3409-4783; cdcmf@ufmg.br
- Aline Alvim Scianni, fisioterapeuta, Ph.D. Professora do Departamento de Fisioterapia da UFMG. Telefone: (31) 3409-4791; ascianni@task.com.br
- Sherindan Ayessa Ferreira de Brito, fisioterapeuta, estudante de doutorado do Programa de Pós-Graduação em Ciências da Reabilitação da UFMG. Telefone: (31) 99562-3721; sherindanayessa@hotmail.com

Você está sendo convidado (a) para participar da pesquisa "Eficácia do treinamento muscular respiratório de alta intensidade na força e endurance muscular respiratória, dispneia e pico de fluxo da tosse em indivíduos com doença de Parkinson: um ensaio clínico aleatorizado". A pesquisa será desenvolvida no Departamento de Fisioterapia da Escola de Educação Física, Fisioterapia e Terapia Ocupacional da UFMG.

O objetivo deste estudo é avaliar os efeitos do treinamento muscular respiratório em indivíduos com doença de Parkinson. Estes indivíduos comumente apresentam redução da força muscular respiratória que acarreta diversos impactos na saúde e qualidade de vida. Entretanto, ainda não foi investigado o efeito do fortalecimento muscular respiratório de alta intensidade na força e resistência muscular respiratória, na tosse e na sensação de falta de ar nessa população.

A avaliação antes de começar o programa de exercícios incluirá uma coleta de dados pessoais e exame físico a ser realizada por um examinador treinado. Caso você participe, será necessário responder alguns questionários acerca da sua saúde e da sua funcionalidade. Você realizará alguns testes para medir sua força muscular, condição física, e algumas medidas das funções pulmonares. Também será aplicado um questionário para avaliação da sua fadiga e qualidade de vida. Todos os testes serão realizados por um examinador treinado respeitando as medidas de prevenção de disseminação de vírus, como o uso de máscara cirúrgica descartável e disponibilização de álcool em gel 70% para higienização das mãos. Além disso, todos os equipamentos reutilizáveis serão higienizados e esterilizados e filtros bacteriológicos serão utilizados durante os testes.

Após a avaliação inicial você realizará sessões de intervenção que serão em ambiente domiciliar. Você receberá um aparelho portátil, seguro, muito utilizado na área da fisioterapia, para treinar seus músculos respiratórios sete vezes por semana, com um pouco de exercícios realizados na parte da manhã e um pouco de exercícios realizados na parte da tarde, durante dois meses. O fisioterapeuta irá te explicar como o treinamento deve ser realizado. Será entregue um diário no qual você deverá preencher informações sobre a realização do

treinamento, como os dias e horários. Se você não conseguir preencher o diário, um familiar e/ou cuidador poderá te ajudar. Será realizada uma visita semanal do fisioterapeuta no seu domicílio para ajustes de carga, de acordo com os objetivos deste estudo e a sua disponibilidade. Os mesmos procedimentos da avaliação inicial, ou seja, todos os testes e medidas empregados, assim como os questionários, serão realizados novamente duas vezes: após as oito semanas de intervenção e após quatro semanas desta última avaliação.

Neste estudo existem dois grupos e será realizado um sorteio para saber em qual dos grupos do estudo você fará parte. Durante os meses de participação no estudo, você não poderá participar de outros exercícios, como os que envolvem o fortalecimento muscular respiratório ou o treino aeróbio (por exemplo, hidroginástica e musculação).

Suas respostas serão tratadas de forma anônima e confidencial, ou seja, em nenhum momento será divulgado seu nome em qualquer fase do estudo. Você receberá um código que será utilizado em todos os seus testes para preservar sua identidade. Quando as informações originadas deste estudo forem publicadas em revista ou evento científico, você não será reconhecido individualmente, pois será representado pelo número. Os dados coletados neste estudo serão armazenados por um período de dez anos.

Você e futuros pacientes poderão se beneficiar com os resultados desse estudo, principalmente porque o objetivo principal do mesmo é determinar a melhor abordagem de tratamento fisioterápico para indivíduos com Doença de Parkinson. Se após a conclusão do estudo for observado maior benefício alcançado em um grupo em relação aos demais, a intervenção de maior benefício será ofertada para os participantes do grupo controle.

Sua participação neste estudo é voluntária e você é livre para concordar ou não em participar. Caso deseje, você pode abandonar o estudo a qualquer momento, sem que isto lhe traga qualquer prejuízo pessoal. Você não receberá nenhuma forma de pagamento pela participação. Caso seja necessário, gastos adicionais serão de responsabilidade dos pesquisadores. Os testes, e todos os materiais utilizados na pesquisa não terão custo para você.

Após ter lido as informações, se desejar participar, por favor, preencha e assine a declaração abaixo.

Eu, _____li e entendi toda a informação repassada sobre o estudo, sendo que os objetivos, procedimentos e linguagem técnica foram satisfatoriamente explicados. Tive tempo suficiente para considerar as informações acima e tive a oportunidade de tirar todas as minhas dúvidas. Estou assinando duas vias deste termo voluntariamente, sendo uma via do documento para mim e outra para os pesquisadores, e tenho direito de, agora ou mais tarde, discutir qualquer dúvida que venha a ter com relação à pesquisa com:

- Christina Danielli Coelho de Morais Faria, fisioterapeuta, Ph.D. Professora do Departamento de Fisioterapia da Universidade Federal de Minas Gerais (UFMG). Telefone: (31) 3409-7448; (31) 3409-4783; cdcmf@ufmg.br
- Aline Alvim Scianni, fisioterapeuta, Ph.D. Professora do Departamento de Fisioterapia da UFMG. Telefone: (31) 3409-4791; ascianni@task.com.br
- Sherindan Ayessa Ferreira de Brito, fisioterapeuta, estudante de doutorado do Programa de Pós-Graduação em Ciências da Reabilitação da UFMG. Telefone: (31) 99562-3721; sherindanayessa@hotmail.com

Além disso, em caso de dúvidas éticas você tem direito de entrar em contato com:

Comitê de Ética em Pesquisa da UFMG: (31) 3409-4592. Endereço: Av. Antônio Carlos, 6627 Unidade Administrativa II, sala 2005. Campus Pampulha, BH/MG. CEP 31270-901.

Assinando esse termo de consentimento, estou indicando que concordo em participar deste estudo.

_____ _____

Assinatura do Participante Data

RG:_____ CPF:_____

End.:_____

_____

_____ _____

Assinatura da Investigadora Responsável Data

Christina DCM Faria/ Aline A Scianni/ Sherindan AF Brito

APÊNDICE C

INFORMAÇÕES DO TREINAMENTO

Data: ___/___/____

Nome: _____
Data de Nascimento: ___/___/____

Você está recebendo o aparelho Orygen Dual Valve. Esse aparelho deve ser utilizado para realizar o treinamento muscular respiratório. Você deve realizar este treinamento sete vezes por semana, durante oito semanas, por 40 minutos diários, sendo 20 minutos pela manhã e 20 minutos à tarde.

Para realização do treinamento, você irá posicionar o aparelho na boca (Orygen Dual Valve) e tentar vencer a resistência contra sua respiração (inspiração e expiração), **em quatro séries de três minutos**, descansando dois minutos entre elas. Uma vez que o exercício seja iniciado, este deve ser realizado por completo, sem interrupções. O treinamento deve ser realizado da forma como foi ensinado pelo terapeuta, sem alterações ou adaptações.

Você é responsável pela execução do treinamento conforme descrito acima. Além disso, você é responsável pela conservação do aparelho e irá devolve-lo ao final das oito semanas.

_____	_____
Assinatura do paciente	Assinatura do terapeuta

Qualquer dúvida entre em contato conosco:
Prof.ª Christina DCM Faria. Telefone: (31) 3409-4783;
Sheridan Ayessa F Brito. Telefone: (31) 99562-3721.

DIÁRIO

Este diário deve ser preenchido todos os dias. Deve ser anotado se você realizou o treinamento no dia e o tempo que realizou. Além disso, você irá pontuar de 0 a 10 o quanto você se sentiu cansado para realizar o treinamento. É essencial que você realize o treinamento com o dispositivo durante oito semanas, sete dias por semana, duas vezes ao dia (manhã e tarde), durante 20 minutos cada, conforme orientado e combinado.

Olhando para essa escala, para cada sessão de treinamento, pontue de 0 a 10, **o quanto você sentiu cansado para respirar durante o exercício.**

ESCALA DE CANSAÇO (BORG)

0	Nenhuma
0,5	Muito, muito leve
1	Muito leve
2	Leve
3	Moderada
4	Pouco intensa
5	Intensa
6	
7	Muito intensa
8	
9	Muito, muito intensa
10	Máxima

Fonte: Burneto *et al.*, 1980; Cavallazzi *et al.*, 2008

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1ª SEMANA		
	MANHÃ	**TARDE**
DIA 1 ____/____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____
DIA 2 ____/____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____
DIA 3 ____/____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____
DIA 4 ____/____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____
DIA 5 ____/____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____
DIA 6 ____/____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____
DIA 7 ____/____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____

2ª SEMANA		
	MANHÃ	**TARDE**
DIA 1 ____/____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____
DIA 2 ____/____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____
DIA 3 ____/____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____
DIA 4 ____/____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____
DIA 5 ____/____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____
DIA 6 ____/____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____
DIA 7 ____/____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____

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3ª SEMANA		
	MANHÃ	**TARDE**
DIA 1 ____/____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____
DIA 2 ____/____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____
DIA 3 ____/____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____
DIA 4 ____/____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____
DIA 5 ____/____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____
DIA 6 ____/____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____
DIA 7 ____/____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____

4ª SEMANA		
	MANHÃ	**TARDE**
DIA 1 ____/____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____
DIA 2 ____/____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____
DIA 3 ____/____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____
DIA 4 ____/____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____
DIA 5 ____/____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____
DIA 6 ____/____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____
DIA 7 ____/____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____

5ª SEMANA		
	MANHÃ	**TARDE**
DIA 1 ____/____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____
DIA 2 ____/____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____
DIA 3 ____/____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____
DIA 4 ____/____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____
DIA 5 ____/____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____
DIA 6 ____/____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____
DIA 7 ____/____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____

6ª SEMANA		
	MANHÃ	**TARDE**
DIA 1 ____/____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____
DIA 2 ____/____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____
DIA 3 ____/____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____
DIA 4 ____/____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____
DIA 5 ____/____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____
DIA 6 ____/____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____
DIA 7 ____/____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____

7ª SEMANA		
	MANHÃ	**TARDE**
DIA 1 ____/____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____
DIA 2 ____/____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____
DIA 3 ____/____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____
DIA 4 ____/____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____
DIA 5 ____/____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____
DIA 6 ____/____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____
DIA 7 ____/____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____

8ª SEMANA		
	MANHÃ	**TARDE**
DIA 1 ____/____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____
DIA 2 ____/____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____
DIA 3 ____/____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____
DIA 4 ____/____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____
DIA 5 ____/____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____
DIA 6 ____/____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____
DIA 7 ____/____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____	Realizou o treinamento: ( ) SIM ( ) NÃO Tempo (minutos): _____ BORG: _____

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SE VOCÊ NÃO TREINOU ALGUM DIA OU TREINOU POR MENOS TEMPO QUE O COMBINADO, ESCREVA AQUI O(S) MOTIVO(S):

DIA	MOTIVO

APÊNDICE D

PROJETO DE PESQUISA: Eficácia do treinamento muscular respiratório de alta intensidade na força e endurance muscular respiratória e pico de fluxo da tosse em indivíduos com doença de parkinson: um ensaio clínico aleatorizado

AVALIAÇÃO (inicial, pós-intervenção ou *follow-up*): _____

DATA: _____ HORÁRIO: _____ CÓDIGO: _____

FICHA DE AVALIAÇÃO

DADOS DEMOGRÁFICOS

Nome: _____ Sexo: _____ Telefone: _____

Endereço: _____

Data de Nascimento: ___/____/_____ Idade: _____ Estado civil: _____

Mora com: _____ Escolaridade (anos estudados): _____

Formação: _____ Ocupação: _____

Nome acompanhante: _____ Telefone: _____

DADOS CLÍNICOS DA DOENÇA DE PARKINSON

Tempo desde o início dos sintomas: _____

Tempo desde o diagnóstico: _____

Diagnosticado por um neurologista: ( ) Não ( ) Sim

Usa estimulação cerebral profunda (DBS): ( ) Não ( ) Sim

DADOS CLÍNICOS GERAIS

MS dominante: ___ MI dominante: ____

Déficit visual: ( ) Não ( ) Sim Déficit auditivo: ( ) Não ( ) Sim

Deambula de forma independente: ( ) Não ( ) Sim

Órteses, dispositivo de auxílio a marcha: ( ) Não ( ) Sim especificar: _____

Doenças associadas: _____

_____

Infecções respiratórias ou cardíacas no último mês: _____

_____

Teve alguma internação por motivo respiratório após a doença de Parkinson? (pneumonia, por exemplo)? ( ) Sim ( ) Não Se sim, qual? _____ Quantas vezes? _____

Você teve COVID-19? ( ) Não ( ) Sim Há quanto tempo (meses)? _____ Se sim, precisou de internação hospitalar? ( ) Não ( ) Sim Teve dificuldade para respirar? ( ) Não ( ) Sim

Vacinação completa para COVID-19? ( ) Não ( ) Sim

Você fuma? ( ) Não ( ) Sim

Você já fumou? ( ) Não ( ) Sim Por quanto tempo (meses)? _____ Há quanto tempo parou de fumar (meses)?_____

Você está realizando algum exercício físico? ( ) Não ( ) Sim Qual? _____ Quantas vezes na semana? _____. Qual a duração (minutos)? _____

Você realizou algum exercício física nas últimas 4 semanas?

( ) Não ( ) Sim Qual? _____ Quantas vezes na semana? _____. Qual a duração (minutos)? _____

Questionar:

Infarto agudo do miocárdio ou angina instável recente ( )

Hipertensão arterial sistêmica grave e sem controle ( )

Aneurisma de aorta ( )

Pneumotórax ( )

Fístulas pleurocutâneas ou pulmonares ( )

Cirurgia ou traumatismo recente sobre as vias aéreas superiores, o tórax ou o abdome ( )

Hérnias abdominais ( )

Problemas agudos de ouvido médio ( )

Glaucoma ou descolamento de retina ( )

Hidrocefalia, meningocele, processos neurológicos que favoreçam o engasgamento das amídalas ( )

Estado geral de deterioração física ou mental que impeça a colaboração do paciente ( )

História de síncope tussígena ( )

Doenças da coluna vertebral ( )

Peso (Kg): _____ Altura (cm): _____ Circunferência abdominal: _____

PA: _____ FC: _____ FR: _____ $SatO_2$: _____

Tosse: ( ) Eficaz ( ) Ineficaz ( ) Produtiva ( ) Seca

Medicamento	Dose	Horário	Tempo de uso

ESCALA DE ESTÁGIOS DE INCAPACIDADE DE HOEHN E YAHR (MODIFICADA)

0: Ausência de sinais da doença
1,0: Alteração unilateral
1,5: Alteração unilateral com comprometimento axial
2,0: Alteração bilateral, sem déficit de equilíbrio
2,5: Alteração bilateral leve com recuperação na prova do empurrão
3,0: Alteração bilateral leve a moderada, certa instabilidade postural, fisicamente independente.

4,0: Incapacidade grave, ainda capaz de caminhar ou permanecer de pé sem ajuda.
5,0: Confinado à cama ou cadeira de rodas a não ser que receba ajuda.

Pontuação: _____

Fonte: SCHENKMAN *et al.*, 2001

UNIFIED PARKINSON´S DISEASE RATING SCALE (UPDRS)

II. ATIVIDADES DA VIDA DIÁRIA

Fala

0= normal

1= comprometimento superficial. Nenhuma dificuldade em ser entendido.

2= comprometimento moderado. Solicitado a repetir frases, às vezes.

3= comprometimento grave. Solicitado frequentemente a repetir frases.

4= retraído, perda completa da motivação.

Pontuação: _____

Salivação

0= normal

1= excesso mínimo de saliva, mas perceptível. Pode babar à noite.

2= excesso moderado de saliva. Pode apresentar alguma baba (drooling).

3= excesso acentuado de saliva. Baba frequentemente.

4= baba continuamente. Precisa de lenço constantemente.

Pontuação: _____

Deglutição

0= normal

1= engasgos raros

2= engasgos ocasionais

3= deglute apenas alimentos moles.

4= necessita de sonda nasogástrica ou gastrostomia.

Pontuação: _____

Escrita

0= normal

1= um pouco lenta ou pequena.

2= menor e mais lenta, mas as palavras são legíveis.

3= gravemente comprometida. Nem todas as palavras são comprometidas.

4= a maioria das palavras não são legíveis.

Pontuação: _____

Cortar alimentos ou manipular

0= normal

1= lento e desajeitado, mas não precisa de ajuda.

2= capaz de cortar os alimentos, embora desajeitado e lento. Pode precisar de ajuda.

3= alimento cortado por outros, ainda pode alimentar-se, embora lentamente.

4= precisa ser alimentado por outros.

Pontuação: _____

Vestir

0= normal.

1= lento mas não precisa de ajuda.

2= necessita de ajuda para abotoar e colocar os braços em mangas de camisa.

3= necessita de bastante ajuda, mas consegue fazer algumas coisas sozinho.

4= não consegue vestir-se (nenhuma peça) sem ajuda.

Pontuação: _____

Higiene

0= normal.

1= lento mas não precisa de ajuda.

2= precisa de ajuda no chuveiro ou banheira, ou muito lento nos cuidados de higiene.

3= necessita de assistência para se lavar, escovar os dentes, pentear-se, ir ao banheiro.

4= sonda vesical ou outra ajuda mecânica.

Pontuação: _____

Girar no leito e colocar roupas de cama.

0= normal.

1= lento e desajeitado mas não precisa de ajuda.

2= pode girar sozinho na cama ou colocar os lençóis, mas com grande dificuldade.

3= pode iniciar, mas não consegue rolar na cama ou colocar lençóis.

4= não consegue fazer nada.

Pontuação: _____

Quedas (não relacionadas ao freezing)

0= nenhuma

1= quedas raras.

2= cai ocasionalmente, menos de uma vez por dia.

3= cai, em média, uma vez por dia.

4= cai mais de uma vez por dia.

Pontuação: _____

***Freezing* quando anda**

0= nenhum

1= raro *freezing* quando anda, pode ter hesitação no início da marcha.

2= *freezing* ocasional, enquanto anda.

3= *freezing* frequente, pode cair devido ao *freezing*.

4= quedas frequentes devido ao *freezing*.

Pontuação: _____

Marcha

0= normal.

1= pequena dificuldade. Pode não balançar os braços ou tende a arrastar as pernas.

2= dificuldade moderada, mas necessita de pouca ajuda ou nenhuma.

3= dificuldade grave na marcha, necessita de assistência.

4= não consegue andar, mesmo com ajuda.

Pontuação: _____

Tremor

0= ausente.

1= presente, mas infrequente.

2= moderado, mas incomoda o paciente.

3= grave, interfere com muitas atividades.

4= marcante, interfere na maioria das atividades.

Pontuação: _____

Queixas sensitivas relacionadas ao parkinsonismo

0= nenhuma.

1= dormência e formigamento ocasional, alguma dor.

2= dormência, formigamento e dor frequente, mas suportável.

3= sensações dolorosas frequentes.

4= dor insuportável.

Pontuação: _____

PONTUAÇÃO TOTAL DOMÍNIO: _____

III. EXAME MOTOR

Fala

0= normal.

1= perda discreta da expressão, volume ou dicção.

2= comprometimento moderado. Arrastado, monótono mas compreensível.

3= comprometimento grave, difícil de ser entendido.

4= incompreensível.

Pontuação: _____

Expressão Facial

0= normal.

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1= hipomimia mínima.

2= diminuição pequena, mas anormal, da expressão facial.

3= hipomimia moderada, lábios caídos/afastados por algm tempo.

4= fácies em máscara ou fixa, com pedra grave ou total da expressão facial. Lábios afastados ¼ de polegada ou mais.

Pontuação: _____

Tremor de Repouso

0= ausente.

1= presente mas infrequente ou leve.

2= persistente mas de pouca amplitude, ou moderado em amplitude mas presente de maneira intermitente.

3= moderado em amplitude mas presente a maior parte do tempo.

4= com grande amplitude e presente a maior parte do tempo.

Pontuação: _____

Tremor postural ou de ação nas mãos

0= ausente

1= leve, presente com a ação.

2= moderado em amplitude, presente com a ação.

3= moderado em amplitude tanto na ação quanto mantendo a postura.

4= grande amplitude, interferindo com a alimentação.

Pontuação: _____

Rigidez (movimento passivo das grandes articulações, com paciente sentado e relaxado, ignorar roda denteada).

0= ausente

1= pequena ou detectável somente quando ativado por movimentos em espelho de outros.

2= leve e moderado.

3= marcante, mas pode realizar o movimento completo da articulação.

4= grave e o movimento completo da articulação só ocorre com grande dificuldade.

Pontuação: _____

Bater dedos continuamente – polegar no indicador em sequencias rápidas com a maior amplitude possível, uma mão de cada vez.

0= normal

1= leve lentidão e/ou redução da amplitude.

2= comprometimento moderado. Fadiga precoce e bem clara. Pode apresentar parada ocasional durante o movimento.

3= comprometimento grave. Hesitação freqüente para iniciar o movimento ou paradas durante o

movimento que está realizando.

4= realiza o teste com grande dificuldade, quase não conseguindo.

Pontuação: _____

Movimentos das mãos (abrir e fechar as mãos em movimentos rápidos e sucessivos e com a maior amplitude possível, uma mão de cada vez).

0= normal

1= leve lentidão e/ou redução da amplitude.

2= comprometimento moderado. Fadiga precoce e bem clara. Pode apresentar parada ocasional durante o movimento.

3= comprometimento grave. Hesitação freqüente para iniciar o movimento ou paradas durante o movimento que está realizando.

4= realiza o teste com grande dificuldade, quase não conseguindo.

Pontuação: _____

Movimentos rápidos alternados das mãos (pronação e supinação das mãos, horizontal ou verticalmente, com a maior amplitude possível, as duas mãos simultaneamente).

0= normal

1= leve lentidão e/ou redução da amplitude.

2= comprometimento moderado. Fadiga precoce e bem clara. Pode apresentar parada ocasional durante o movimento.

3= comprometimento grave. Hesitação frequente para iniciar o movimento ou paradas durante o movimento que está realizando.

4= realiza o teste com grande dificuldade, quase não conseguindo.

Pontuação: _____

Agilidade da perna (bater o calcanhar no chão em sucessões rápidas, levantando toda a perna, a amplitude do movimento deve ser de cerca de 3 polegadas/ ±7,5 cm).

0= normal

1= leve lentidão e/ou redução da amplitude.

2= comprometimento moderado. Fadiga precoce e bem clara. Pode apresentar parada ocasional durante o movimento.

3= comprometimento grave. Hesitação frequente para iniciar o movimento ou paradas durante o movimento que está realizando.

4= realiza o teste com grande dificuldade, quase não conseguindo.

Pontuação: _____

Levantar da cadeira (de espaldo reto, madeira ou ferro, com braços cruzados em frente ao peito).

0= normal

1= lento ou pode precisar de mais de uma tentativa

2= levanta-se apoiando nos braços da cadeira.

3= tende a cair para trás, pode tentar se levantar mais de uma vez, mas consegue levantar

4= incapaz de levantar-se sem ajuda.

Pontuação: _____

Postura

0= normal em posição ereta.

1= não bem ereto, levemente curvado para frente, pode ser normal para pessoas mais velhas.

2= moderadamente curvado para frente, definitivamente anormal, pode inclinar-se um pouco para os lados.

3= acentuadamente curvado para frente com cifose, inclinação moderada para um dos lados.

4= bem fletido com anormalidade acentuada da postura.

Pontuação: _____

Marcha

0= normal

1= anda lentamente, pode arrastar os pés com pequenas passadas, mas não há festinação ou propulsão.

2= anda com dificuldade, mas precisa de pouca ajuda ou nenhuma, pode apresentar alguma festinação, passos curtos, ou propulsão.

3= comprometimento grave da marcha, necessitando de ajuda.

4= não consegue andar sozinho, mesmo com ajuda.

Pontuação: _____

Estabilidade postural (resposta ao deslocamento súbito para trás, puxando os ombros, com paciente ereto, de olhos abertos, pés separados, informado a respeito do teste)

0= normal

1= retropulsão, mas se recupera sem ajuda.

2= ausência de respostas posturais, cairia se não fosse auxiliado pelo examinador.

3= muito instável, perde o equilíbrio espontaneamente.

4= incapaz de ficar ereto sem ajuda.

Pontuação: _____

Bradicinesia e hipocinesia corporal (combinação de hesitação, diminuição do balançar dos braços, pobreza e pequena amplitude de movimentos em geral)

0= nenhum.

1= lentidão mínima. Podia ser normal em algumas pessoas. Possível redução na amplitude.

2= movimento definitivamente anormal. Pobreza de movimento e um certo grau de lentidão.

3= lentidão moderada. Pobreza de movimento ou com pequena amplitude.

4= lentidão acentuada. Pobreza de movimento ou com pequena amplitude.

Pontuação: _____

PONTUAÇÃO TOTAL DOMÍNIO: _____

PONTUAÇÃO TOTAL UPDRS: _____

Fonte: NIEUWBOER *et al.*, 2000

ESCALA DE CONGELAMENTO DA MARCHA (FOGQ)

1. Durante o seu pior estado – Você anda:

0 - Normalmente

1 - Quase normalmente – um pouco lento

2 -Devagar mas totalmente independente

3 – Precisa de ajuda ou de um aparelho para andar

4 – Incapaz de andar

2. Suas dificuldades para andar estão afetando suas atividades de vida diária ou a sua independência?

0 – Nem um pouco

1 – Um pouco

2 – Moderadamente

3 – Severamente

4 – Incapaz de andar

3. Você sente que seus pés estão grudados no chão enquanto você anda, vira ou quandotenta começar a andar (congelamento)?

0 – Nunca

1 – Muito raramente – uma vez por mês

2 – Raramente – uma vez por semana

3 – Freqüentemente – uma vez por dia

4 – Sempre – toda vez que anda

4. Quanto tempo dura seu maior episodio de congelamento?

0 – nunca aconteceu

1 – 1 a 2 segundos

2 – 3 a 10 segundos

3 – 11 a 30 segundos

4 – Incapaz de andar por mais de 30 segundos

5. Quanto tempo dura seu típico episodio de hesitação para começar a andar(congelamento

para dar o primeiro passo)?

0 – Nada

1 – Leva mais que 1 segundo para começar a andar

2 – Leva mais que 3 segundos para começar a andar

3 – Leva mais que 10 segundos para começar a andar

4 – Leva mais que 30 segundos para começar a andar

6. Quanto tempo dura sua típica hesitação para virar (congelamento enquanto vira)?

0 – Nada

1 – Em torno de 1 a 2 segundos

2 – Em torno de 3 a 10 segundos

3 – Em torno de 11 a 30 segundos

4 – Incapaz de realizar a virada por mais de 30 segundos.

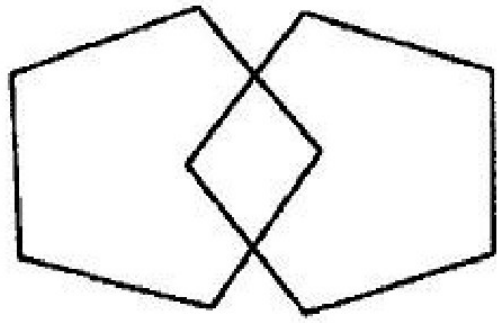
AVALIAÇÃO COGNITIVA

ORIENTAÇÃO TEMPORAL		Pontos	Pontuação
Que dia é hoje?		1	
Em que mês estamos?		1	
Em que ano estamos?		1	
Em que dia da semana estamos?		1	
Qual a hora aproximada?	Considere a variação de uma ou menos 1 hora	1	
ORIENTAÇÃO ESPACIAL		Pontos	Pontuação
Em que local nós estamos?	Consultório, dormitório, sala - apontando para o chão	1	
Que local é este aqui?	Apontando ao redor num sentido mais amplo: hospital, casa de repouso, própria casa	1	
Em que bairro nós estamos ou qual o nome de uma rua próxima.		1	
Em que cidade nós estamos?		1	
Em que Estado nós estamos?		1	
MEMÓRIA IMEDIATA		Pontos	Pontuação
Eu vou dizer três palavras e você irá repeti-las a seguir: carro, vaso, tijolo	Dê 1 ponto para cada palavra repetida acertadamente na 1ª vez, embora possa repeti-las até três vezes para o aprendizado, se houver erros.	3	
CÁLCULO		Pontos	Pontuação
Subtração de setes seriadamente: **Quanto é:** **100-7, 93-7, 86-7, 79-7, 72-7, 65**	Considere 1 ponto para cada resultado correto. Se houver erro, corrija-o e prossiga. Considere correto se o examinado espontaneamente se autocorrigir. **(VER*)**	5	
EVOCAÇÃO DAS PALAVRAS		Pontos	Pontuação
Quais as palavras que você acabou de repetir?	*Pergunte quais as palavras que o sujeito acabara de repetir - 1 ponto para cada*	3	
NOMEAÇÃO		Pontos	Pontuação
Que objeto é este?	Peça para o sujeito nomear os objetos mostrados (relógio, caneta) - 1 ponto para cada.	2	
REPETIÇÃO		Pontos	Pontuação
Preste atenção: vou lhe dizer uma frase e quero que você repita depois de mim: "Nem aqui, nem ali nem lá".	Considere somente se a repetição for perfeita (1 ponto)	1	
COMANDO		Pontos	Pontuação
"Pegue este papel com sua mão direita (1 ponto), dobre-o ao meio (1 ponto) e coloque-o no chão (1 ponto)".	Total de 3 pontos. Se o sujeito pedir ajuda no meio da tarefa não dê dicas.	3	
LEITURA	Mostre a frase escrita 'FECHE OS OLHOS' e peça para o indivíduo fazer o que está sendo mandado. Não auxilie se pedir ajuda ou se só ler a frase sem realizar o comando.	1	

11

FRASE Escreva uma frase	Peça ao indivíduo para escrever uma frase. Se não compreender o significado, ajude com: alguma frase que tenha começo, meio e fim; alguma coisa que aconteceu hoje; alguma coisa que queira dizer. Para a correção não são considerados erros gramaticais ou ortográficos	1	
COPIA DO DESENHO: Faça uma cópia deste desenho o melhor possível	Mostre o modelo e peça para fazer o melhor possível. Considere apenas se houver 2 pentágonos interseccionados (10 ângulos) formando uma figura de quatro lados ou com dois ângulos (1 ponto)	1	
TOTAL	30		

*Soletrar a palavra MUNDO de trás para frente. - *um ponto para cada letra na posição correta - *Obs: Será considerado apenas a nota referente ao melhor desempenho*



FORÇA E *ENDURANCE* MUSCULAR RESPIRATÓRIA

PRESSÃO INSPIRATÓRIA MÁXIMA (PImáx)

Antes	**Após**
PA inicial (mmHg): _____	PA final (mmHg): _____
FC inicial (bpm): _____	FC final (bpm): _____
SpO_2 inicial (%): _____	SpO_2 final (%): _____
Dispneia (Borg): _____	Dispneia (Borg): _____

PmedMax:_____

Pimax:_____%Previsto:_____60% da PmedMáx:_____

	Test 1	**Test 2**	**Test 3**
PmedMax			
PicoPress			
PressPlatô			

PRESSÃO EXPIRATÓRIA MÁXIMA (PEmáx)

Antes	**Após**
PA inicial (mmHg): _____	PA final (mmHg): _____
FC inicial (bpm): _____	FC final (bpm): _____
SpO_2 inicial (%): _____	SpO_2 final (%): _____
Dispneia (Borg): _____	Dispneia (Borg): _____

PMedMax:_____

PEmax:_____%Previsto:_____60% da PMedMax:_____

	Test 1	**Test 2**	**Test 3**
PmedMax			
PicoPress			
PressPlatô			

TESTE DE ENDURANCE POWERbreathe (ANOTAR CARGA PARA REAVALIAÇÃO)

Antes	**Após**
PA inicial (mmHg): _____	PA final (mmHg): _____
FC inicial (bpm): _____	FC final (bpm): _____
SpO_2 inicial (%): _____	SpO_2 final (%): _____
Dispneia (Borg): _____	Dispneia (Borg): _____

Número de repetições: _____ Tempo de duração do teste: _____

Load: _____

Press: _____

Flow: _____ Power: _____ Volume: _____

TTI: _____ Work: _____

Obs: _____

PICO DE FLUXO DA TOSSE (LEMBRAR DE ANOTAR QUAL O VALOR DA MAIOR MEDIDA):

Antes	**Após**
PA inicial (mmHg): _____	PA final (mmHg): _____
FC inicial (bpm): _____	FC final (bpm): _____
FR inicial (rpm): _____	FR final (rpm): _____
Dispneia (Borg): _____	Dispneia (Borg): _____

Pico de fluxo da tosse (maior medida): _____

Medida-1	**Medida-2**	**Medida-3**

AVALIAÇÃO DA DISPNEIA

Após a doença de Parkinson, ficou com dispneia (falta de ar)? Sim ( ) Não ( )

ESCALA DE AVALIAÇÃO DA DISPEIA DA *MEDICAL RESEARCH COUNCIL*

1. Só sofre de falta de ar durante exercícios intensos.
2. Sofre de falta de ar quando andando apressadamente ou subindo uma rampa leve.
3. Anda mais devagar do que pessoas da mesma idade por causa de falta de ar ou tem que parar para respirar mesmo quando andando devagar.

4. Para para respirar depois de andar menos de 100 metros ou após alguns minutos.

5. Sente tanta falta de ar que não sai mais de casa, ou quando está se vestindo.

Pontuação:_____

Fonte: KOVELIS *et al.*, 2008.

Quanto a dispneia afeta a sua vida diária (atividades do dia-a-dia)?

0 – nada 1 – muito pouco 2 – pouco 3 – moderado 4 – muito 5 - extremamente

A dispneia te impede de participar de algum compromisso social (ir à missa, visitar parentes, etc)?

( ) Sim ( ) Não

AVALIAÇÃO DA FADIGA (FSS)

Após a doença de Parkinson, ficou com fadiga (cansaço excessivo)? Sim ( ) Não ( )

Orientar o paciente a escolher um escore de 1 a 7. O escore 1 indica uma forte discordância com o item e o 7 uma forteconcordância. As afirmações/itens referem-se as duas últimas semanas.

Descrição dos itens	**Escores**						
1 Minha motivação é menor quando eu estou fadigado	1	2	3	4	5	6	7
2 Exercícios me deixam fadigado	1	2	3	4	5	6	7
3 Eu estou facilmente fadigado	1	2	3	4	5	6	7
4 A fadiga interfere com meu desempenho	1	2	3	4	5	6	7
5 A fadiga causa problemas freqüentes para mim	1	2	3	4	5	6	7
6 Minha fadiga impede um desempenho físico constante	1	2	3	4	5	6	7
7 A fadiga interfere com a execução de certas obrigações e responsabilidades	1	2	3	4	5	6	7
8 A fadiga é um dos três sintomas mais incapacitantes que tenho	1	2	3	4	5	6	7
9 A fadiga interfere com meu trabalho, minha família ou com minha vida social	1	2	3	4	5	6	7
Total							

Fonte: VALDERRAMAS *et al.*, 2012.

Quanto a fadiga afeta a sua vida diária (atividades do dia-a-dia)?

0 – nada 1 – muito pouco 2 – pouco 3 – moderado 4 – muito 5 - extremamente

A fadiga te impede de participar de algum compromisso social (ir à missa, visitar parentes, etc)?

( ) Sim ( ) Não

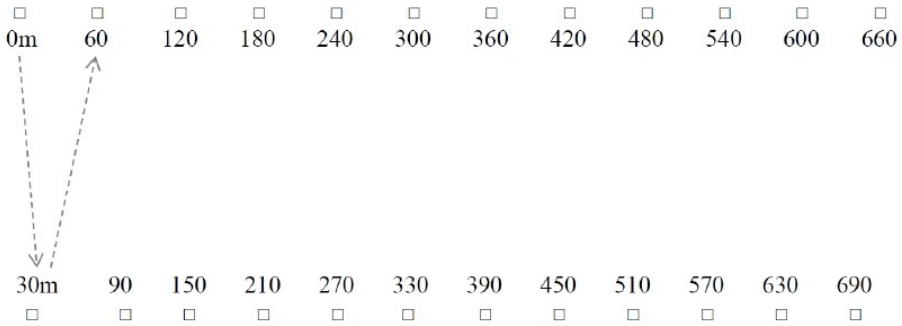
TESTE DE CAMINHADA DE SEIS MINUTOS (TC6) (LEMBRAR DE SOLICITAR A MAIOR DISTÂNCIA POSSÍVEL E 6 MINUTOS/ ANOTAR 2 MINUTOS):

Teste 1

Antes	**Após**
PA inicial (mmHg): _____	PA final (mmHg): _____
FC inicial (bpm): _____	FC final (bpm): _____
FR inicial (rpm): _____	FR final (rpm): _____
SpO_2 inicial (%): _____	SpO_2 final (%): _____
Fadiga MMII (Borg): _____	Fadiga MMII (Borg): _____
Dispneia (Borg): _____	Dispneia (Borg): _____

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Teste	FC (bpm)	SpO_2 (%)	Fadiga MMII (Borg)	Dispneia (Borg)	Distância (m)
1º minuto					Não se aplica
2º minuto					
3º minuto					Não se aplica
4º minuto					Não se aplica
5º minuto					Não se aplica
6º minuto					



Parou/pausa antes de seis minutos? ( ) Não ( ) Sim, motivo: _____ Por quanto tempo? _____ Outros sintomas: _____

Distância percorrida em **seis** minutos (m): _____ Distância percorrida em **dois** minutos (m): _____

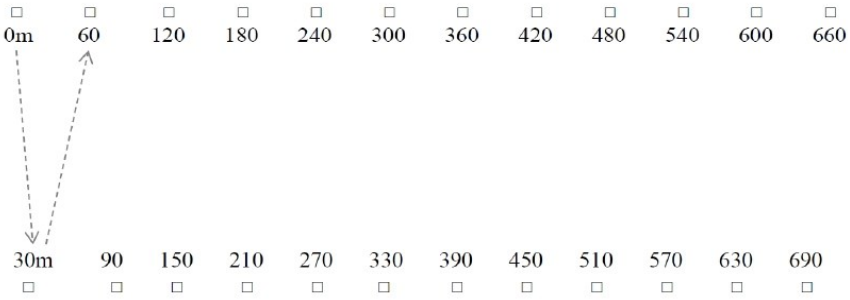
FC pico (bpm): _____

TESTE DE CAMINHADA DE SEIS MINUTOS (TC6): Teste 2

Antes	Após
PA inicial (mmHg): _____	PA final (mmHg): _____
FC inicial (bpm): _____	FC final (bpm): _____
FR inicial (rpm): _____	FR final (rpm): _____
SpO_2 inicial (%): _____	SpO_2 final (%): _____
Fadiga MMII (Borg): _____	Fadiga MMII (Borg): _____
Dispneia (Borg): _____	Dispneia (Borg): _____

Teste	FC (bpm)	SpO_2 (%)	Fadiga MMII (Borg)	Dispneia (Borg)	Distância (m)
1º minuto					Não se aplica
2º minuto					
3º minuto					Não se aplica
4º minuto					Não se aplica
5º minuto					Não se aplica
6º minuto					

15



Parou/pausa antes de seis minutos? ( ) Não ( ) Sim, motivo: _____ Por quanto tempo? _____ Outros sintomas: _____

Distância percorrida em **seis** minutos (m): _____ Distância percorrida em **dois** minutos (m): _____

FC pico (bpm): _____

Em geral, o senhor diria que sua saúde é:

( ) Muito boa ( ) Boa ( ) Razoável ( ) Ruim ( ) Muito Ruim

QUALIDADE DE VIDA

PDQ-39 - QUESTIONÁRIO SOBRE A DOENÇA DE PARKINSON

POR SER PORTADOR DA DOENÇA DE PARKINSON, com que freqüência osenhor/a sentiu os seguintes, durante o último mês?

Por ser portador da doença de Parkinson, durante o último mês, com que freqüência... *Assinale* ***um quadradinho*** *para cada questão*

	Nunca	**De vez em Quando**	**Às vezes**	**Frequen-temente**	**Sempre ou é impossível para mim**
1. Teve dificuldades paraparticipar de atividades recreativas que gosta de fazer?					
2. Teve dificuldades para cuidar de sua casa (por ex., fazer pequenos consertos, trabalho de casa, cozinhar)?					
3. Teve dificuldades para carregar sacolas de compras?					
4. Teve problemas para andar um quilômetro (10 quarteirões)?					
5. Teve problemas para andar 100 metros (1 quarteirão)?					
6. Teve problemas para se movimentar pela casa com a facilidade que gostaria?					
7. Teve dificuldades para se movimentar em locais públicos?					
8. Necessitou de alguém para acompanhá-lo ao sair?					
9. Sentiu-se assustado ou preocupado com medo de cair em público?					
10. Ficou sem sair de casa mais do que gostaria?					
11. Teve dificuldades para se lavar?					

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	Nunca	De vez em Quando	Às vezes	Frequen-temente	Sempre ou é impossível para mim
12. Teve dificuldades para se vestir?					
13. Teve dificuldades para abotoar roupas ou amarrar sapatos?					
14. Teve problemas para escrever de maneira legível?					
15. Teve dificuldades para cortar a comida?					
16. Teve dificuldades para segurar uma bebida sem derramar?					
17. Sentiu-se deprimido/a?					
18. Sentiu-se isolado/a e só?					
19. Sentiu que poderia começar a chorar facilmente?					
20. Sentiu-se com raiva ou amargurado/a?					
21. Sentiu-se ansioso/a?					
22. Sentiu-se preocupado/a com seu futuro?					
23. Houve necessidade de esconder sua doença de Parkinson das outras pessoas?					
24. Evitou situações em que tivesse que comer ou beber em público?					
25. Sentiu-se envergonhado/a em público por ter a doença de Parkinson?					
26. Sentiu-se preocupado/a com as reações de outras pessoas?					
27. Teve problemas de relacionamento com as pessoas mais próximas?					
28. Faltou apoio que precisava por parte do seu/sua esposo (a) ou companheiro (a)? Se não tem esposo (a) ou companheiro (a), assinale aqui ( )					
29. Faltou apoio que precisava por parte de sua família ou amigos?					
30. Adormeceu inesperadamente durante o dia?					
31. Teve problemas de concentração, por ex. ao ler ou ao assistir à televisão?					
32. Sentiu que sua memória estava ruim?					
33. Teve sonhos perturbadores ou alucinações?					
34. Teve dificuldades para falar?					
35. Sentiu-se incapaz de comunicar-se com clareza com as pessoas?					
36. Sentiu-se ignorado por outras pessoas?					
37. Teve cãibras musculares dolorosas ou espasmos?					
38. Teve dores nas articulações ou em outras partes do corpo?					
39. Sentiu-se desconfortavelmente quente ou frio?					

Fonte: CAROD-ARTAL *et al.*, 2007.

ANEXO A

Sistema Acadêmico
Consulta de Informações dos
Alunos da Pós-Graduação

Usuário: **Sherindan Ayessa Ferreira de Brito** | Número de Matrícula do Aluno: **2020718175** | SAIR

Menu
- NÚMEROS DO ALUNO
  - Selecionar
- ALUNO
  - Dados Pessoais
  - Dados de Admissão
  - Situação no Curso
  - Dados SisGen
  - Ocorrências Acadêmicas
- HISTÓRICO ESCOLAR
  - Atividades Cursadas e Em Curso
  - Emitir Histórico Autenticável
- MATRÍCULA
  - Oferta de Atividades
- CURRÍCULO
  - Grade Curricular

Consultar Atividades em Curso e Cursadas

[Informação para simples consulta]

Aluno **2020718175 SHERINDAN AYESSA FERREIRA DE SOUZA**

Curso **3581 CIÊNCIAS DA REABILITAÇÃO/D**

Relação de Atividades no Histórico

Período	Turma	Nome Atividade	Tipo Mat	Freq	Nota	Conc	Sit Final	Créd	Integr ?
2020/2	DCR GER000	DISPENSA DE CREDITO					4	15	Sim
2020/2	DIP CRE8011	METODOLOGIA DA PESQUISA CIENTÍFICA I					4	4	Sim
2020/2	DIP CRE8041	ÉTICA EM PESQUISA		S	94	A	A	02	Sim
2020/2	DIP CRE8081	MODELOS DE FUNÇÃO E DISFUNÇÃO HUMANA		S	93	A	A	04	Sim
2020/2	DIP CRE8171	INICIAÇÃO À DOCÊNCIA I		S	100	A	A	2	Sim
2020/2	DIP EST8141	PRINCIPIOS DE BIOESTATISTICA					4	4	Sim
2021/1	DIP ENF820A	TELEGESTÃO/TELESSAÚDE	E	S	99	A	A	02	Não
2021/1	DIP CRE8021	METODOLOGIA DA PESQUISA CIENTÍFICA II		S	96	A	A	04	Sim
2021/1	DIP CRE8071	SEMINÁRIOS DE DOUTORADO		S	90	A	A	02	Sim
2021/1	DIP CRE8181	INICIAÇÃO À DOCÊNCIA II		S	100	A	A	2	Sim
2021/2	ETF GER000	ELABORACAO DE TRABALHO FINAL						0	Sim
2022/1	**EQP CRE005**	**EXAME DE QUALIFICAÇÃO**					**A**	**0**	**Sim**
2022/1	ETF GER000	ELABORACAO DE TRABALHO FINAL						0	Sim
2022/2	ETF GER000	ELABORACAO DE TRABALHO FINAL						0	Sim
2023/1	ETF GER000	ELABORACAO DE TRABALHO FINAL						0	Sim
2023/2	ETF GER000	ELABORACAO DE TRABALHO FINAL						0	Sim
2024/1	ETF GER000	ELABORACAO DE TRABALHO FINAL						0	Sim
2024/2	ETF GER000	ELABORACAO DE TRABALHO FINAL						0	Sim

LEGENDA		
Tipo Mat	Tipo de Matrícula: Normal ou Eletiva	
Freq	Frequência	S = Suficiente I = Insuficiente
Conc	Conceito	
Sit Final	Situação Final na Atividade	A = Aprovado R = Reprovado 1 = Trancamento Total 2 = Trancamento Parcial sem Justificativa 3 = Trancamento Parcial com Justificativa 4 = Dispensa
Créd	Número de créditos atribuídos	
Integr?	Indica se a atividade será computada ou não na integralização dos créditos exigidos.	

[Informação para simples consulta]

ANEXO B

UNIVERSIDADE FEDERAL DE MINAS GERAIS

PARECER CONSUBSTANCIADO DO CEP

DADOS DO PROJETO DE PESQUISA

Título da Pesquisa: Efeito do Treinamento Muscular Respiratório de Alta Intensidade na Força e Endurance Muscular Respiratório, Pico de Fluxo da Tosse e Dispneia em Indivíduos com Doença de Parkinson: Um Ensaio Clínico Aleatorizado

Pesquisador: Christina Danielli Coelho de Morais Faria

Área Temática:

Versão: 2

CAAE: 53970421.0.0000.5149

Instituição Proponente: PRO REITORIA DE PESQUISA

Patrocinador Principal: Financiamento Próprio

DADOS DO PARECER

Número do Parecer: 5.356.570

Apresentação do Projeto:

O presente projeto trata-se de um ensaio clínico aleatorizado, com avaliador cegado e com alocação oculta. Pretende investigar o efeito de um protocolo de treinamento respiratório em indivíduos com Parkinson. A mensuração dos cinco desfechos primários (Pressão inspiratória máxima (PImáx) e Pressão expiratória máxima (PEmáx), endurance muscular, pico de fluxo da tosse e dispneia) e dos cinco desfechos secundários (capacidade de exercício, fadiga, nível de atividade física, sono e qualidade de vida) de interesse serão realizadas no laboratório (LabCare) do Departamento de Fisioterapia da Escola de Educação Física, Fisioterapia e Terapia Ocupacional da Universidade Federal de Minas Gerais (EEFFTO/UFMG). A hipótese apresentada pelo proponente é que o treinamento muscular respiratório de alta intensidade é eficaz para aumentar a força muscular inspiratória e expiratória, endurance muscular respiratório, pico de fluxo da tosse, e reduzir dispneia em indivíduos com Doença de Parkinson. Uma amostra determinada por conveniência, com 34 adultos, de ambos os sexos, será recrutada na comunidade geral da cidade de Belo Horizonte a partir de contato com ambulatórios, clínicas, hospitais, centros de saúde, associações, grupos de pesquisa e projetos de extensão desenvolvidos com a população de interesse. Serão incluídos indivíduos segundo os seguintes critérios: DP idiopática, diagnosticada por um neurologista; com capacidade de deambular de forma independente com ou sem dispositivos auxiliares; idade> 50 anos; em uso de medicação anti-parkinsoniana e que estejam

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medicamente estáveis a pelo menos 6 meses; classificados entre estágios 1 a 3 da escala de Hoehn e Yahr modificada; que apresentem pressão inspiratória máxima <80 cmH2O ou pressão expiratória máxima <90 cmH2O. Serão excluídos indivíduos que estejam realizando treinamento muscular respiratório ou o tenham realizado nas últimas quatro semanas; que apresentem alterações cognitivas avaliadas com a versão traduzida para o português e adaptada para população brasileira da escala de Montreal Cognitive Assessment (MoCA-BR) de acordo o ponto de corte de 22,5 pontos, utilizado para distinguir entre indivíduos com DP classificados como possível cognição normal e distúrbio cognitivo leve; indivíduos em uso de estimulação cerebral profunda (DBS); fumantes ou que pararam de fumar há menos de seis meses; tenham sido acometidos por infecções respiratórias ou cardíacas no último mês; e indivíduos que apresentem outros distúrbios neurológicos, musculoesqueléticos e respiratórios que interfiram na execução dos testes e intervenções propostas. Os participantes serão alocados em dois grupos (experimental e controle). As mensurações serão realizadas na avaliação inicial (semana 0), imediatamente após o término do treinamento (semana 8) e um mês após o término do treinamento (semana 12). Os participantes serão submetidos a um treinamento muscular inspiratório e expiratório de alta intensidade (grupo experimental), ou a uma intervenção placebo, que consistirá do mesmo protocolo de exercícios do grupo experimental, porém sem a carga para o treinamento muscular (grupo controle). A única diferença entre os dois grupos será a presença / ausência da carga imposta durante o treinamento. Para a realização da intervenção, será utilizado o dispositivo Orygen-Dual Valve. O aparelho deve ser posicionado na boca e o indivíduo deve respirar calmamente, tentando vencer a resistência contra a respiração (inspiração e expiração). A intervenção será realizada por 40 minutos, divididos em dois blocos de 20 minutos, um realizado pela manhã e outro à tarde, sete vezes na semana, durante oito semanas. A intervenção será dividida em quatro blocos de quatro minutos, com descanso de um minuto entre os blocos. Uma vez por semana, um fisioterapeuta previamente treinado realizará visitas domiciliares na residência dos participantes para ajustes de carga. O grupo controle receberá a mesma visita, porém a carga será mantida. Todos os dispositivos serão envolvidos com um material opaco para que a carga ou possível carga de treinamento respiratório não seja visualizada. Estatísticas descritivas serão utilizadas para caracterização da amostra. Todas as análises serão realizadas com intenção de tratar. ANOVA two-way com medidas repetidas será utilizada para avaliar a diferenças entre grupos nos três momentos de avaliação (semana 0, semana 8 e semana 12) para as variáveis força muscular inspiratória e expiratória, endurance muscular respiratório, pico de fluxo da tosse, nível de atividade física, parâmetros do sono e

capacidade de exercício. O teste Mann-Whitney U será utilizado para avaliar a diferença entre grupos para as variáveis: fadiga, dispneia e qualidade de vida. Todas as análises serão realizadas com o programa estatístico SPSS 20.0 e será considerado um =0,05.

Objetivo da Pesquisa:

Objetivo Primário: Investigar o efeito do fortalecimento muscular inspiratório e expiratório de alta intensidade na força muscular inspiratória e expiratória, endurance muscular respiratório, pico de fluxo da tosse e dispneia em indivíduos com Doença de Parkinson. Objetivo Secundário: Investigar o efeito do fortalecimento muscular inspiratório e expiratório de alta intensidade na fadiga, capacidade de exercício, nível de atividade física, sono e qualidade de vida desses indivíduos.

Avaliação dos Riscos e Benefícios:

Segundo o proponente, os riscos associados com o processo de avaliação e com o programa de intervenção são similares aos que o indivíduo está exposto no seu dia a dia. Ele poderá sentir dores musculares leves durante e após os testes, pois os testes exigem um esforço físico maior do que aquele que comumente é realizado diariamente. Como solicitado no parecer anterior, foi acrescido que caso isso ocorra, o voluntário será assistido pelo pesquisador responsável, pelo tempo necessário. Para minimizar a ocorrência deste desconforto, será realizado um período de descanso entre as medidas e obedecendo à demanda dos participantes.

Também segundo o proponente, os indivíduos incluídos no estudo e futuros pacientes poderão se beneficiar com os resultados desse estudo, principalmente porque o objetivo principal do mesmo é determinar uma melhor abordagem de tratamento fisioterápico para indivíduos com Doença de Parkinson. Se após a conclusão do estudo for observado maior benefício alcançado em um grupo em relação aos demais, a intervenção de maior benefício será ofertada para os participantes do grupo controle.

Comentários e Considerações sobre a Pesquisa:

Projeto de pesquisa do programa de pós-graduação em Ciências da Reabilitação, com orçamento viável e financiamento próprio. Segundo parecer consubstanciado, o projeto é importante para sua área de estudo. Também segundo o parecer, a pesquisadora responsável possui capacidade técnica para sua execução. O cronograma apresentado também é viável. As solicitações e pendências apontadas no parecer anterior foram atendidas e realizadas, conforme carta resposta

apresentada.

Considerações sobre os Termos de apresentação obrigatória:

Foram apresentados os seguintes termos: carta resposta ao CEP, projeto completo; informações básicas do projeto; cronograma, carta de anuência dos laboratórios de pesquisa; folha de rosto, parecer consubstanciado, ficha de avaliação, orçamento e TCLE. O TCLE foi ajustado conforme solicitações do parecer anterior e apresentado na carta resposta. Portanto, esse termo está adequado.

Conclusões ou Pendências e Lista de Inadequações:

Somos, S.M J., favoráveis a aprovação do projeto.

Considerações Finais a critério do CEP:

Tendo em vista a legislação vigente (Resolução CNS 466/12), o CEP-UFMG recomenda aos Pesquisadores: comunicar toda e qualquer alteração do projeto e do termo de consentimento via emenda na Plataforma Brasil, informar imediatamente qualquer evento adverso ocorrido durante o desenvolvimento da pesquisa (via documental encaminhada em papel), apresentar na forma de notificação relatórios parciais do andamento do mesmo a cada 06 (seis) meses e ao término da pesquisa encaminhar a este Comitê um sumário dos resultados do projeto (relatório final).

Este parecer foi elaborado baseado nos documentos abaixo relacionados:

Tipo Documento	Arquivo	Postagem	Autor	Situação
Informações Básicas do Projeto	PB_INFORMAÇÕES_BÁSICAS_DO_PROJETO_1862474.pdf	16/02/2022 11:19:29		Aceito
Outros	PARECER_CAMARA.pdf	16/02/2022 11:17:27	Christina Danielli Coelho de Morais Faria	Aceito
Outros	CARTAS_DE_ANUENCIA.pdf	16/02/2022 11:13:20	Christina Danielli Coelho de Morais Faria	Aceito
Outros	FICHA_DE_AVALIACAO.pdf	16/02/2022 11:12:25	Christina Danielli Coelho de Morais Faria	Aceito
Cronograma	CRONOGRAMA.pdf	16/02/2022 11:07:14	Christina Danielli Coelho de Morais Faria	Aceito
Projeto Detalhado / Brochura Investigador	PROJETO_COMPLETO.pdf	16/02/2022 11:06:51	Christina Danielli Coelho de Morais Faria	Aceito

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Continuação do Parecer: 5.356.570

TCLE / Termos de Assentimento / Justificativa de Ausência	TCLE.pdf	16/02/2022 11:06:36	Christina Danielli Coelho de Morais Faria	Aceito
Outros	Carta_Resposta.pdf	16/02/2022 11:02:46	Christina Danielli Coelho de Morais Faria	Aceito
Folha de Rosto	FOLHA_DE_ROSTO.pdf	29/11/2021 07:54:21	Christina Danielli Coelho de Morais Faria	Aceito
Orçamento	ORCAMENTO.pdf	26/11/2021 19:29:27	Christina Danielli Coelho de Morais Faria	Aceito

Situação do Parecer:
Aprovado

Necessita Apreciação da CONEP:
Não

BELO HORIZONTE, 18 de Abril de 2022

Assinado por:
Críssia Carem Paiva Fontainha
(Coordenador(a))

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ANEXO C

Taylor & Francis
Taylor & Francis Group

Disability and Rehabilitation

Telephone-based assessment of fatigue and dyspnea in individuals with Parkinson's disease

Submission ID	241804687
Article Type	Research Article - double anonymous peer review
Keywords	dyspnea, fatigue, Parkinson disease, telephone, validation study
Authors	Sherindan Brito, Aline Scianni, Kênia Parreiras de Menezes, Mariany Scaldaferri, Jordana Magalhães, Christina Faria

For any queries please contact:

IDRE-peerreview@journals.tandf.co.uk

Note for Reviewers:

To submit your review please visit https://mc.manuscriptcentral.com/dandr

ANEXO D

UNIVERSIDADE FEDERAL DE MINAS GERAIS
ESCOLA DE EDUCAÇÃO FÍSICA, FISIOTERAPIA E TERAPIA OCUPACIONAL
PROGRAMA DE PÓS-GRADUAÇÃO EM CIÊNCIAS DA REABILITAÇÃO
DEPARTAMENTO DE FISIOTERAPIA
E-mail: mesreab@eef@ufmg.br

CARTA DE ANUÊNCIA

Declaro, para os devidos fins, a anuência do "Laboratório de Avaliação e Pesquisa em Desempenho Cardiorrespiratório" (LabCare) da Escola de Educação Física, Fisioterapia e Terapia Ocupacional da Universidade Federal de Minas Gerais, ao desenvolvimento do projeto de pesquisa intitulado "Efeito do treinamento muscular respiratório de alta intensidade na força e *endurance* muscular respiratória, pico de fluxo da tosse e dispneia em indivíduos com Doença de Parkinson: um ensaio clínico aleatorizado"

Belo Horizonte, 03 de novembro de 2021

Prof.ª Verônica Franco Parreira, Ph.D.
Coordenadora do LabCare
Departamento de Fisioterapia
Escola de Educação Física, Fisioterapia e Terapia Ocupacional
Universidade Federal de Minas Gerais

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EEFFTO
ESCOLA DE EDUCAÇÃO FÍSICA, FISIOTERAPIA E TERAPIA OCUPACIONAL

CARTA DE ANUÊNCIA

Declaro, para os devidos fins, a anuência do "Laboratório de Estudos em Reabilitação Neurológica do Adulto" (NEUROLAB) da Escola de Educação Física, Fisioterapia e Terapia Ocupacional da Universidade Federal de Minas Gerais, ao desenvolvimento do projeto de pesquisa intitulado "Efeito do treinamento muscular respiratório de alta intensidade na força e *endurance* muscular respiratória, pico de fluxo da tosse e dispneia em indivíduos com Doença de Parkinson: um ensaio clínico aleatorizado"

Belo Horizonte, 03 de novembro de 2021

Prof.ª Christina Danielli Coelho de Morais Faria, P.T., Ph.D.
Departamento de Fisioterapia
Coordenadora do Laboratório de Estudos em Reabilitação Neurológica do Adulto (NEUROLAB)
Escola de Educação Física, Fisioterapia e Terapia Ocupacional
Universidade Federal de Minas Gerais

ANEXO E

Escola de Educação Física Fisioterapia e Terapia Ocupacional | UFMG

PARECER

Belo Horizonte, 09 de novembro de 2021

Interessado (a): Christina Danielli Coelho de Morais Faria, professora do Departamento de Fisioterapia da Universidade Federal de Minas Gerais (UFMG).

Assunto: Relato sobre o projeto de pesquisa "EFEITO DO TREINAMENTO MUSCULAR RESPIRATÓRIO DE ALTA INTENSIDADE NA FORÇA E ENDURANCE MUSCULAR RESPIRATÓRIO, PICO DE FLUXO DA TOSSE E DISPNEIA EM INDIVÍDUOS COM DOENÇA DE PARKINSON: UM ENSAIO CLÍNICO ALEATORIZADO".

Mérito:

A professora Christina Danielli Coelho de Morais Faria solicita aprovação em câmara do Departamento de Fisioterapia do projeto supracitado. O estudo se refere a um projeto de pesquisa a ser desenvolvido como orientação de doutorado no Programa de Pós-Graduação em Ciências da Reabilitação, orientado pela professora. O objetivo primário da pesquisa é investigar o efeito do fortalecimento muscular inspiratório e expiratório de alta intensidade na força muscular inspiratória e expiratória (PImáx e PEmáx), *endurance* muscular respiratório, pico de fluxo da tosse e dispneia em indivíduos com Doença de Parkinson (DP). O objetivo secundário é investigar o efeito do fortalecimento muscular inspiratório e expiratório de alta intensidade na fadiga, capacidade de exercício, nível de atividade física, sono e qualidade de vida desses indivíduos. A justificativa da pesquisa se baseia na ausência de estudos de qualidade metodológica adequada sobre a temática apesar de já ter sido descrita a relevância tanto do treinamento muscular inspiratório quanto do expiratório nos indivíduos com DP. Adicionalmente, a associação do treinamento muscular inspiratório e expiratório parece ser promissora por demandar um menor tempo de realização se comparado ao treinamento muscular isolado. Trata-se de um ensaio clínico aleatorizado, com avaliador cegado e com alocação oculta que será realizado no Laboratório de Avaliação e Pesquisa em Desempenho Cardiorrespiratório (LabCare) e no Laboratório de Estudos em Reabilitação Neurológica do Adulto (NEUROLAB) do Departamento de Fisioterapia da Escola de Educação Física, Fisioterapia e Terapia Ocupacional da UFMG. A pesquisa será registrado no www.ClinicalTrials.gov e realizada conforme as recomendações do *Consolidated Standards of Reporting Trials* (CONSORT). Durante a execução do estudo, as medidas de prevenção a disseminação do coronavírus serão observadas (COMITÊ PERMANENTE DE ENFRENTAMENTO DO NOVO CORONAVÍRUS DA UFMG, 2020; MINISTÉRIO DA SAÚDE, 2020). Uma amostra de conveniência, composta de indivíduos com DP idiopática, será recrutada na comunidade geral da cidade de Belo Horizonte a partir de contato com ambulatórios, clínicas, hospitais,

centros de saúde, associações, grupos de pesquisa e projetos de extensão desenvolvidos com a população de interesse. Para execução do ensaio clínico, os participantes serão alocados aleatoriamente em dois grupos (experimental e controle), de forma estratificada, de acordo com a pressão inspiratória máxima (≥45 cmH2O- fraqueza muscular respiratória leve; <45 cmH2O- fraqueza muscular grave). Os participantes serão submetidos a um treinamento muscular inspiratório e expiratório de alta intensidade (grupo experimental), ou a uma intervenção placebo, que consistirá do mesmo protocolo de exercícios do grupo experimental, porém sem a carga para o treinamento muscular (grupo controle). Será realizada a mensuração dos cinco desfechos primários (PImáx e PEmáx, *endurance* muscular, pico de fluxo da tosse e dispneia) e dos cinco desfechos secundários (capacidade de exercício, fadiga, nível de atividade física, sono e qualidade de vida). Tais mensurações serão realizadas na avaliação inicial, imediatamente após o término do treinamento e um mês após o término do treinamento. Todas as análises estatísticas serão realizadas por um examinador independente, cegado quanto a todos os procedimentos realizados no estudo, inclusive com relação à alocação dos grupos.

O projeto de pesquisa tem objetivos claros e método adequado, sendo relevante, pois busca compreender de forma aprofundada os efeitos da associação do treinamento muscular inspiratório e expiratório em indivíduos com DP. Sua viabilidade está demostrada, visto a disponibilidade de materiais nos laboratórios de realização da pesquisa. O projeto não prevê ônus financeiro ao Departamento de Fisioterapia, visto que todos os custos serão assumidos pelos pesquisadores do projeto de pesquisa na ausência de auxílio financeiro de agências de fomento. Além disso, a professora pesquisadora responsável pelo projeto tem expertise na área de avaliação proposta para a pesquisa.

Voto:

Diante do exposto, sou, S.M.J., favorável à aprovação do projeto de pesquisa "EFEITO DO TREINAMENTO MUSCULAR RESPIRATÓRIO DE ALTA INTENSIDADE NA FORÇA E ENDURANCE MUSCULAR RESPIRATÓRIO, PICO DE FLUXO DA TOSSE E DISPNEIA EM INDIVÍDUOS COM DOENÇA DE PARKINSON: UM ENSAIO CLÍNICO ALEATORIZADO" de interesse do professora Christina Danielli Coelho de Morais Faria.

Christina D.C.M Faria, PhD
Chefe do Departamento de Fisioterapia
EEFFTO/UFMG - Inscr. 22340-9

Aprovado em reunião
de câmara departamental
em 09/11/2021

Prof (a). Danielle Aparecida Gomes Pereira - relatora

MINICURRÍCULO

1. **Formação acadêmica/titulação**
    - **2020 – 2024** Doutorado em Ciências da Reabilitação. Instituição: Universidade Federal de Minas Gerais, UFMG. Orientadora: Christina Danielli Coelho de Morais Faria.
    - **2018 – 2020** Mestrado em Ciências da Reabilitação. Instituição: Universidade Federal de Minas Gerais, UFMG. Orientadora: Christina Danielli Coelho de Morais Faria.
    - **2020 – 2022** Especialização em Fisioterapia Respiratória com Prática Hospitalar. (Carga Horária: 660h). Instituição: Faculdade Ciências Médicas de Minas Gerais, FCM-MG.
    - **2013 – 2018** Graduação em Fisioterapia. Instituição: Universidade Federal de Minas Gerais, UFMG. Orientadora: Christina Danielli Coelho de Morais Faria.

2. **Formação Complementar**
    - **2024**
      Excelência em Ensino: Técnicas de Apresentação Presencial e Online.
      Qualidade de Dados em Saúde para IA.
    - **2023**
      Curso anual de atualização em distúrbios do movimento.
    - **2022**
      Curso de atualização em fisioterapia neurofuncional.
      Fisioterapia & AVC na Prática Clínica.
    - **2021**
      Capacitação do teleatendimento em fisioterapia.
      Elaborando um protocolo de ensaio clínico randomizado: racional, objetivos.
      Simpósio Internacional Online em Ciências da Reabilitação.
    - **2020**
      AEROBICS for Stroke Training Program.
      Protocolos de manejo clínico do coronavírus (COVID-19).
      Treinamento do Portal de Periódicos da CAPES.
      Doenças Crônicas 360°.

3. **Vínculo Institucional**

2023-Atual Hospital Sírio-Libanês
Cargo: Especialista de projetos
Carga horária: 44h/semanais

2020-2023 Hospital Sírio-Libanês
Cargo: Fisioterapeuta consultor
Carga horária: 30h/semanais

2020-Atual Universidade Federal de Minas Gerais

Aluno pesquisador de doutorado
Regime: Dedicação parcial

2018-2020 Universidade Federal de Minas Gerais
Aluno pesquisador de mestrado
Regime: Dedicação integral
Carga horária: 40h/semanais

4. **Revisor de periódico**
2023-atual: Brazilian Journal of Physical Therapy

5. **Prêmios e títulos**
2018
Melhores trabalhos - Força muscular de extensores de joelho indica força global do membro pós-AVE, COBRAFIN/ABRAFIN.

2018
Relevância acadêmica XXVII SIC UFMG - Validade e confiabilidade do teste do esfigmomanômetro modificado para avaliação da força muscular de membros inferiores e preensores palmares de indivíduos idoso, PRPQ/UFMG.

2018
Trabalho formato pôster premiado no XXII Congresso Brasileiro de Fisioterapia (COBRAF), Associação de Fisioterapeutas do Brasil.

6. **Palestras:**
2023
Palestrante no Congresso Brasileiro de Fisioterapia Funcional. Temática. Treinamento muscular respiratório em fisioterapia neurofuncional do adulto e do idoso: das funções musculares respiratórias à qualidade de vida.

2020 a 2022
Professor convidado para ministrar aulas em disciplinas do curso de graduação em fisioterapia/UFMG. Instituição: Universidade Federal de Minas Gerais (UFMG)/Belo Horizonte. Disciplina: medidas clínicas e observacionais

2021
Palestrante na XI Jornada de Fisioterapia Hospital Geral de Fortaleza. Temática: Recuperação funcional pós COVID-19.

7. **Artigos completos publicados em periódicos:** 18 artigos
2020 a 2024

- Benfica PDA, Brito SAF, Carmargo LB, Estarlino LD, Reis MTFD, Santana MM, Faria CDCM. Predictors of muscle strength assessed with the modified sphygmomanometer test. J Bodyw Mov Ther. 2024 Apr;38:425-436.
- Brito SAF, Benfica PDAY, Aguiar LT, Gomes GC, Faria CDCM. A single trial of the five-repetition sit-to-stand test provides adequate measures in community-dwelling older adults: A cross-sectional study. J Bodyw Mov Ther. 2024 Jul;39:536-540.
- Brito SAF, Scianni AA, Peniche PDC, Faria CDCM. Measurement properties of outcome measures used in neurological telerehabilitation: A systematic review protocol. PLoS One. 2022 Mar 21;17(3):e0265841.
- Silva LC, Faria CDCM, Peniche PC, Brito SAF, Aguiar LT. Validity of the two-minute walk test to assess exercise capacity and estimate cardiorespiratory fitness in individuals after stroke: a cross-sectional study. Top Stroke Rehabil. 2024;31(2):125-134.
- Brito SAF, Scianni AA, Silveira BMF, Oliveira ERM, Mateus ME, Faria CDCM. Effects of high-intensity respiratory muscle training on respiratory muscle strength in individuals with Parkinson's disease: Protocol of a randomized clinical trial. PLoS One. 2023 Sep 8;18(9):e0291051.
- Franco J, Silva PFS, Menezes AR, Brito SAF, Faria CDCM. Trunk biomechanical changes between the sit-to-stand and stand-to-sit performed at self-selected and fast speeds in stroke survivors. Disabil Rehabil. 2023 Oct 14:1-8.
- Quintino LF, Aguiar LT, de Brito SAF, Dos Reis MTF, Polese JC, Faria CDCM. How to Score the Peak Oxygen Consumption Obtained Through Cardiopulmonary Exercise Test in Individuals after Stroke? J Stroke Cerebrovasc Dis. 2022 Apr;31(4):106314.
- Brito SAF, Aguiar LT, Quintino LF, Ribeiro-Samora GA, Britto RR, Faria CDCM. Assessment of V̇o2peak and Exercise Capacity After Stroke: A Validity Study of the Human Activity Profile Questionnaire. Arch Phys Med Rehabil. 2022 Sep;103(9):1771-1776.
- Brito SAF, Scianni AA, Peniche PDC, Faria CDCM. Measurement properties of outcome measures used in neurological telerehabilitation: A systematic review protocol. PLoS One. 2022 Mar 21;17(3):e0265841.
- Brito SAF, Santana MM, Benfica PDA, Aguiar LT, Gomes GC, Faria CDCM. The modified sphygmomanometer test for assessment of muscle strength of community-dwelling older adults in clinical practice: reliability and validity. Disabil Rehabil. 2022 Jan;44(1):131-138.
- Brito SAF, Aguiar LT, Garcia LN, Peniche PDC, Reis MTFD, Faria CDCM. Cardiopulmonary exercise testing and aerobic treadmill training after stroke: Feasibility of a controlled trial. J Stroke Cerebrovasc Dis. 2020 Jul;29(7):104854. doi: 10.1016/j.jstrokecerebrovasdis.2020.104854. Epub 2020 May 11. PMID: 32404287.

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8. **Capítulos de livros publicados: 5** capítulos
    - Faria CDCM, Scianni AA, Peniche PC, Brito SAF, Teixeira-Salmela LF. Emerging Technologies in Neurorehabilitation: A Perspective from Brazil. Emerging Technologies in Healthcare. 2024.
    - Peniche PC, BRITO SAF, Scianni AA, Teixeira-Salemela LF, Faria CDCM. Tecnologias emergentes na fisioterapia neurofuncional do adulto: utilização prática e projeções no contexto brasileiro. PROFISIO. 2024.
    - Menezes KKP, Brito SAF, Silveira BMF, Faria CDCM. Treinamento muscular respiratório em adultos com doenças do sistema nervoso. PROFISIO. 2024.
    - Faria CDCM, Aguiar LT, Brito SAF. Avaliação e Intervenção Fisioterapêutica em Fisioterapia Neurofuncional do Adulto. Questões Comentadas em Fisioterapia. 2022.
    - Brito SAF, Teixeira-Salmela LF, Faria CDCM. Perfil de Atividade Humana para avaliação do nível a atividade e aptidão física de idosos. Medidas de Desempenho Físico e Funcional de Pessoas Idosas. 2022

9. **Trabalhos em andamento:**
    - Effects of using conventional assistive devices on spatiotemporal gait parameters of adults with neurological disorders: a systematic review protocol.
    - Effects of speed-based interventions to reduce bradykinesia in individuals with Parkinson's disease: a protocol for a systematic review.

10. **Artigos submetidos para publicação:** 2
11. **Resumos publicados em anais de congressos:** 53
12. **Apresentações de Trabalho:** 15
13. **Outras produções bibliográficas:** 5
14. **Participação em bancas:** 7
15. **Participação em eventos, congressos, exposições e feiras:** 40
16. **Organização de eventos, congressos, exposições e feiras:** 2

17. Orientações e supervisões concluídas: 2 (1 de especialização e 1 de graduação)